IMSRP VI

Bibliography of Selected References Related to Subsidence: An Update

B. A. Trent, R. A. Bauer, and P. B. DuMontelle
Illinois State Geological Survey

Illinois Mine Subsidence Research Program

cooperating agencies

ILLINOIS STATE GEOLOGICAL SURVEY
Department of Energy and Natural Resources

BUREAU OF MINES
United States Department of the Interior

The **Illinois Mine Subsidence Research Program** (IMSRP) was established in 1985 to investigate methods and develop guidelines for underground mining operations that aim to maximize coal extraction yet preserve the productivity of prime farmland. The research program was initiated by the Illinois Coal Association and the Illinois Farm Bureau.

The Illinois State Geological Survey, a division of the Illinois Department of Energy and Natural Resources, directed the IMSRP. Participating research institutions included Southern Illinois University at Carbondale, the University of Illinois at Urbana-Champaign, Northern Illinois University, and the Illinois State Geological Survey. A five-year Memorandum of Agreement, signed by the State of Illinois and the Bureau of Mines, U. S. Department of the Interior, ensured collaboration, cooperation, and financial support through 1991. Major funding was also provided by the Illinois Coal Development Board.

This publication is one in a series printed and distributed by the Illinois State Geological Survey as a service to the IMSRP. In the interest of making this information available to the public as quickly as possible, this bibliography has been reviewed for technical accuracy only.

Trent, B.A.

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Bibliography of Selected References Related to Subsidence: An Update

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Illinois State Geological Survey

IMSRP

Illinois Mine Subsidence Research Program

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Introduction and Background

The Illinois Mine Subsidence Research Program (IMSRP) compiled this bibliography to aid mine subsidence researchers, mining company technical personnel, and persons involved with agriculture in coal-resource areas in Illinois. Entries were collected from journals, proceedings, bibliographies, and library catalogs. The references were compiled using a computer database management system at the Illinois State Geological Survey (ISGS). The bibliography was printed in 1988 as IMSRP Technical Series Volume V; it contained about 2,200 references. For the present publication, the original set of references was updated, corrected, and expanded; almost 1,000 new references were added.

This bibliography emphasizes mine subsidence. References on other types of subsidence are included, however, such as that caused by groundwater withdrawal. In general, the following broad topics are covered: general information, background, and synthesis; regulations and law; monitoring and instrumentation; case studies; modeling and prediction; structural damage; backfilling and other subsidence control measures; mitigation of both land and structures; and active and abandoned mines. The references cover worldwide problems; however, the greatest number concern the United States, the United Kingdom, Australia, Europe, South Africa, and India. For the United States, many of the references are tagged by state and, if related to coal mine subsidence, they may be noted as specific to the Appalachian Coal Region, the Illinois Coal Basin, or the Rocky Mountain Coal Region.

The references are listed alphabetically by first author and year of publication. Short abstracts or descriptions of the works are included with many of the entries. Key subjects and locations are included for most entries. The database was originally designed for computer access using a combination of more than one keyword. During an on-line search, a second, third, or fourth keyword could be entered to better fit the researcher's interest. While we recognize the limitations of a printed bibliography compared with on-line searching, we printed the bibliography as a reference list.

Publication dates of the references run through the first half of 1993. If the reference is from a conference, symposium, or workshop, its date of publication is the same as the year of the conference unless otherwise stated. The availability of subsidence information varies. The best sources of subsidence-related references are university and college libraries, especially those with strong mining, geology, or engineering departments. Some references may be found at federal and state agencies, such as the U.S. Bureau of Mines or state geological surveys. Many reports on federally sponsored research contracts are available through the National Technical Information Service (NTIS).

Abbreviations

Following is a list of abbreviations used in this bibliography:

AIHS	Association Internationale d'Hydrologie Scientifique
AIME	American Institute of Mining, Metallurgical and Petroleum Engineers
ASCE	American Society of Civil Engineers
B	Bulletin
DOE	Department of Energy
EPA	Environmental Protection Agency
IAHS	International Association of Hydrological Sciences
IC	Information Circular
ISGS	Illinois State Geological Survey
NCB	National Coal Board
NTIS	National Technical Information Service
OFR	Open file report
OSM	Office of Surface Mining
RI	Report of Investigations
SMCRA	Surface Mining Control and Reclamation Act of 1977
SME	Society for Mining, Metallurgy, and Exploration
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USBM	United States Bureau of Mines
USGS	United States Geological Survey

Acknowledgments

This bibliography was constructed using INMAGIC, a database management system developed for library use by Inmagic, Incorporated, Cambridge, Massachusetts. The original 741 references came from U.S. Bureau of Mines Information Circular 9007, *Subsidence Information for Underground Mines--Literature Assessment and Annotated Bibliography*. We thank the IMSRP Technical Committee who helped to select entries and keywords. The ISGS library staff provided helpful reviews. This research was supported by the IMSRP, which was funded by the U.S. Bureau of Mines and the Illinois Coal Development Board of the Illinois Department of Energy and Natural Resources. The IMSRP was administered by the ISGS.

Abel, J. F., D. W. Gentry. A Longwall Subsidence Prediction Model. American Society of Civil Engineers National Spring and Continuing Education Convention, Pittsburgh, PA, April 24-28, 1978, session 71, ASCE preprint 3293, p. 56-76.

This paper presents a preliminary subsidence prediction model. Data were obtained from an instrumentation program implemented at the York Canyon Mine, near Raton, New Mexico.

Keyword(s): vertical displacement, prediction, longwall, modeling

Location(s): Rocky Mountain Coal Region, New Mexico, United States

Abel, J. F., F. T. Lee. Lithologic Controls On Subsidence. Society of Mining Engineers of AIME Fall Meeting, Minneapolis, MN, October 22-24, 1980, SME-AIME Preprint 80-314, 16 p.

Keyword(s): geologic features

Location(s): United States

Abel, J. F., F. T. Lee. Subsidence Potential in Shale and Crystalline Rocks. U.S. Geological Survey OFR 80-1072, May, 1980, 99 p.

This report presents a statistical summary of worldwide subsidence experience in shale and crystalline rocks. It includes an expanded bibliography of the most significant references on mining-induced subsidence in these rocks. No measurements have been reported in the literature of subsidence in "massive" shale and crystalline rocks (potential host rocks for radioactive-waste repositories). Predictions of the subsidence response of massive rock made on the basis of information gained from less uniform rocks will be subject to unknown but possibly large error.

Keyword(s): literature search, geologic features, backfilling, prediction

Location(s): United States

Abel, J. F. Surface Subsidence Monitoring Guidelines. U.S. Geological Survey contract 14-08-0001-18822, Colorado School of Mines, June 30, 1982, 11 p. (Available for consultation at the Denver USBM Research Center.)

The author suggests guidelines for monitoring subsidence over longwall and room-and-pillar retreat mines. Included are details on monument-layout patterns, monument construction and installation, monument spacing, survey timing, and strain-measurement techniques. A rationale is provided for these guidelines. This paper should be useful for those planning a subsidence-monitoring program.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, longwall, room-and-pillar, high-extraction retreat, horizontal displacement, vertical displacement, instrumentation

Location(s): United States

Ackenheil, A. C., M. T. Dougherty. Recent Development in Grouting for Deep Mines. American Society of Civil Engineers Annual Meeting and National Meeting on Structural Engineering, Sept., 1968, preprint 727.

Keyword(s): engineering, grouting

Location(s): United States

Ackenheil, A. C., M. T. Dougherty. Recent Developments in Grouting for Deep Mines. IN: Proceedings of Journal of the Soil Mechanics and Foundations Division, American Society of Civil Engineers, v. 96, no. SM 1, 1970.

This paper describes the use of grout columns for support of sites over abandoned mines; it also discusses borehole photography.

Keyword(s): foundations, photography, abandoned mines, grouting

Location(s): United States

Adamek, R., J. Lojas. Eksploatacja Instalacji Poksadzkowych Glebockich Kopaln (Operation of Hydraulic Stowage Installations in Deep Mines). Przeglad Gorniczy, v. 24, no. 6, 1968, p. 262-275.

Keyword(s): hydraulic backfilling

Adamek, V., P. W. Jeran. Evaluation of Existing Predictive Methods for Mine Subsidence in the U.S. IN: Proceedings 1st Annual Conference on Ground Control in Mining, West Virginia University, July 27-29, 1981, S.S. Peng, ed., Morgantown, WV, p. 209-219.

Two existing predictive methods were chosen for evaluation: an influence function (Bals Theory) and a profile function (hyperbolic). These were applied to seven field-measured subsidence profiles in two major coal basins in the United States. The effect of homogenous versus non-homogenous overburden on surface subsidence is demonstrated and the use of Bals Theory as a subsidence predictive method for both types of overburden is examined. The major factor affecting subsidence profile characteristics is the migration of the inflection point toward the centerline of the longwall panel.

Keyword(s): prediction, prediction theories, influence function, profile function, coal mining, overburden, longwall

Location(s): West Virginia, Ohio, Appalachian Coal Region, Illinois, Illinois Coal Basin, United States

Adamek, V., P. W. Jeran. Evaluation of Existing Predictive Methods for Mine Subsidence in the U.S. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 3, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 88-89.

Two existing prediction methods are evaluated for use over United States coal mines: an influence function and a profile function. These methods were applied to several field-measured subsidence profiles.

Keyword(s): vertical displacement, prediction, prediction theories, empirical model, profile function, influence function, coal mining

Location(s): West Virginia, Appalachian Coal Region, Ohio, Illinois, Illinois Coal Basin, United States

Adamek, V., P. W. Jeran. Evaluation of Surface Deformation Characteristics Over Longwall Panels in the Northern Appalachian Coalfield. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, SME-AIME, Y.P. Chugh and M. Karmis, eds., Sept., 1982, p. 183-197.

This paper details the characteristics of surface deformations, including subsidence, inclination, curvature, and horizontal strain based on information obtained by direct field measurements over three longwall panels in the Northern Appalachian Coalfield. The authors apply two European prediction theories to Appalachian geologic conditions.

Keyword(s): prediction theories, vertical displacement, horizontal displacement, coal mining, longwall, prediction, ground control, survey methods

Location(s): West Virginia, Appalachian Coal Region, United States

Adamek, V., P. W. Jeran. Precalculation of Subsidence Over Longwall Panels in the Northern Appalachian Coal Region. IN: Mine Subsidence Control, Proceedings Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, September 19, 1985, U.S. Bureau of Mines IC 9042, p. 34-56.

Specific lithological conditions over the Pittsburgh Coalbed prevent the use of European predictive methods. This paper describes the development of a prediction methodology suitable to the mining and geological conditions in the northern Appalachian Coal Region. Owing to lithological conditions over the Pittsburgh Coalbed, the subsidence coefficient varies within the area of the subsidence trough. This is different from the European conditions, where the subsidence coefficient is considered to be a constant.

Keyword(s): prediction theories, geologic features, angle of draw, longwall, coal mining

Location(s): Appalachian Coal Region, United States

Adamek, V., P. W. Jeran, M. A. Trevits. Evaluation of Influence Function-Based Subsidence Prediction Models. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Aug. 8-10, 1990, Mt. Vernon, IL, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 268-275.

Recently, several computer algorithms have been published using the Budryk-Knothe influence function for subsidence prediction. This influence function was developed from Knothe's profile function in a two-dimensional coordinate system. It is the opinion of the authors that, because the two functions are conceptually incompatible, the use of a profile function in an influence function technique for underground geometries not satisfying the limitations for the use of the profile function lacks justification. Although a conception, in general, cannot be proven or disproven mathematically, a properly chosen comparative study can give insight into its soundness.

Keyword(s): influence function, prediction, modeling, computer, profile function, longwall, active mines, coal mining

Location(s): United States

Adamek, V., P. W. Jeran, M. A. Trevits. Development of Dynamic Subsidence Over Longwall Panels in the Northern Appalachian Coal Region. IN: Rock Mechanics, Proceedings 33rd U.S. Symposium, Sweeney Convention Center, Santa Fe, NM, June 3-5, 1992, J.R. Tillerson and W.R. Wawersik, eds., A.A. Balkema, Rotterdam, p. 243-251.

It is a common perception that an increased rate of longwall face advance will result in a flatter dynamic subsidence trough above the panel, thus diminishing the magnitude of surface deformations, including inclination, curvature, and horizontal strain. A thorough analysis of centerline field data from 14 USBM longwall panel studies revealed, however, the only effect of the differing rates of face advance on dynamic subsidence was the duration of its development. There was no effect on either the magnitude or the distribution of the surface deformations. Because the rate of face advance does not play a role in dynamic subsidence development, it has been determined that the prediction of dynamic subsidence can be approached using a methodology developed for static subsidence prediction.

Keyword(s): longwall, prediction, vertical displacement, horizontal displacement

Location(s): Appalachian Coal Region, United States

Adamek, V., P. W. Jeran, M. A. Trevits. Static and Dynamic Subsidence Prediction in the Northern Appalachian Based on the Use of a Variable Subsidence Coefficient. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 10-21.

Due to the variability of subsidence characteristics across coalfields in the United States, it was concluded that it would be practically impossible to develop a universal predictive model for mining-induced subsidence based on theoretical assumptions. Therefore, an effort was made to find a procedure to develop an empirical predictive model based on a sufficient amount of field data from one mining area. If successful, this procedure could be used as the template for developing predictive capabilities for other coalfields with different subsidence characteristics, given a reasonable amount of field data. This paper presents the theory, development, and application of the static and dynamic subsidence prediction models.

Keyword(s): modeling, prediction, prediction theories, empirical model, longwall, geologic features, vertical displacement, horizontal displacement, computer, angle of draw

Location(s): Appalachian Coal Region, United States

Adams, S., P. A. Hart, P. W. McDowell. Ground Conditions at Lion Salt Works Site, Marston, Cheshire. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J. D. Geddes, ed., Pentech Press, London, 1992, p. 443-458.

The unused buildings at Lion Salt Works have been visibly affected by various mining activities extracting halite from beneath the site since the late 19th century. As the works are of special industrial archaeological value, prior to the commencement of preservation operations, an investigation of ground conditions, analysis of findings, and assessment of the ramifications for site preservation were performed. Two economic halite beds had been simultaneously exploited by relatively deep room-and-pillar workings and by brine well pumping at shallower depths. Overlying strata were anticipated to contain many voids, these being responsible for numerous irregularly shaped depressions on the surface.

Keyword(s): non-metal mining, abandoned mines, land-use planning, surface subsidence damage, surface structural damage, monitoring methods, geologic features, foundations, geophysical, structural mitigation

Location(s): United Kingdom

Adler, L. The Mechanics of Longwall Caving. Transactions, AIME, v. 217, 1960, p. 190-193.

Keyword(s): longwall

Location(s): United States

Adler, L., M. C. Sun. Ground Control in Bedded Formations. Research Division, Virginia Polytechnic Institute, Blacksburg, Bulletin 28, December, 1968, 266 p.

The important phases of ground control have been divided into three basic elements: roof, pillar, and floor. For each element, the significant literature dealing with the application of its respective concepts and with the available field evidence has been studied. A special application of roof control concepts to longwall mining methods has also been reviewed.

Keyword(s): ground control, literature search, longwall, roof support, pillar strength, floor stability, ground control, bumps, roof stability

Adler, L. A. Coordinated Approach--Preliminary and Integrated Analyses. IN: SME Mining Engineering Handbook, v. 1, A.B. Cummins and I.A. Givens, eds., 1973, SME-AIME, New York, p. 13-9--13-36.

This chapter discusses the design and control of underground structures in terms of preliminary analyses of individual elements such as the roof and pillars, and in terms of an integrated analysis of a synthesis of these components.

Keyword(s): mine design, roof stability, geologic features, ground control

Advani, S. H., Y. T. Lin. Subsidence and Roof Response Studies Related to Underground Coal

Gasification. IN: Proceedings 3rd Annual Underground Coal Conversion Symposium, Fallen Leaf Lake, CA, June 6-9, 1977, L.Z. Shuck and J.D. Spencer, eds., Morgantown Energy Technology Center, DOE, Morgantown, WV, p. 422-429.
Keyword(s): coal gasification, roof stability
Location(s): United States

Advani, S. H., O. K. Min, J. K. Lee. Stress and Failure Evaluations Associated with Selected Coal Mine Pillar Geometries. Ohio State University, SAND80-7098, Sandia National Laboratories, Albuquerque, NM, June, 1980, 41 p.
Keyword(s): pillar strength, mine design, room-and-pillar, coal mining
Location(s): United States

Adyalkar, P. C., K. R. Srinivasan. Role of Hydrogeology in Coal Mining Near Chandrapur in Maharashtra, India. IN: Symposium on Water in Mining and Underground Works, SIAMOS--78, Granada, Spain, 1978, p. 1-16.
The Barakar Series of the Lower Gondwanas of Central India are stratigraphically important for the occurrence of rich deposits of coal of economic significance. Coal India Ltd. plans to adopt the depillaring program in advanced coal mines in this formation to achieve maximum production based on the cost-benefit ratio. The problem of heavy seepage may occur however. Hydrogeological studies were undertaken by the Central Ground Water Board with the construction of a test wellfield near the Mahakali Colliery of Chandrapur in India. These studies have illuminated the precise status of the groundwater regime of the overlying Kamthis and the Barakars, and established the basic aquifer parameters for quantification of seepage flows during the depillaring program. These studies are of great significance for planning and designing the pumping program to prevent sudden flooding in the coal mines.
Keyword(s): hydrology, coal mining, subsurface water, pillar extraction, geologic features, mine design
Location(s): India

Afrouz, A. Floor Behavior Along Longwall Roadways. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 12, 1975, p. 229-240.
Keyword(s): longwall, floor stability

Afrouz, A. Yield and Bearing Capacity of Coal Mine Floors. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 12, 1975.
Keyword(s): coal mining, floor stability

Afrouz, A., F. P. Hassani, M. J. Scoble. Geotechnical Assessment of the Bearing Capacity of Coal Mine Floors. International Journal of Mining and Geological Engineering, 1988, v. 6, no. 4, p. 297-312.
This investigation concerns three longwall faces having variable strata and mining conditions. Bearing capacity tests along the faces were conducted to evaluate the factors influencing floor deformation and failure. The effect of size, shape, and perimeter of the base plates; thickness of the floor layer; time; and moisture on the ultimate bearing capacity of the floor was measured and discussed. The application of this work is the prediction of stability and support performance of face ends, as well as the design of support systems and ground control on production faces.
Keyword(s): floor stability, coal mining, longwall, in situ testing, instrumentation, geotechnical

Agapito, J.F.T., J. R. Aggson, S. J. Mitchell, M. P. Hardy, W. N. Hoskins. A Study of Ground Control Problems in Coal Mines with High Horizontal Stresses. IN: Rock Mechanics: A State of the Art, Proceedings 21st Symposium on Rock Mechanics, May 28-30, 1980, D.A. Summers, ed., University of Missouri at Rolla, p. 820-828.
This study developed in two stages: (1) the determination of horizontal stresses in the roof by overcoring to verify the regional existence of high stresses, and (2) numerical analyses based on these stress determinations to investigate alternate mine geometries that might reduce ground control problems.
Keyword(s): rock mechanics, ground control, coal mining, roof stability, geologic features, modeling, overburden, bituminous, yielding supports, mine design
Location(s): West Virginia, Appalachian Coal Region, United States

Agapito, J.F.T., S. J. Mitchell, M. P. Hardy, W. N. Hoskins. Determination of Insitu Horizontal Rock Stress in Both a Mine-Wide and District-Wide Basis. Report to U.S. Bureau of Mines by Tosco Research Inc., and Agapito & Associates, 1980, p. 1-173. (NTIS PB 81-139735)

Keyword(s): rock mechanics, in situ testing
Location(s): United States

Aggson, J. R. Coal Mine Floor Heave in the Beckley Coalbed, An Analysis. U.S. Bureau of Mines RI 8274, 1978, 32 p.
Keyword(s): floor stability, coal mining
Location(s): United States

Aggson, J. R. Insitu Stress Fields and Associated Mine Roof Stability. IN: Proceedings, Mini Symposium on Application of Geotechnical Data to Underground Mine Design, SME-AIME Fall Meeting, Mini Symposium Series no. 78-1, 1978, p. 16-20.
Keyword(s): roof stability, geotechnical, mine design
Location(s): United States

Aggson, J. R. Stress-Induced Failures in Mine Roof. U.S. Bureau of Mines RI 8338, 1979, 16 p.
This report presents a finite element analysis of roof stresses associated with an underground coal mine entry 4 feet high by 18 feet wide. This analysis starts with known loading conditions determined in an underground coal mine in West Virginia and is extended to other possible underground loading conditions. The roof failures predicted by the finite element analysis under known loading conditions correlate well with the roof failures observed underground. The most probable failure modes are identified for the various loading conditions considered. Various failure preventive measures are discussed.
Keyword(s): roof stability, finite element, ground control, rock mechanics, geologic features, coal mining
Location(s): West Virginia, Appalachian Coal Region, United States

Aggson, J. R. Design of Room and Pillar Mining Systems. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, Aug. 22-24, 1979, Southern Illinois University, Carbondale, June, 1980, p. 44-52.
Recent investigations into ground control problems in underground coal mines have shown a strong correlation between the results of theoretical structural analyses of coal mine openings and observed failures in operating mines. This paper presents a general overview of the various loading conditions that can be expected underground and the response of the mine roof to those loading conditions. Potential ground control problems and recommended solutions are discussed for several roof types under various loading conditions.
Keyword(s): room-and-pillar, ground control, coal mining, roof stability, geologic features, mine design
Location(s): United States

Agioutantis, Z., G. Goodman, A. Jarosz, M. Karmis, P. Schilizzi. Prediction of Ground Movements Due to Underground Mining in the Eastern United States Coalfields Volume 1. Development of Prediction Methods. Report on Office of Surface Mining Contract J5140137, Virginia Polytechnic Institute and State University, Department of Mining and Minerals Engineering, Blacksburg, December, 1987, 205 p. (NTIS PB90-148594)
This report presents basic concepts of prediction methods and monitoring programs, analysis and refinement of prediction methods applicable to the eastern United States coalfield, subsidence control, and socio-economic considerations and conclusions.
Keyword(s): coal mining, prediction, mathematical model, economics, longwall, high-extraction retreat, room-and-pillar, empirical model, profile function, influence function, zone area, prediction theories, instrumentation, monitoring methods, monitoring equipment, survey data processing, angle of draw, yielding supports
Location(s): Appalachian Coal Region, United States

Agioutantis, Z., M. Karmis, A. Jarosz. Prediction of Surface Subsidence and Strain in the Appalachian Coalfields Using Numerical Methods. IN: Proceedings of 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 95-100.
This paper presents a two-dimensional numerical procedure that incorporates concepts related to the mechanics of strata deformation as well as empirical indices associated with subsidence engineering. Regional deformation data were employed to establish overburden deformation zones, while material properties were kept constant. Scaling of final displacement was based on empirically predicted values for subsidence and strain for the Appalachian coalfield. The model was validated with a number of regional case studies and predicted subsidence and strain curves were compared with those obtained using a semi-empirical influence function formulation.

Keyword(s): prediction, modeling, overburden, influence function, empirical model, computer, coal mining

Location(s): Appalachian Coal Region, United States

Ahola, M. Application of the Discrete Element Method Toward Roof Stability Problems in Underground Coal Mines. IN: Proceedings 1st U.S. Conference on Discrete Element Methods, Golden, CO, October 19-20, 1989, Colorado School of Mines, 9 p.

Keyword(s): modeling, roof stability, coal mining

Ahola, M. P. Geomechanical Evaluation of Escarpments Subjected to Mining Induced Subsidence. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Golden, CO. Balkema, Rotterdam, p. 129-136.

This paper presents preliminary results of numerical modeling conducted by the Bureau of Mines to illustrate the capabilities of the boundary-element method in predicting, comparing, and assessing the effects of mining beneath massive sandstone escarpments. This is rapidly becoming a major environmental concern in the Western United States. As an escarpment is undermined, the resulting subsidence induced by the mining has the potential to cause blocks of material to fail along existing joint planes and slide or topple down the talus slope below. This failure has the potential to impact wildlife habitat, raptor nesting sites, vegetation, and other land uses. A two-dimensional boundary-element analysis was conducted along a vertical cross section through a mine in Utah.

Keyword(s): modeling, boundary element, prediction, environment, longwall, coal mining, geologic features, wildlife

Location(s): Utah, Rocky Mountain Coal Region, United States

AIME. Report of Sub-Committee on Coal Mining to Committee on Ground Movement and Subsidence. Transactions, AIME, v. 74, 1926, p. 734-809.

At the time (1926), this report was considered to be the most complete collection of subsidence data. In addition to cases already in the literature, questionnaires were sent out to all the large operating bituminous coal companies and to many engineers. The effects of subsidence were discussed under the four main categories of squeezes, multiple-seam extraction, room-and-pillar mining, and longwall mining. Contains a bibliography of subsidence literature from 1913-1924.

Keyword(s): pillar extraction, multiple-seam extraction, mine operation, historical, room-and-pillar, longwall, literature search, coal mining

Location(s): Illinois, England, Appalachian Coal Region, Oklahoma, United States

AIME-SME, Coal Division. Elements of Practical Coal Mining. Port City Press, Inc., Baltimore, Maryland, 1973, 614 p.

This book presents basics of mine design and operation, including mining methods and roof support.

Keyword(s): roof support, mine design, mine operation, coal mining

Location(s): United States

Akagi, T. Some Land Subsidence Experiences in Japan and Their Relevance to Subsidence in Bangkok, Thailand. Geotechnical Engineering, v. 10, 1979, p. 1-48.

Location(s): Japan, Thailand

Akimov, A. G. On Methods of Precalculating Ground Surface Movements. Ugol, v. 2, 1958, p. 20-23.

Keyword(s): prediction

Albert, E. K., R. L. Flegal. Developing an Information System to Choose Abandoned Mine Sites for Reclamation. Mining Engineering, November, 1990, p. 1246.

A management information system that combines scientific selection procedures is being developed to provide for a flexible and customized selection procedure for AML projects.

Keyword(s): abandoned mines, reclamation, computer, coal mining

Location(s): United States

Albright, J. N., P. M. Halleck, C. Pearson, M. Fehler. Subsurface Subsidence Damage Monitoring: Seismic Tomography and Microgravimetry. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S. S. Peng and M. Harthill, eds.,Department of Mining Engineering, West Virginia University, Morgantown, March, 1982, p. 198-205.

Both microgravimetry and crosshole seismic tomography are means by which subsurface collapse and rock failure may be observed. The authors show results of calculations that predict changes in gravity and gravity gradient that result from void migration, bulking, and hydrology disruption due to room-and-pillar mining.

Keyword(s): monitoring design, monitoring equipment, monitoring installation, seismic, subsurface water, hydrology, overburden

Location(s): West Virginia, Appalachian Coal Region, United States

Albright, M. B. Subsidence Related to Oil Field Activity. IN: Proceedings, 2nd Geologic Hazards Conference, Landslides and Subsidence, Los Angeles, CA, 1966, California Resources Agency, Sacramento, p. 130-134.

Keyword(s): oil extraction

Alder, H., A. Walker, L. Walker. Subsidence and Its Bearing on Mining Methods. Transactions, Institute of Mining Engineers, London, v. 107, no. 2, May, 1942, p. 302-326 and 421-424.

This paper discusses the effects of subsidence from underground mining on the surface and intermediate strata. Various mining methods are recommended that provide for maximum economical coal extraction along with minimum subsidence.

Keyword(s): mine design, overburden, partial extraction, room-and-pillar, longwall

Location(s): England

Alder, H., A. Walker, L. Walker. Subsidence and Its Bearing on Mining Methods. Colliery Guardian, v. 166, 1943, p. 569-572, 600-604, and 628-632.

Total extraction of coal over a sufficiently large area is inevitably followed by subsidence of the surface regardless of the depth of working, the method of mining, or the thickness of the seam.

Keyword(s): angle of draw, geologic features, coal mining, mine design, mine operation, partial extraction, pillar strength

Location(s): United Kingdom

Alder, H., E. L. Potts, A. Walker. Research on Strata Control in the Northern Coal Field of Great Britain. IN: Proceedings, International Conference About Rock Pressure and Support in the Workings, April 24-28, 1951, Liege, Belgium, Institut National de l'Industrie Charbonniere, p. 104-113.

Keyword(s): ground control, coal mining

Location(s): England

Aljoe, W. W., J. W. Hawkins. Investigation and Characterization of Groundwater Flow Systems in Abandoned Underground Coal Mines. IN: Reclamation 2000: Technologies for Success, Proceedings National Meeting American Society of Surface Mining and Reclamation, 1991, W. Oaks and J. Bowden, eds., p. 241-260.

Keyword(s): abandoned mines, coal mining, hydrology, subsurface water

Alke, R. B., B. L. Thompson. A Case History of the Effect of Mine Subsidence on a Concrete Arch Bridge in Northern West Virginia. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 907-913.

A reinforced portland concrete arch filled bridge was undermined by an active longwall in West Virginia. After the subsidence, the bridge retained its structural integrity and adequately carried the required live loads. Normal traffic was maintained continuously during and after the subsidence period. The only repair to the structure required as a result of mining was epoxy injection of the cracks. Although the bridge settled differentially, it was never out of service. Temporary supports were installed, but they never became functional nor was public safety ever in question.

Keyword(s): surface structural damage, longwall, coal mining, active mines, engineering, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

Allen, A. S. Review of the Causes of Subsidence. U.S. Department of the Interior, Geological Survey Professional Paper 400-B, 1960, p. B147-B148.

Keyword(s): fluid extraction

Location(s): United States

Allen, A. S. Geologic Settings of Subsidence. Reviews in Engineering Geology, v. 2, D.J. Varnes and G. Kiersch, eds. Geological Society of America, Boulder, CO, 1969, p. 305-342.

Keyword(s): geologic features, engineering

Location(s): United States

Allen, A. S., C. W. Anderson. Recent Developments in the Use of Mine Waste for Subsidence Control. IN: Proceedings, 4th Mineral Waste Utilization Symposium, cosponsored by U.S. Bureau of Mines and Illinois Institute of Technology Research Institute, Chicago, IL, May 7-8, 1974, p. 213-221.

This paper provides information on pumped-slurry backfilling procedures as well as the use of mine waste as fill for controlling subsidence in abandoned room-and-pillar mines that have become flooded or are otherwise inaccessible.

Keyword(s): hydraulic backfilling, mine waste, abandoned mines, room-and-pillar

Location(s): Pennsylvania, Appalachian Coal Region, United States

Allen, A. S. Basic Questions Concerning Coal Mine Subsidence in the United States. Bulletin of the Association of Engineering Geologists, v. 15, no. 2, 1978, p. 147-161.

Keyword(s): coal mining

Location(s): United States

Allen, C.A. Coal Losses in Illinois. Illinois State Geological Survey, Mining Investigation Bulletin 30, 1925, Urbana, 34 p.

This report discusses extraction percentages in 27 counties in Illinois. Pillars and roof coal were two of the reasons for coal being left behind. Other unavoidable coal losses were left to support railroads and streams.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Allen, C. A. Coal Losses in Illinois. Illinois State Geological Survey, Mining Investigation Bulletin 30, 1925, Urbana, 36 p.

This report discusses the amount of coal in Illinois that was left unmined as pillars and for other reasons. The author showed how extraction ratios could be increased in many cases from 50% to 80%. In some counties, coal was left to protect railroads, roads, water supplies, and/or surface agricultural land from subsidence.

Keyword(s): historical, coal mining, partial extraction, economics, agriculture, land values

Location(s): Illinois, Illinois Coal Basin, United States

Allen, C. W. Subsidence Resulting from the Athens System of Mining at Neganee, Michigan. Transactions, AIME, v. 109, 1934, p. 195-202.

Location(s): Michigan, United States

Allen, D. R. Physical Changes of Reservoir Properties Caused by Subsidence and Pressuring Operations. Journal of Petroleum Technology, v. 20, no. 1, 1968, p. 23-29.

Keyword(s): oil extraction, hydrology, subsurface water

Allen, D. R. Collar and Radioactive Bullet Logging for Subsidence Monitoring. IN: Proceedings, 10th Annual Society of Professional Well Log Analysts Logging Symposium, Houston, 1969, p. G.1-G.19.

Keyword(s): fluid extraction, monitoring methods, oil extraction

Allen, D. R., M. N. Mayuga. The Mechanics of Compaction and Rebound, Wilmington Oil Field, Long Beach, California, International Association Hydrological Sciences Publication 89, 1970, p. 410-423.

Keyword(s): oil extraction, fluid extraction

Location(s): California, United States

Allett, E. J. Environmental Aspects of New Mine Planning. Colliery Guardian, v. 231, no. 8, 1983, p. 434-435, 437-439, and 441.

Keyword(s): environment, mine design, land-use planning

Allgaier, F. K. Subsidence Monitoring Over Western Coal Mines. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., West Virginia University, Morgantown, March, 1982, p. 156-161.

This paper describes subsidence monitoring equipment and procedures used at five coal mines in Colorado and Utah with substantially different mine plans, mining methods, depths of cover, and topography. The monitoring procedures used at each site were similar and included designing the monitoring network layout, installing the subsidence monuments, initial and periodic surveying, and processing the survey data. Data from the monitoring program are supplied to cooperating mining companies and used by the Bureau to accomplish the long-term objective of developing and validating subsidence prediction techniques applicable to mines in the West.

Keyword(s): monitoring installation, monitoring equipment, monitoring design, survey methods, survey equipment, survey data processing, coal mining, prediction

Location(s): Colorado, Utah, Rocky Mountain Coal Region, United States

Allgaier, F. K. Surface Subsidence Over Longwall Panels in the Western United States. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, SME-AIME, Y.P. Chugh and M. Karmis, eds., Sept., 1982, p. 199-209.

The geology, mine plan, and survey network are outlined for three study sites as part of an ongoing subsidence prediction research program conducted in central Utah. Measured values from study sites are compared with two prediction methods: the NCB method and the Donets profile function.

Keyword(s): prediction, prediction theories, empirical model, vertical displacement, monitoring design, monitoring equipment, survey methods, longwall, National Coal Board, profile function

Location(s): Utah, Rocky Mountain Coal Region, United States

Allgaier, F. K. Surface Subsidence Over Longwall Panels in the Western United States: Monitoring Program and Preliminary Results at the Deer Creek Mine, Utah. U.S. Bureau of Mines IC 8896, 1982, 24 p.

Preliminary site information, subsidence results, and a report of the instrumentation are given for a study performed over four adjacent longwall panels in central Utah. Information is given to estimate labor and time needed for such a project.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, longwall, economics, survey equipment, survey data processing

Location(s): Utah, Rocky Mountain Coal Region, United States

Amato, R. B., T. V. Leshendok. Geologic Factors Related to Surface Subsidence Due to Underground Coal Mining. Geological Society of America Northeastern Section, 10th Annual Meeting, 1975, Abstracts with Programs, v. 7, p. 21-22.

Keyword(s): geologic features, coal mining

Location(s): United States

Amuedo, A. S., J. B. Ivey. Ground Subsidence and Land Use Considerations Over Coal Mines in the Boulder-Weld Coal Field, Colorado. Colorado Geological Survey Environmental Geology Series no. 9, 1975.

Keyword(s): coal mining, land-use planning, environment

Location(s): Colorado, Rocky Mountain Coal Region, United States

Andromalos, K. B., C. R. Ryan. Subsidence Control by High Volume Grouting. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication no. 19, 1988, p. 53-68.

Grouting techniques have been used for years to stabilize existing structures and new construction over abandoned coal mines. The purpose of mine grouting programs is to provide additional support at mine level to control future mine subsidence.

Keyword(s): grouting, abandoned mines, coal mining, mine waste

Location(s): Pennsylvania, Appalachian Coal Region, United States

Andros, S. O. Coal Mining Practice in District VIII. Illinois State Geological Survey, Mining Investigation Bulletin 2, 1914, 47 p.

Keyword(s): historical, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Andros, S. O. Coal Mining Practice in District VII. Illinois State Geological Survey, Mining Investigation Bulletin 4, 1914, 53 p.

Keyword(s): historical, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Andros, S. O. Coal Mining Practice in District V. Illinois State Geological Survey, Mining Investigation Bulletin 6, 1914, 34 p.

Keyword(s): historical, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Andros, S. O. Coal Mining Practice in District II. Illinois State Geological Survey, Mining Investigation Bulletin 7, 1914, 22 p.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Andros, S. O. Coal Mining Practice in District I (Longwall). Illinois State Geological Survey, Mining Investigation Bulletin 5, 1914, 42 p.

Keyword(s): longwall, coal mining, historical

Location(s): Illinois, Illinois Coal Basin

Andros, S. O. Coal Mining Practice in District VI (Mines in Bed 6 in Franklin, Jackson, Perry and Williamson Counties). Illinois State Geological Survey, Mining Investigation Bulletin 8, 1914, 49 p.

Keyword(s): mine operation, coal mining, historical
Location(s): Illinois, Illinois Coal Basin, United States

Andros, S. O. Coal Mining in Illinois. Illinois State Geological Survey, Mining Investigation Bulletin 13, 1915, 250 p.
This bulletin summarizes earlier district reports so as to compare mining practice and to make generalizations about the state as a whole. A historical chapter on the economic development of Illinois is included, as well as an appended bibliography of the geology, chemistry, and exploration of the different seams.
Keyword(s): historical, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Andros, S. O. Coal Mining Practice in District III. Illinois State Geological Survey, Mining Investigation Bulletin 9, 1915, 30 p.
Keyword(s): coal mining, historical
Location(s): Illinois, Illinois Coal Basin, United States

Andros, S. O. Coal Mining Practice in District IV. Illinois State Geological Survey, Mining Investigation Bulletin 12, 1915, 57 p.
Keyword(s): coal mining, historical
Location(s): Illinois, Illinois Coal Basin, United States

Ang, C. Y. A Study of Subsidence Caused by Underground Mining with Special Emphasis on Angle of Break. Thesis, Colorado School of Mines, Golden, CO, 1947.
This is a study of problems related to the angle of break in subsidence. In laboratory experiments, subsidence was observed to reach the surface unless a strong, natural arch was formed. Angle of break is a function of bed inclination, the minimum angle being 62 degrees.
Keyword(s): lab testing, modeling, physical model, overburden, surface subsidence damage
Location(s): United States

Aoki, S. Land Subsidence in Niigata. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, 1977. International Association of Hydrological Sciences Publication no. 121, Washington, D.C., 1977, p. 105-112.
Keyword(s): hydrology

Arcamone, J., P. Schroeter, M.J.P. Dejean. State of the Art of Mining Subsidence in France. IN: Proceedings, 88th Annual General Meeting of Canada Institute of Mining, Montreal, May, Paper no. 84, 1986, 17 p.
Location(s): France

Archibald, G. I., A. M. Weir. A Field Study of Subsidence. Chartered Surveyor, v. 102, no. 4, 1969, p. 177-186.
Keyword(s): survey methods

Arndt, E. Zur Anwendung der Methode der Endlichen Elemente in der Bergschadenkunde (Application of Finite Element Method in Mining Subsidence Assessment). Glueckauf-Forschungshefte, v. 38, no. 2, 1977, p. 82-85.
Keyword(s): finite element, modeling
Location(s): Germany

Arnould, M. Problems of Underground Cavities in the Paris Area. IN: Proceedings, Symposium on Geological and Geographical Problems of Areas of High Population Density, Association of Engineering Geologists Annual meeting, Washington, D.C., October 23, 1970.
The author discusses approaches to subsidence problems resulting from abandoned limestone mines and solution cavities in limestone.
Keyword(s): abandoned mines, non-metal mining, backfilling
Location(s): France, Europe

Arup, O. N., R. S. Jenkins. The Design of a Reinforced-Concrete Factory at Brynmawr, South Wales. IN: Proceedings, Institution of Civil Engineers, v. 2, pt. 3, no. 3, December, 1953, p. 345-397.
The authors describe construction of a factory over abandoned room-and-pillar and longwall coal workings.
Keyword(s): ground control, abandoned mines, room-and-pillar, longwall, foundations, architecture, engineering, coal mining
Location(s): Wales

Ash, N. F., D.-W. Park. 3-D Finite Element Modeling of Longwall Mining Using Progressive Failure Concept. IN: Rock Mechanics: Proceedings of the 28th U.S. Symposium, University of Arizona, Tucson, June 29-July 1, 1987, I.W. Farmer, et al., eds. Balkema, Rotterdam, 1987, p. 725-734.

This study uses the three-dimensional finite element method and integrates the technique of progressive failure to simulate stress redistribution at a longwall mining section. The two selected sites for which the simulation is performed are located in the Black Warrior Coal Basin of Alabama.

Keyword(s): modeling, finite element, longwall, pillar strength, overburden, roof stability, coal mining, active mines, yielding supports

Location(s): Alabama, United States

Ash, S. H., J. Westfield. Backfilling Problem in the Anthracite Region as it Relates to Conservation of Anthracite and Prevention of Subsidence. U.S. Bureau of Mines IC 7342, 1946, 18 p.

This circular describes the history of subsidence in Pennsylvania; it also discusses areas suitable for backfilling. The authors argue for federal and state involvement in subsidence-prevention research.

Keyword(s): backfilling, anthracite, coal mining, historical, subsidence research

Location(s): Pennsylvania, Appalachian Coal Region, United States

Ashmead, D. C. How the Kingston Coal Company Reduces Subsidence and Conserves Coal by Rock Filling and Silting. Coal Age, v. 20, August, 1921, p. 167-171.

This paper describes the investigation of backfilling methods using mine waste in Pennsylvania.

Keyword(s): backfilling, mine waste, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Ashworth, E., ed. Research and Engineering Applications in Rock Masses. Proceedings, 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, Balkema, Boston, 1985, v. 1 and 2, 1292 p.

Keyword(s): rock mechanics, modeling, prediction, overburden, room-and-pillar, longwall, finite element, roof support, ground control, mine design, boundary element, continuum mechanics, computer, pillar strength, seismic, instrumentation

Location(s): Canada, Illinois, United States, Appalachian Coal Region, Utah, Brazil, France, Nevada

Astin, J. A Viscoelastic Analysis of Ground Movement Due to an Advancing Coal Face. Journal of Engineering Mathematics, v. 2, 1968, p. 9-22.

Keyword(s): coal mining, modeling, viscoelastic model, phenomenological model

Aston, R. L. Subsidence Waiver Upheld in Virginia. Coal, April 1990, v. 95, no. 4, p. 77.

A Virginia federal court granted summary judgment for a coal company, holding that the company could not be held liable to a surface owner's property as a result of breaking strata that was caused by the miner's use of the longwall method of mining where there had been an express waiver.

Keyword(s): law, longwall, coal mining, surface subsidence damage, active mines

Location(s): Virginia, Appalachian Coal Region, United States

Aston, R. L. SMCRA Rules Reviewed and Remanded by D.C. Coal, September, 1990, p. 81-83.

The U.S. District Court for the District of Columbia reviewed rules under the federal Surface Mining Control and Reclamation Act (SMCRA) of 1977 for the fourth time since it became law. The court was called in by the National Wildlife Federation to decide five separate challenges to SMCRA regulations. Three issues dealt with subsidence of land over underground coal mines, and two with when the act should begin to apply to certain types of coal mine operations.

Keyword(s): law, coal mining, active mines, surface structural damage, environment, reclamation

Location(s): United States

Aston, T.R.C. Discussion Paper: Subsidence Research in the Sydney Coalfield. CANMET, Canadian Centre for Mineral and Energy Technology Division Report ERP/CRL 83-10(R), April, 1983, Energy Research Program, Coal Research Laboratories, Sydney, Nova Scotia, 23 p.

The applicability to the Sydney Coalfield of existing guidelines for the safe working of undersea coal reserves is uncertain. Land-truthed data has been extrapolated to undersea conditions, rather than empirically derived from seabed-truthed data. It is therefore proposed to initiate a major research effort to monitor subsidence development over these undersea workings.

Keyword(s): surface water, subsurface water, coal mining, multiple-seam extraction, longwall, monitoring design, modeling, instrumentation, prediction, subsidence research, inflow

Location(s): Canada

Aston, T.R.C., R. N. Singh. A Reappraisal of Investigations into Strata Permeability Changes Associated with Longwall Mining. International Journal of Mine Water, v.2 , no. 1, 1983, p. 1-14.
Keyword(s): longwall, overburden, hydrology, subsurface water

Aston, T.R.C., B. N. Whittaker. Undersea Longwall Mining Subsidence with Special Reference to Geological and Water Occurrence Criteria in the North-East of England Coalfield. Mining Science and Technology, v. 2, 1985, p. 105-130.
To date, the use of classical statistical techniques for the identification and analysis of parameters that control the occurrence of water on longwall panels has proved inconclusive. An alternative and potentially more meaningful approach is to examine the interaction between the tensile strain induced by mining and the geological and hydrogeological environment surrounding the workings.
Keyword(s): subsurface water, hydrology, longwall, coal mining, geologic features, inflow
Location(s): England

Aston, T.R.C., H. Y. Tammemagi, A. W. Poon. A Review and Evaluation of Empirical and Analytical Subsidence Prediction Techniques. Mining Science and Technology, v. 5, 1987, p. 59-69.
A review and evaluation of a number of different empirical and analytical subsidence prediction techniques were undertaken as part of a long-term research program into seafloor subsidence in the Sydney Coalfield, Nova Scotia. After an initial review of these methods, as well as the available computer programs for subsidence prediction, a comparison is made between the results obtained from six specific prediction methods applied to a hypothetical case history.
Keyword(s): prediction theories, empirical model, prediction, coal mining, modeling, National Coal Board, profile function, influence function, stochastic model, finite element, boundary element, mathematical model, computer, surface water, vertical displacement, active mines
Location(s): Canada

Aston, T.R.C. Longwall Seafloor Subsidence Monitoring: Why and How. Mining Engineering, December, 1989, p. 1210-1212.
Extensive undersea coal reserves, identified in the offshore portion of the Sydney coalfield, Nova Scotia, have resulted in the implementation of a multi-year research program to develop site specific guidelines for the undersea longwall mining operations. Preliminary studies have revealed four potential schemes for monitoring seafloor longwall subsidence profiles: seasurface, subsea, geophysics, and direct monitoring. Further work has indicated, however, that the use of marine geophysical techniques may be the most effective method of identifying and evaluating seafloor subsidence profiles by comparing pre- and post-mining seafloor topographies.
Keyword(s): coal mining, longwall, monitoring methods, geophysical, active mines
Location(s): Canada

Aston, T.R.C. That Sinking Feeling: Scientists Monitor Seafloor Subsidence in Nova Scotia's Sydney Coalfield. Geos, v. 4, 1989, p. 18-21.
Researchers are monitoring the seafloor and measuring water depth to see whether the ocean bottom is sinking above undersea mines. Although artificial structures are rarely built on the seafloor, scientists still want to know how the rock mass behaves on the seafloor in the zone of tensile strain. Essentially, the rock mass is being pulled apart, creating a potential fracture-fissure network, which could result in a direct hydraulic connection between the mine workings and the seafloor. Although a catastrophic inrush of water to the mine workings is extremely unlikely, researchers worry about the slow but cumulative increase in water, which significantly raises production costs because of increased pumping and dewatering measures.
Keyword(s): coal mining, monitoring methods, seismic, surface water, inflow
Location(s): Canada

Atchison, T. C., Chairman. Coal Mining, Including Ground Control and Gas Outbursts. IN: Discussion C3, Rock Mechanics for Resource Development, Mining and Civil Engineering, Proceedings 5th Congress of International Society for Rock Mechanics, Melbourne, Australia, 1983. A.A. Balkema, Rotterdam, p. G219-G222.
This paper contains questions and answers from authors of papers in this section.
Keyword(s): coal mining, ground control, rock mechanics, prediction, longwall

Atkinson, J. H., D. M. Potts. Subsidence Above Shallow Circular Tunnels in Soft Ground. Department of Engineering, University of Cambridge, England, Report CUED/C-SOILS/T. R. 27, 1976.
Keyword(s): engineering, tunnelling, soils

Attewell, P. B. Ground Movements Caused by Tunnelling in Soil. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 812-948.

This paper briefly reviews some theoretical, laboratory, and in situ methods of predicting, measuring, and analyzing the ground movements caused by tunnelling in soil. The character of the ground losses at the tunnel with respect to the type of soil is investigated, together with the manner in which these losses are transferred to the ground surface. Practical examples of deformation distribution, as derived from field measurement programs, are given. The paper incorporates collations of case history data with particular attention being paid to surface settlement parameters. A concluding section is devoted to a brief appraisal of the type of structural damage that might be caused by tunnelling settlements.

Keyword(s): surface structural damage, tunnelling, soils, monitoring methods, lab testing, in situ testing, modeling

Location(s): United Kingdom

Attewell, P. B. Large Ground Movements and Structural Damage Caused by Tunnelling Below the Water Table in a Silty Alluvial Clay. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 307-356.

Ground movements were measured both inside and outside of a factory under which a tunnel was being constructed below the water table in a silty alluvial clay.

Keyword(s): surface structural damage, tunnelling, soils, monitoring methods

Location(s): United Kingdom

Attewell, P. B. Settlement Development Caused by Tunnelling in Soil. Ground Engineering, v. 18, no. 8, November, 1985, p. 17-20.

Keyword(s): tunnelling, soils

Attewell, P. B., J. Yeates, A. R. Selby. Soil Movements Induced by Tunnelling and Their Effects on Pipelines and Structures. Blackie, Glasgow, 1986.

Keyword(s): tunnelling, pipelines, soils, surface structural damage

Auchmuty, R. L. Subsidence and Ground Movement in a Limestone Mine Caused by Longwall Mining in a Coal Bed Below. Transactions, AIME, Coal Division, v. 94, 1931, p. 27-50.

A cement company in Illinois successfully stopped a coal company from mining underneath its property. The cement company was mining limestone and shale about 125 feet under the surface, by the room-and-pillar method. The coal company was mining by longwall advance methods in a seam about 450 feet below the limestone bed. Survey data were collected for over 3 years and used as evidence in the suit.

Keyword(s): longwall, law, non-metal mining, room-and-pillar, multiple-seam extraction, utilities, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Aughenbaugh, N. B. The Time Factor on Subsidence. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, Aug. 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 260-267.

In recent years, subsidence due to underground coal mining has been receiving much attention mostly because residential and commercial developments placed over old, abandoned mines have sustained damage due to differential settlement. With renewed activity in coal mining and the continued development of the surface to urban-type use, conflicts continue to arise between development of coal reserves and surface land use. Very little information is available about the time factor on subsidence. The data that have been published relate only to longwall mining. This paper discusses only the time factor on room-and-pillar mining of coal.

Keyword(s): time factor, room-and-pillar, ground control, coal mining, modeling, land-use planning, active mines, abandoned mines

Location(s): Illinois, Illinois Coal Basin, United States

Aughenbaugh, N. B., C. D. Elifrits. Subsidence and Time. SME-AIME preprint no. 83-388, SME-AIME Fall Meeting and Exhibit, Salt Lake City, UT, October 19-21, 1983, 9 p.

Subsidence due to abandoned coal mines has received copious attention recently. This is a result of many factors such as the enactment of new mining laws and the effect subsidence has on land use over the mines. Prediction of subsidence features and the time aspects over supercritical extraction (i.e., longwall and high extraction ratio pillaring) is relatively accurate. However, predicting when subsidence will occur and the surface features' size and shape above subcritical extraction of room-and-pillar mining is not yet possible. This paper discusses the factors that influence the time aspects of subsidence in room-and-pillar mining.

Keyword(s): time factor, room-and-pillar, abandoned mines, prediction, law, overburden, coal mining, pillar extraction

Location(s): United States

Australasian Institute of Mining and Metallurgy. Proceedings of the Jubilee Symposium on Mine Filling, Mount Isa, Australia, Aug. 19-22, 1973, 282 p.

This symposium details research on fill properties and filling techniques.

Keyword(s): backfilling

Location(s): Australia

Awasthi, R., L. R. Powell, E. C. Drumm. Measurement of Structural Deformation and Tilt During Subsidence. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 233-242.

The application of a horizontal inclinometer and a tiltmeter to measure tilt, curvature, and deformations of shallow footings during mine subsidence is described. The measurements were taken during mining of a longwall panel in Southern Illinois and were supplemented with precision level survey data. Six different footings were constructed and instrumented at two sites; one above the panel centerline, and the second inside the edge of the panel in the anticipated zone of maximum tension.

Keyword(s): active mines, coal mining, longwall, vertical displacement, horizontal displacement, foundations, surface structural damage, monitoring methods, monitoring equipment, monitoring installation, survey methods

Location(s): Illinois, Illinois Coal Basin, United States

Ayala, C. F. J., H. R. Lain, H. L. Lain, V. E. Perianes. Subsidence Control (Determination of Movements at the Surface; Consequences of the Subsidence at the Surface.) IN: Introduccion a los Usos Industriales y Urbanos del Espacio Subterraneo y Su Tecnologia (Introduction to the Industrial and Urban Uses of the Underground Space, and Their Technology.), Instituto Geologico y Minero de Espana, Madrid, 1986, Ch. 3.7, p. 191-194 (English version).

Keyword(s): ground control, surface subsidence damage

Ayala, C. F. J., H. R. Lain, H. L. Lain, V. E. Perianes. Introduccion a los Usos Industriales y Urbanos del Espacio Subterraneo y Su Tecnologia (Introduction to the Industrial and Urban Uses of the Underground Space, and Their Technology.) Instituo Geologico y Minero de Espana, Madrid, 1986, 351 p.

Keyword(s): land-use planning, historical, tunnelling, non-metal mining, abandoned mines, utilities, railroads, roads, architecture, subsurface water, modeling, roof stability, pillar strength, phenomenological model, elastic model, roof bolting, rock mechanics

Aynsley, W. J., G. Hewitt. Subsidence Observations Over Shallow Workings, Including Pneumatic Stowing and Rapidly-Advancing Faces. The Mining Engineer, London, v. 120, no. 7, April, 1961, p. 552-569.

This paper discusses the effects of different backfilling systems on surface subsidence and resulting surface damage in shallow workings; it compares subsidence recorded where both a full and partial area of influence have been worked. The authors also compare rapidly advancing faces versus conventional machine mine workings. The slope of the subsidence profile is shown as a measure of strain.

Keyword(s): pneumatic backfilling, stowing, mine design

Location(s): England

Aynsley, W. J., G. Hewitt. Subsidence Observations Over Shallow Workings. Colliery Guardian, v. 202, May 18, 1961, p. 577-583.

Keyword(s): backfilling

Babcock, C. O., V. E. Hooker. Results of Research to Develop Guidelines for Mining Near Surface and Underground Bodies of Water. U.S. Bureau of Mines IC 8741, 1977, 17 p.

This publication presents guidelines for mining near surface and underground bodies of water. The guidelines were based on information developed under contract in three phases of study, as follows: (1) collection and documentation of data from worldwide sources; (2) application of existing guidelines (foreign, federal, and state) to case histories of previous inundations; and (3) development of recommended guidelines for underground coal mining near bodies of water aimed at maximum efficient use of underground coal resources consistent with minimizing inundation hazards. Tables are given for the determination of the size of coal pillars needed.

Keyword(s): surface water, subsurface water, hydrology, mine operation, coal mining, mine design, engineering, longwall, high-extraction retreat, partial extraction, inflow

Location(s): United States

Babcock, S. D. Undermining as an Element in Land Use Planning. M.S. Thesis, Southern Illinois University, Edwardsville, IL, 1973, 84 p.

Undermining, the result of underground mineral extraction, is one limiting physical characteristic of both urban and rural development. Subsidence of the surface, resulting from the failure of the underground void created by mining, is often the consequence of undermining.

Keyword(s): coal mining, metal mining, non-metal mining, abandoned mines, land-use planning, foundations, surface structural damage, engineering

Location(s): Illinois, Illinois Coal Basin, United States

Badenhorst, G. P. Legal Aspects on the Undermining of Structures and the Use of Undermined Ground. IN: Proceedings, SANGORM Symposium, October 21, 1986, International Society for Rock Mechanics, South African National Group, Sandton, South Africa, p. 1-6.

In almost all the cases where minerals are mined, a dual relationship, in legal terms, is to be found. First, there is a relationship between the owner of the land and the holder of the mineral rights, regulated mainly by principles of private law. Second, the State exercises control over the mining of minerals to a greater or lesser extent, depending on the nature of the minerals, and its relationship with the mineral right holder is regulated by public law.

Keyword(s): surface structural damage, law, government, historical, metal mining, engineering

Location(s): South Africa, Australia, California

Baeckstrom, L., L. Carlsson, A. Carlstedt, A. Hornsten. Influence on the Groundwater Conditions in a Multilayered Aquifer System by Alum-Shale Mining. IN: Symposium on Water in Mining and Underground Works, SIAMOS--78, Granada, Spain, 1978, p. 17-26.

Keyword(s): subsurface water, non-metal mining, hydrology

Bahuguna, P. P., B. Singh, A. M. C. Srivastava. An Empirical Method for Calculation of Maximum Subsidence. IN: Rock Mechanics as a Multidisciplinary Science, Proceedings 32nd U.S. Symposium, The University of Oklahoma, Norman, July 10-12, 1992, J.-C. Roegiers, ed., A.A. Balkema, Rotterdam, p. 801-809.

Most of the empirical methods are based on the prior knowledge of quantity Smax, the maximum possible subsidence or S, the maximum subsidence that normally occurs at or near the center of the mined-out area. The subsidence profile and other associated parameters along any line in the subsidence trough are predicted, in most cases, as a function of either of these quantities (Smax or S) and the distance of the point at which subsidence is to be calculated either from a point vertically above the center of the excavation or from the point of half subsidence that is near the ribside. This paper describes a method of calculating the value of Smax due to critical or super-critical area, the value of S, occurring at or near the center of a sub-critical area. The method uses an empirical formula developed for Indian coal mines.

Keyword(s): empirical model, vertical displacement, coal mining, overburden, geologic features, room-and-pillar, longwall

Location(s): India

Bai, M., D. Elsworth. Prediction of the Fracture Zone Over Mine Workings--An Analytical Model. IN: Key Questions in Rock Mechanics, Proceedings of the 29th U.S. Symposium, Minneapolis, MN, June 13-15, 1988, P.A. Cundall, R.L. Sterling, and A.M. Starfield, eds., Balkema, Rotterdam, p. 519-527.

A method is presented for evaluating stresses and displacements in multiply layered media based on the Fourier complex variation principle. Basic solutions are specifically presented for a three layer model of seam extraction from which surface slopes, curvatures, and body strains may be recovered. Subject to the initial assumptions of linear elasticity, zones of potential fracture are predicted based on empirical strain based failure criteria.

Keyword(s): modeling, overburden, prediction, geologic features

Bai, M., D. Elsworth, L. W. Saperstein. Prediction of Surface Movement with Emphasis on Horizontal Deformation Due to Mining. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 731-738.

In predicting the integrity of undermined structures, surface horizontal displacements and curvatures are frequently of greater importance than the more homogeneous vertical displacements. Accurate evaluation of mining induced subsidence and horizontal displacement further requires that the predictive model adequately represents the subsurface geology, mining geometry, and extraction sequencing. The paper documents an extension of the SPASID method of evaluation of horizontal strains. Comparisons are made between predictions from SPASID and two other empirical methods against measured data from a case study. The system identification method is illustrated to predict horizontal displacements and strains most consistently with the in situ data.

Keyword(s): prediction, horizontal displacement, surface structural damage, vertical displacement, prediction, geologic features, modeling, empirical model, coal mining, profile function, influence function, longwall

Location(s): Illinois, Illinois Coal Basin, United States

Bai, M., D. Elsworth. Some Aspects of Mining Under Aquifers in China. Mining Science and Technology, v. 10, no. 1, January, 1990, p. 81-91.

A number of case studies of mining-induced permeability enhancement are documented. The extent of strata failure around active underground mines is determined through use of a borehole discharge test. The test delimits zones and the severity of extraction induced fracturing. From these data, empirical relationships are developed to determine the vertical and horizontal extents of the caving and fracture zones induced by mining. These relationships are developed for a variety of strata types and strengths and give quantitative recommendations applicable to similar mining conditions elsewhere.

Keyword(s): overburden, coal mining, hydrology, longwall

Location(s): China

Bailey, C. H. The Reports of the Royal Commission on Mining Subsidence. Colliery Guardian, v. 136, 1928, p. 431-433, 530-552.

Keyword(s): mine design, construction, engineering, law

Location(s): England

Bakker, D. The Undermining of Surface Structures. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 249-260.

At present uniform rules are applied, based on percentage extraction, to protect surface structures when mining operations are taking place underneath them. Guidelines are proposed for application in the Central Witwatersrand and Bushveld Igneous Complex Regions which are based on geotechnical detail in these regions. Safe mining spans and pillar design criteria form the essence of the proposals.

Keyword(s): surface structural damage, geotechnical, mine design, law, angle of draw, pillar strength

Location(s): South Africa

Bakker, D. The Undermining of Surface Structures and Construction/Erection Over Undermined Ground: Coal Mines. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 262-270.

The undermining of surface structures and the construction of structures on undermined land by mining is restricted by the terms of the Minerals Act. The restrictions for various mining methods in the coalfields as applied by the Department of Mineral and Energy Affairs is described.

Keyword(s): coal mining, surface structural damage, construction, law, room-and-pillar, pillar strength, longwall, utilities, pillar extraction, prediction, roads

Location(s): South Africa

Balia, R., P. P. Manca, G. Massacci, M. Congiu, E. Fioravanti, S. Lai, D. Lipari, R. Sarritzu. Progressive Hangingwall Caving and Subsidence Prediction at the San Giovannie Mine, Italy. IN: Proceedings 9th

International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 303-311.

The upper part of the "Contatto Ovest" orebody, at the San Giovanni Pb-Zn sulphur mine (Sardinia, Italy), is mined by a sublevel caving method. With increasing depth, a progressive caving of the hanging wall and discontinuous subsidence occurs.

Keyword(s): metal mining, prediction, modeling

Location(s): Italy

Bals, R. Beitrag zur Frage der Vorausberechnung Bergbaulicher Senkungen. (Contribution to the Problem of Precalculating Mining Subsidence.) Mitteilungen aus dem Markscheidewesen, v. 42/43, 1931-32, p. 98-111 (in German).

Keyword(s): prediction, modeling, empirical model, influence function

Bamberger, K. F., E. Bauer, D. Hartmann, F. Hollman, H. O. Luetgendorf, K. Pflaeging, G. Schoene-Warnefeld, R. Teschers. Early Detection of Mining Damages. Bundesministerium fuer Forschung und Technologie, Bonn-Bad Godesborg, Federal Republic of Germany, August, 1980, (in German) 259 p. (NTIS BMFT-FB-T-80-039)

At present, 17 different German and 10 foreign methods are available for the advanced calculation of mining subsidences. The stress behavior of pipelines as well as the behavior of construction soils under the influence of mining operations have not been investigated as yet. In view of the strong surface impact of intensified coal extraction, losses in coal deposits are to be avoided by optimized advanced calculation for the Ruhr and Saar coalfields, along with an improved protection of pipelines and buildings. Existing processes are to be improved by mathematical methods as well as checked by measurements and, partly, by geodetical methods. The theoretically calculated subsidence syncline can be adjusted to the subsidence syncline measured by aerophoto-grammetry by means of suitable functions of superposition (Ruhr district). Predictions on ground movements are possible (Saar district) using the proper geological and operational parameters. The stresses on straight and deflected pipes with all relevant parameters can be determined. Fields of movement and not planes of break develop in the building ground. Results have to be quantified further. These are generally valid processes, which may be purposefully applied in any coalfield with intensive surface building activities (e.g., also in France, Great Britain, Poland, and the USSR), to avoid losses in deposits.

Keyword(s): surface subsidence damage, coal mining, prediction, pipelines, surface structural damage, active mines

Location(s): Germany, France, United Kingdom, Poland, Soviet Union

Bao-Szen, L. Application of Theory of Stochastic Media to Determination of Profile of Subsidence Trough on Ground Surface Due to Exploitation of Inclined Deposit. Bulletin Academie Polonaise des Sciences, Serie des Sciences Techniques, v. 9, no. 9, 1961, p. 541-546.

Keyword(s): prediction, modeling, empirical model, stochastic model

Barczak, T. M. The History and Future of Longwall Mining in the United States. U.S. Bureau of Mines IC 9316, 1992, 26 p.

This report chronicles the historical development of longwall mining in the United States and speculates on future developments to the turn of the century. The involvement and contributions made by the USBM during these developments are also discussed.

Keyword(s): longwall, coal mining, roof support

Location(s): United States

Barker, O. B. A Phased Approach to the Optimal Utilisation of Undermined Ground in the Central Rand - Wits Basin. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 201-220.

Regulations controlling the surface use of undermined ground have created a strip of derelict land running east and west of central Johannesburg. The basis of the argument is that marginally economic mining operations have been holding up the development of prime industrial land. This paper presents an approach to the resolution of the problem. Recognizing the surface and subsurface engineering geological and rock mechanics problems, it provides a method of approach to resolve them and to reinstate the land in a progressive manner which reflects the growth in value of the surface.

Keyword(s): land-use planning, land values, engineering, geologic features, law, metal mining, rock mechanics, soils

Location(s): South Africa

Barla, G., P. Jarre. Subsidence Over an Abandoned Dissolving Salt Mine. IN: Rock Mechanics as a Multidisciplinary Science, Proceedings 32nd U.S. Symposium, The University of Oklahoma, Norman, July 10-12, 1992, J.-C. Roegiers, ed., A.A. Balkema, Rotterdam, p. 871-880.

The viscoelastic closure of the underground cavities and the dissolution of the mine structures through fresh water flooding caused subsidence above the deep kainite San Cataldo mine, Sicily (Italy), opened in the early 1960s. The present paper describes the instruments installed and measurements taken to observe the phenomena. The systems used include automatic deep wire extensometers in the rock mass above the mine, measurements by surveying methods on the area above the cavities and in the neighborhood, inclinometers in the slope above the mine, piezometer sensors in the mine; microseismic monitoring, and remote sensing. A simple model has been taken to interpret all the various data collected and to compute the time for the fresh water to fill all the underground cavities.

Keyword(s): non-metal mining, instrumentation, monitoring methods, monitoring equipment, remote sensing, modeling

Location(s): Italy

Barla, G. B., S. Boshkov. Investigations of Differential Strata Movements and Water Table Fluctuations During Longwall Operations at the Somerset Mine No. 60. Department of Energy contract ET-76-C-01-9041, Columbia University, 1978, 49 p. (NTIS FE-9041-1)

This paper gives the results of research done near Washington, PA. The research involved the instrumentation and monitoring of water table fluctuations and differential strata movements over a longwall mine.

Keyword(s): subsurface water, monitoring design, monitoring installation, monitoring equipment, coal mining, longwall

Location(s): Pennsylvania, Appalachian Coal Region, United States

Barnard, S. Key Administrative Aspects of Subsidence Abatement Projects. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 271-280.

The Wyoming Abandoned Mined Lands program is structured such that the investigation, design, and construction management is done by consulting engineers. During the administration of these projects, it became apparent that not only is the design of vital importance, but many "non-engineering" items also play a key role in the overall success of the projects.

Keyword(s): abandoned mines, reclamation, hydraulic backfilling, grouting, engineering, historical, land-use planning, land values, coal mining, subsidence research

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Barnes, D. Subsidence Awareness and Planning in the City of Colorado Springs. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 267-270.

The author discusses land-use planning and development in the Colorado Springs area related to mine subsidence and the City's Planning Department Geology Section report, "Guide for Future Land Use."

Keyword(s): abandoned mines, land-use planning, surface structural damage, soils, reclamation, land values, utilities, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, United States

Barr, B.I.G., R. Delpak. Prediction of Ground Movement in Areas of Mining Subsidence. Highway Engineering, v. 21, June, 1974, p. 18-22, 36.

This paper deals with the estimation of surface strains and deflections caused as a result of longwall methods. The Sims-Bridle method of prediction is discussed, and displacement-calculation procedures are detailed.

Keyword(s): horizontal displacement, prediction, prediction theories, computer, longwall

Location(s): England

Barraclough, L. J. Roof Breaks in Longwall Workings. Colliery Guardian, v. 145, 1932, p. 572-577, 662-664, 845.

Properties of roof materials from longwall mines in Wales were studied in the laboratory.

Keyword(s): backfilling, roof stability, longwall, lab testing, coal mining

Location(s): Wales

Barron, K. An Analytical Approach to the Design of Coal Pillars. Canadian Institute of Mining Bulletin, v. 868, no. 77, 1984, p. 37-44.
Keyword(s): coal mining, pillar strength, mine design

Barron, K. A New Method for Coal Pillar Design. IN: Proceedings, Symposium on Ground Movement and Control Related to Coal Mining, Illawarra, Australia, August, 1986, N.I. Aziz, ed., Australasian Institute of Mining and Metallurgy, p. 118-124.
A failure criterion for coal is proposed in which a distinction is made between brittle and "pseudo-ductile" failure. This criterion is then used in the development of new equations for coal pillar strength, including a transition from brittle fracture to pseudo-ductile yielding. In addition, equations are obtained that allow the critical minimum pillar dimensions to be calculated to avoid "catastrophic" and "ultimate failure." The use of these formulae is then demonstrated by comparing the results with pillar case histories derived from the literature.
Keyword(s): pillar strength, coal mining

Barron, L. R. Longwall Stability Analysis of a Deep, Bump-Prone Western Coal Mine - Case Study. IN: Proceedings, 9th International Conference on Ground Control in Mining, 1990, Department of Mining Engineering, West Virginia University, Morgantown, p. 142-149.
Keyword(s): longwall, bumps, coal mining
Location(s): Rocky Mountain Coal Region, United States

Barry, A. J., J. J. Wojciechowski. Roof Movement Study of Mechanized Retreating Longwall Operation, Lancashire No. 15 Mine, Bakerton, Cambria County, PA. U.S. Bureau of Mines RI 5028, January, 1954.
This report details an instrumented study of roof behavior on a longwall operation. An investigation was conducted at a mechanized longwall operation in the Lancashire No. 15 mine, Barnes & Tucker Co., Cambria County, Bakerton, PA, to study the factors that affect roof control. The objective was to measure strata movement, correlate these movements with mining operations, and determine their effect on roof control.
Keyword(s): coal mining, longwall, active mines, roof stability, instrumentation
Location(s): Pennsylvania, Appalachian Coal Region, United States

Barry, A. J., O. B. Nair. In-Situ Tests of Bearing Capacity of Roof and Floor in Selected Bituminous Coal Mines. A Progress Report--Longwall Mining. U.S. Bureau of Mines RI 7406, 1970, 20 p.
The authors discuss the development and field testing of a method for estimation of the bearing capacity of mine roofs and floors. The relationship between penetration of the strata and imposed loads is determined by in situ tests to define bearing plate dimensions for hydraulic roof support jacks at longwall extraction faces.
Keyword(s): pillar strength, roof stability, floor stability, longwall, in situ testing, roof support, coal mining, bituminous
Location(s): United States

Barry, A. J. Ground Control with Longwall Mining. Mining Congress Journal, June, 1970, p. 53-55.
The author describes surface and underground instrumentation used by the USBM at an Illinois mine to gather information to determine the significance of various parameters involved in full caving longwall mining.
Keyword(s): longwall, ground control, mine design, coal mining, instrumentation
Location(s): Illinois, Illinois Coal Basin, United States

Barton, T. M., C. Mark. Field Evaluation of Three Longwall Pillar Systems in a Kentucky Coal Mine. U.S. Bureau of Mines RI 9283, 1989, 13 p.
The USBM is conducting research to assess the effectiveness of different chain pillar designs in maintaining gate entry stability. A particular concern is ground control for deep-cover longwalls located at depths in excess of 1,000 feet. The study was performed in two experimental sections in one longwall headgate section that contained three different pillar designs. Two of the designs used conventional abutment pillars; the third was a total-yielding pillar system. Entry convergence, roof sag, and changes in roof quality were monitored.
Keyword(s): longwall, active mines, coal mining, yielding supports, monitoring methods, mine design, pillar strength, roof stability, floor stability
Location(s): Kentucky, Appalachian Coal Region, United States

Basham, K. D., B. A. Suprenant, M. G. Karfakis, W. L. Johnson. Suggested Guidelines and Recommendations for Residential Construction to Minimize Subsidence Related Damage. IN: Proceedings, Symposium on Evolution of

Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, 14 p. (supplement).
The development of criteria for construction requirements to minimize subsidence-related damage in Wyoming are discussed.
Keyword(s): structural mitigation, construction, land-use planning, abandoned mines, surface structural damage, insurance, utilities, economics, coal mining, foundations
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Batchelor, A. S. Correlation of Roadway Displacement With Stress Redistribution and Strata Movement Caused by Longwall Mining. Ph.D. Thesis, Department of Mining Engineering, University of Nottingham, England, 1968.
Keyword(s): longwall, overburden

Bateman, A. M., H. G. Moulton. Ground Movement and Subsidence. IN: Mining Engineers Handbook, v. 1, Sec. 10,. Art. 112, 1941, R. Peale, ed., John Wiley & Sons, Inc., New York.
This article reviews theories of ground movement due to mining, including opposing opinions concerning the extent and mechanics of surface subsidence.
Keyword(s): prediction, surface subsidence damage

Bauer, E. R., G. J. Chekan, J. L. Hill III. A Borehole Instrument for Measuring Mining-Induced Pressure Changes in Underground Coal Mines. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 1075-1084.
Current ground control research at the USBM indicates the need for a simple and inexpensive instrument for measuring mining-induced pressure changes in coal pillars and mine roofs. The Borehole Platened Flatjack (BPF) is an adaptation of existing such instrumentation.
Keyword(s): instrumentation, monitoring equipment, pillar strength, roof stability, ground control, coal mining
Location(s): United States

Bauer, E. R., G. J. Chekan, G. P. Sames. Influence of Subjacent Gob on Longwall Development Mining in the Upper Kittanning Coalbed of South-Central Pennsylvania. U.S. Bureau of Mines RI 9403, 1992, 13 p.
The USBM is investigating strata interactions associated with mining of multiple coalbeds to provide the mining industry with improved methods of planning and developing multiple coalbeds, conserving resources, and increasing the safety of underground coal mining. This study involves analytical predictions and underground observations of longwall development ground control problems at a south-central Pennsylvania coal mine, which was affected by subsidence induced by multiple-seam mining. As predicted, strata interactions were found in upper mine areas mined over lower mine gob.
Keyword(s): longwall, multiple-seam extraction, coal mining, ground control, mine waste, mine safety, geologic features, prediction, roof stability
Location(s): Pennsylvania, Appalachian Coal Region, United States

Bauer, R. A., P. J. DeMaris. Geologic Conditions of a Longwall Mining Demonstration at the Old Ben No. 24 Mine. SME-AIME Preprint No. 77-I-349, for presentation at the 1977 SME Fall Meeting and Exhibit, St. Louis, MO, October 19-21, 1977, 12 p.
A longwall mining demonstration in the Herrin (No. 6) Coal Member near Benton, IL, involved the extraction of three adjacent panels by the longwall method. The first panel was completed in May 1977. The ISGS was involved in this project for two reasons: (1) to detail the geology of the roof and relate the geologic features to the behavior of the roof during mining operations, and (2) to study the nature and occurrence of coal balls encountered during this demonstration.
Keyword(s): longwall, geologic features, coal mining, roof stability
Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A. The Loss of Natural Moisture Content and its Effect on the Mechanical Properties of Some Pennsylvanian Shales from the Illinois Basin. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 89-94.
Preservation of the natural moisture content of shale cores should be a primary concern to companies that are engaged in exploration and want to know the physical properties of rocks associated with coal seams. Testing should be conducted on cores that represent the natural conditions of the rock in order to properly evaluate pre-mining roof and floor conditions of coal seams;

therefore, the moisture content of these rock cores should resemble that of the rock mass being tested.
Keyword(s): rock mechanics, coal mining, geotechnical
Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A., S. Hunt. Profile, Strain, and Time Characteristics of Subsidence from Coal Mining in Illinois. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S. S. Peng and M. Harthill, eds., West Virginia University, 1982, p. 207-217.
This paper documents subsidence in Illinois, discusses its characteristic parameters, and reports on an investigation to determine whether a time factor (based on the time interval from abandonment of the mine to occurrence of subsidence) exists in Illinois. The data used to characterize subsidence in Illinois were gathered from many sources. To characterize the subsidence completely, these data were combined with mine plan information and other sources at the ISGS.
Keyword(s): time factor, coal mining, overburden, angle of draw, rock mechanics, geologic features, room-and-pillar, active mines, abandoned mines
Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A., P. J. DeMaris. Geologic Investigation of Roof and Floor Strata: Longwall Demonstration, Old Ben Mine No. 24. Illinois State Geological Survey, Contract/Grant Report 1982-2, Champaign, IL, 49 p.
In-mine mapping of three longwall panels at the Old Ben No. 24 Mine has revealed both major and minor roof-stability problems and multiple areas of concentrated coal balls within the Herrin (No. 6) Coal Member. The roof-stability problems are related to three interacting factors: variations in roof lithology, various structural features, and mining plan. Major roof-stability problems are rare at the longwall face but more common in the longwall support entries. Several major falls have occurred in areas where potential problems were identified previously during mapping. Lesser roof-stability problems are associated with "rolls" containing compaction faults and with a tectonic fault zone running perpendicular to the face of the second panel.
Keyword(s): coal mining, longwall, roof stability, geologic features, lab testing
Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A., P. B. DuMontelle. Disturbance of Overburden Bedrock by Coal Mine Subsidence in Illinois. Geological Society of America Annual Meeting, Abstracts with Programs, v. 15, no. 6, 1983, p. 523.
Keyword(s): overburden, subsurface subsidence damage, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A. Damage That May be Mistaken for Coal-Mine Subsidence. ISGS Reprint 1983-E, 1983. Reprinted from Proceedings of Illinois Mining Institute 90th Annual Meeting, Springfield, IL, October 7-8, 1982, p. 66-72.
In Illinois we tend to think of subsidence primarily in association with the failure of coal mines. Subsidence can, however, result from other conditions. Consequently, if the geologic and environmental factors of an area are not properly evaluated, damage to a home can be falsely attributed to coal-mine subsidence. Correct identification of the cause of the damage is sometimes useful in choosing a method to alleviate the problem.
Keyword(s): surface structural damage, coal mining, soils, foundations, subsurface water
Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A. Subsidence of Bedrock Above Abandoned Coal Mines in Illinois Produces Few Fractures. Presented at Society of Mining Engineers of AIME Fall Meeting, Denver, CO, October 24-26, 1984, SME-AIME preprint 84-400, 1984, 8 p.
This paper documents the investigation of possible fracturing of bedrock within subsided areas over abandoned mines through exploration drilling and closed circuit television.
Keyword(s): abandoned mines, coal mining, longwall, room-and-pillar, geologic features
Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A. Longwall Coal Mining in Illinois. Field Trip Guidebook for 25th U.S. Symposium on Rock Mechanics, June 27-28, 1984, Illinois State Geological Survey, Champaign, IL, 57 p.
This field trip guidebook covers the modern longwall coal mining being performed in Illinois in 1984. Old Ben Coal Company had three active

underground coal mines in Franklin County, all or which were operating in the Herrin Coal.

Keyword(s): longwall, coal mining, active mines, geologic features, rock mechanics

Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A. Application of Time Domain Reflectometry to Subsidence Monitoring. IN: Proceedings 8th Annual National Abandoned Mine Lands Conference, August 10-15, 1986, Billings, MT, p. 47-53.

Time Domain Reflectometry (TDR) is an electrical pulse testing technique originally developed to locate breaks in power transmission lines. In the past decade, this technique has been adapted to monitor the movement of rock masses during mining. The long-term objectives of this project were to evaluate the use of TDR as an inexpensive technique for monitoring subsidence over abandoned and active mines.

Keyword(s): monitoring design, monitoring equipment, monitoring installation, monitoring methods, high-extraction retreat, coal mining, active mines, instrumentation

Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A., E. M. Gefell, D. W. Barkley. Characterization of Coal Mine Subsidence and Impacts on Bedrock and Near Surface Hydrology Over a Shallow High-Extraction Retreat Mining Operation in Illinois. IN: Proceedings, National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, December 7-11, 1987, Springfield, IL, Office of Engineering Services, University of Kentucky, Lexington, p. 197-202.

This study, conducted under the Illinois Mine Subsidence Research Program, investigated the effects of coal mine subsidence on the overburden above a shallow high-extraction retreat mine (250 feet deep) in southern Illinois. The site was instrumented to monitor movements on the surface, strain in the overburden, and changes in piezometric levels in the bedrock and overlying drift.

Keyword(s): active mines, coal mining, high-extraction retreat, hydrology, subsurface water, overburden, monitoring methods, survey methods, subsidence research

Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A. The Effects of Valleys on the Strength of Rock Materials at Depth. IN: Rock Mechanics: Proceedings of the 28th U.S. Symposium, Tucson, AZ, June 29-July 1, 1987, I.W. Farmer, et al., eds., Balkema, Rotterdam, p. 345-349.

Most investigations of the effects valleys have on rock properties have been performed where surface excavations occurred in a valley. The impact valleys have at depth into the bedrock has been limited to borehole measurements of hydrologic conductivity, various models of stress distribution, and empirical relationships with roof instability of underground coal mines. This investigation used core from borings extending below and adjacent to bedrock valleys. Laboratory measurements of strength, slake durability, and P-wave velocities were compared between the cores. Test results show that the strength of samples from bedrock below valleys ranges from 10% to 26% less than adjacent or shallower areas of the valley. This work also shows that the deeper parts of the valleys have a greater effect on the bedrock strength.

Keyword(s): lab testing, geologic features, coal mining, roof stability, rock mechanics

Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A., P. B. DuMontelle. Illinois Mine Subsidence Research Program: What Have We Learned in Five Years? IN: Proceedings, Illinois Mining Institute 98th Annual Meeting, September 27-28, 1990, p. 35-40.

This paper briefly describes the four basic study areas of the Illinois Mine Subsidence Research Program: (1) coal mine floor stability, (2) coal pillar stability, (3) overburden deformation during subsidence, and (4) impacts on crop production.

Keyword(s): subsidence research, coal mining, active mines, agriculture, hydrology, floor stability, overburden

Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A., C. H. Dowding, D. J. Van Roosendaal, B. B. Mehnert, M. B. Su, K. O'Connor. Application of Time Domain Reflectometry to Subsidence Monitoring. U.S. Department of the Interior, Office of Surface Mining, Assistance Agreement No. HQ51-CT6-01537, Final Report, Illinois State Geological Survey, Champaign, IL, 1991, 48 p. (NTIS PB91-228411)

The report describes how reflected voltage pulses from coaxial antenna cable grouted in rock masses can be used to quantify type and magnitude of rock mass deformation (movements) during abandoned mine subsidence events. Rock mass movements locally deform the grouted cable, which changes cable capacitance and thereby the reflected wave form of induced voltage pulse. By monitoring changes in these reflected signatures, it is possible to monitor rock mass deformation.

Keyword(s): lab testing, in situ testing, active mines, abandoned mines, monitoring methods, monitoring equipment, monitoring installation, longwall, surface structural damage, instrumentation, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A., D. J. Van Roosendaal. Monitoring Problems: Are We Really Measuring Coal Mine Subsidence? IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 332-338.

Geology and weather effects produce natural ground movements that may be misinterpreted as mine subsidence. Common practices of monument and benchmark design and placement do not address the problem of natural ground movements. Monuments can be designed to minimize some natural ground movements. Differential displacements can be reduced by competent placement of benchmarks and monuments of similar design and construction. Multiple baseline surveys of an entire monitoring system should be conducted before the onset of subsidence to establish subsidence detection limits.

Keyword(s): monitoring methods, monitoring design, monitoring equipment, monitoring installation, survey design, survey equipment, survey methods, coal mining, vertical displacement, geologic features, soils

Location(s): Illinois, Illinois Coal Basin, United States

Bauer, R. A., D. J. Van Roosendaal. Monitoring Problems: Are We Really Measuring Coal Mine Subsidence? IN: Proceedings, Illinois Mining Institute, Centennial Year, 1992, p. 39-52.

Geology and weather effects produce natural ground movements that may be misinterpreted as mine subsidence. Weather, local geology, and vegetation clearly influence the elevation of the ground surface through frost action, changes in groundwater levels, and soil moisture content. Monuments can be designed to minimize some natural ground movements. Differential displacements can be reduced by competent placement of benchmarks and monuments of similar design and construction. Multiple baseline surveys of the entire monitoring system, conducted before the onset of subsidence, should be used to establish subsidence detection limits.

Keyword(s): monitoring methods, survey methods, surface structural damage, survey equipment, monitoring equipment, instrumentation, survey design

Bauer, R. A., B. A. Trent, P. B. DuMontelle. Mine Subsidence in Illinois: Facts for Homeowners. Illinois State Geological Survey, Environmental Geology 144, 1993, Champaign, IL,16 p.

The ISGS prepared this publication to explain the causes and nature of subsidence and to discuss ways of minimizing the damage caused by subsidence. With this information, homeowners will be able to decide whether they live in subsidence-prone areas, understand some common effects of mine subsidence, and recognize problems that can be mistaken for mine subsidence.

Keyword(s): insurance, abandoned mines, active mines, surface structural damage, coal mining, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Baumgardner, R. W., A. D. Hoadley. Geology and Hydrology of the Wink Sink, Texas. Bureau of Economic Geology, University of Texas, Austin, October, 1980, 12 p.

Keyword(s): hydrology, geologic features

Location(s): Texas, United States

Bawden, W. F., P. Mottahed. Comparison of Three Subsidence Prediction Techniques Applied to Saskatchewan Potash Mining. IN: Proceedings 88th Annual General Meeting of Canada Institute of Mining, Montreal, Paper no. 89, 1986, 34 p.

Keyword(s): prediction, prediction theories, non-metal mining

Location(s): Canada

Beard, J. T. The Action Influence and Control of Roof in Long Workings. Transactions, Institute of Mining Engineers, London, v. 28, 1904-05, p. 341-347.

Keyword(s): longwall, mine design, roof stability, roof support, historical, coal mining

Location(s): England

Beck, B. F., ed. Sinkholes: Their Geology, Engineering and Environmental Impact. Proceedings, 1st Multidisciplinary Conference on Sinkholes, Orlando, FL, October 15-17, 1984, Florida Sinkhole Research Institute, University of Central Florida, Balkema, Rotterdam, 429 p.

The editor states that the term sinkhole (or doline) should refer only to localized land surface depressions arising from karst processes. Solution sinkholes form from the slow dissolution of bedrock and are not generally an engineering problem although they may be an avenue for groundwater pollution. Collapse sinkholes arise when the roof of a bedrock cavern collapses; such incidents are rare. Subsidence sinkholes (geology) or ravelling sinks (engineering) form by the piping of unconsolidated overburden into karstic openings in the underlying soluble bedrock, usually limestone. Localized land surface subsidence, rapid or slow, may also arise from numerous non-karstic causes, particularly mining and soil piping. It is suggested that these features be referred to collectively as subsidence pits to distinguish them from true sinkholes.

Keyword(s): environment, engineering, geologic features, fluid extraction

Beck, R. E., S. Sigwerth. Illinois Coal Mine Subsidence Law. DePaul Law Review, v. 29, no. 2, Chicago, IL, 1980.

This paper provides an historical overview of the development of subsidence law in Illinois; it reviews the principles of liability and legal problems established by cases.

Keyword(s): law, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Beck, R. E. Illinois Coal Mine Subsidence Law Updated. Southern Illinois University Law Journal, v. 1985, no. 3, 1986, The Board of Trustees of Southern Illinois University, Carbondale, IL.

A considerable number of important developments in the Illinois coal mine subsidence law have taken place since 1980.

Keyword(s): law, government, economics, coal mining, longwall, insurance

Location(s): Illinois, Illinois Coal Basin, United States

Beck, R. E. Recent Illinois Court Decisions on Coal Mine Subsidence. Mineral Matters, v. 8, no. 5, October, 1986, Southern Illinois University, Carbondale, IL.

During 1985 both the federal district court for the Southern District of Illinois and the Illinois Circuit Court for the Second Judicial Circuit announced decisions relating to two coal mine subsidence cases. While neither case has been concluded, the decisions to date contain several interesting points. Both cases involved subsidence resulting from longwall mining, and several questions were raised.

Keyword(s): longwall, coal mining, active mines, law, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Beck, W. W., A. L. Russnow, G. H. Emrich. Relationship Between Underground Mine Water Pools and Subsidence in the Northeastern Pennsylvania Anthracite Fields. Appalachian Regional Commission Report ARC-73-111-2553, April, 1975, 411 p. (NTIS PB 242 467)

This study is part of a comprehensive program related to the land subsidence that occurred in the anthracite region of northeastern Pennsylvania in response to Tropical Storm Agnes. The objectives of the study were to (1) determine the mine pool factors that contribute to or influence subsidence, (2) define and document present mine pool conditions in the anthracite fields of Northeastern Pennsylvania, and (3) recommend the most effective and feasible methods of controlling the mine pools to reduce or prevent future subsidences. The findings of this investigation were as follows: (1) peak precipitation precedes subsidence 87% of the time; (2) subsidence occurs in areas where roof rock conditions are poor or where abnormally high hydrostatic pressure occurs in structurally weak areas; (3) subsidence occurs along outcrop areas and where a high percentage of coal has been removed; and (4) subsidence occurred during Tropical Storm Agnes where high hydrostatic pressure developed.

Keyword(s): subsurface water, anthracite, coal mining, geologic features

Location(s): Pennsylvania, Appalachian Coal Region, United States

Beck, W. W., G. H. Emrich. Coal Mine Subsidence and Mine Pools--Northern Anthracite Field, Pennsylvania. American Society of Civil Engineers National Spring Convention and Continuing Education, Pittsburgh, PA, April 24-28, 1978, ASCE Preprint 3293, p. 1-25.

Subsidence has been a problem almost since the inception of deep mining in the anthracite region of northeastern Pennsylvania. It appears to have been a more acute problem during active mining than after mining. This paper explores causes of subsidence in the area, including rock failure, flow of water, high precipitation periods, and attributes of the overburden (especially sandstone).

Keyword(s): subsurface water, anthracite, coal mining, geologic features, hydrology, historical, abandoned mines

Location(s): Pennsylvania, Appalachian Coal Region, United States

Bee, R. W. Environmental Action Programs for Northeastern Pennsylvania Refuse Bank Removal/Subsidence. U.S. Bureau of Mines OFR 3-73, Mitre Corporation, Contract SO111414, 1972, 529 p. (NTIS PB 214 535)

Keyword(s): environment, land-use planning, mine waste

Location(s): Pennsylvania, Appalachian Coal Region, United States

Beevers, C., K. Wardell. Recent Research in Mining Subsidence. Transactions, Institute of Mining Engineers, London, v. 114, 1954-55, p. 223-253.

Recent observations in the Yorkshire coalfield by precise surveying techniques are described and illustrated in this paper. Some conclusions relating to maximum possible subsidence, limiting angle, and the general angle of ground movement are discussed. The importance and influence of traveling or dynamic ground movements, particularly over comparatively shallow workings, is emphasized and examples are given.

Keyword(s): mine design, survey methods, partial extraction, stowing, survey methods, subsidence research, angle of draw, coal mining

Location(s): England

Begley, R. D., L. E. Gray, G. M. Zickefoose. Design Considerations for Structures to be Built on Subsidence Prone Land. IN: Proceedings, 2nd Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, Morgantown, p. 181-193.

This paper presents detailed design drawings of a flexible single floor residential superstructure proposed for both longwall and room-and-pillar mining conditions. All efforts were made to provide an immediately available economical alternative for future home builders on subsidence prone land. Because of this, a basement was not included in the design because additional costs and measures would be required to minimize cracking and leakage. A cost comparison with a traditional superstructure demonstrated that this would be a cost effective alternative.

Keyword(s): surface structural damage, architecture, construction, foundations, economics, coal mining

Begley, R. D., A. W. Khair. Development of a Mechanistic Model for Prediction of Maximum Subsidence and Subsidence Profile Due to Longwall Mining. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 495-502.

This paper summarizes the development of a mechanistic model to predict longwall mining induced surface subsidence. The model was originally developed from data acquired from a recent field study conducted in Northern West Virginia. Additional data have been collected from published sources and used to refine the model.

Keyword(s): modeling, prediction, longwall, angle of draw, overburden, geologic features, rock mechanics, coal mining, time factor

Location(s): West Virginia, Appalachian Coal Region, United States

Begley, R. D. Development of a Mechanistic Model for Prediction of Subsidence Over Longwall Mines. Ph.D. Dissertation, 1989, Department of Mining Engineering, West Virginia University, Morgantown.

Keyword(s): modeling, prediction, coal mining, longwall

Location(s): United States

Bell, F. G. The Character of the Coal Measures. IN: Site Investigations in Areas of Mining Subsidence, Chapter 2, 1975, F.G. Bell, ed., Newnes-Butterworths, London, p. 25-39.

Keyword(s): overburden, coal mining, geologic features

Location(s): England

Bell, F. G. Salt and Subsidence in Cheshire, England. Quarterly Journal of Engineering Geology, v. 9, 1975, p. 237-247.

Keyword(s): non-metal mining

Location(s): England

Bell, F. G. Ground Conditions in Mining Areas. Methods of Treatment of Unstable Ground,1975, F.G. Bell, ed., Newnes-Butterworths, London, p. 112-140. (NTIS Accession No. 77-08479)

Keyword(s): engineering, foundations, coal mining, soils, soil mechanics, geologic features, mine operation
Location(s): Europe, England

Bell, F. G. Risk of Subsidence. Building, 15 April, 1977, p. 96-99.
The need for urban redevelopment on a large scale together with the increase in the rate of construction due to increasing mechanisation and the increasing scarcity of suitable sites has meant that in recent years sites formerly regarded as unsuitable have been considered for building purposes. Furthermore, most of the large industrial centers of Britain, in all of which redevelopment is going on, are underlain by rocks of coal measures. Therefore an added redevelopment concern in such areas is concerned is the problem of past or existing mineral workings.
Keyword(s): land-use planning, active mines, abandoned mines, coal mining, surface structural damage, roads, non-metal mining, foundations, vertical displacement, horizontal displacement, National Coal Board, mitigation, structural mitigation, backfilling, angle of draw
Location(s): United Kingdom

Bell, F. G. Subsidence Due to Mining Operations. IN: Proceedings Conference on Foundation Engineering in Difficult Ground, September, 1976, Sheffield, England, 1978, F.G. Bell, ed., Newnes-Butterworths, London, p. 322-362. (NTIS Accession No. 78-47931)
Keyword(s): coal mining, foundations, backfilling, non-metal mining, engineering
Location(s): Europe

Bell, F. G. Location of Abandoned Workings in Coal Seams. Bulletin of the International Association of Engineering Geology, v. 33, April, 1986, p. 123-132.
Coal mining has gone on in many parts of Western Europe and North America, frequently for 200 years or more. Consequently, in many urban areas, there are abandoned workings at shallow depth that often are unrecorded. Investigation of abandoned coal mine workings is no easy task and requires some knowledge of past methods of mineral exploitation.
Keyword(s): coal mining, abandoned mines, geophysical
Location(s): Europe, United States

Bell, F. G. Subsidence. IN: Ground Engineer's Reference Book, Ch. 15, August, 1987, F.G. Bell, ed., Butterworths, London, 24 p.
The author states that subsidence is an inevitable consequence of mining activities, and it reflects the movements that occur in the mined out area. Unfortunately, subsidence can and does have serious effects on surface structures, services and communications; it can also be responsible for flooding and lead to the sterilization of land or make remedial measures or special constructional design in site development necessary.
Keyword(s): historical, room-and-pillar, monitoring methods, mitigation, longwall, geologic features, prediction, surface structural damage, fluid extraction, coal mining, non-metal mining

Bell, F. G. The Influence of Subsidence Due to Present Day Coal Mining on Surface Development. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference of the Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 359-367.
Urban development and redevelopment in areas of present day coal mining faces a potential problem due to associated subsidence. Obviously the main aim of a developer is to produce a successful development with economy of design and minimization of any subsequent subsidence damage so that structures fulfill their function throughout their design life.
Keyword(s): land-use planning, active mines, coal mining, engineering, longwall, National Coal Board, surface structural damage, structural mitigation, foundations
Location(s): United Kingdom

Bell, F. G., J. C. Cripps, M. G. Culshaw, M. O'Hara. Aspects of Geology in Planning. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 1-38.
In this paper, the opportunity is taken to explore some of the more important geological factors that may significantly influence the planned use of land. Both natural and man-made geological hazards (including mine subsidence) are considered.
Keyword(s): land-use planning

Bell, F. G. The History and Techniques of Coal Mining and the Associated Effects and Influence on Construction. Bulletin of the Association of Engineering Geologists, v. 15, no. 4, 1988, p. 471-504.

Coal mining has gone on in many parts of western Europe and North America, frequently for 200 years or more. Consequently, in many urban areas, there are abandoned workings at shallow depth beneath the ground surface that are frequently not recorded. These may present a potential hazard when such areas are redeveloped. Subsidence from longwall mining can be regarded as more or less contemporaneous with the mining activity, and, it normally is predictable within about 10%. Obviously, measures must be taken to avoid significant damage to structures resulting from mining activity. Such measures differ according to the type of subsidence problem to be dealt with, that is, whether it is generated by the existence of old workings or by present day extraction.

Keyword(s): coal mining, historical, longwall, room-and-pillar, active mines, abandoned mines, land-use planning, surface structural damage, engineering, construction, non-metal mining, overburden, geologic features, law, foundations, pillar strength, pillar extraction, floor stability, roof stability, horizontal displacement, prediction, modeling, prediction theories, backfilling, National Coal Board

Location(s): United States, Europe, United Kingdom, Appalachian Coal Region, England, South Africa, Germany, France, Poland, Soviet Union, Illinois Coal Basin, Rocky Mountain Coal Region

Bell, F. G., J. M. Coulthard. Subsidence Prediction by the Use of Influence Functions. IN: Engineering Geology of the Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 265-273.

Surface subsidence occurs as a result of extraction of a mineral resource at some depth below the surface. Most coal is mined in this way in the U.K., and such coal workings are responsible for most subsidence and the associated damage that occurs. Hence, it has become necessary to develop methods of predicting the amount of subsidence likely to develop due to coal mining. Many methods have been advanced, dating back to the latter part of the last century. However, they can be separated into three groups, namely the theoretical, the empirical, and the semi-empirical methods. A number of these methods were reviewed with the object of selecting one that lent itself to the development of a relatively simple computer program that could be used on a microcomputer. The complementary influence function method was chosen, and a program was developed to predict a complete subsidence profile for a given set of circumstances. The concept of complementary influence functions considers not only the influence of the extracted elements on a surface point but also the influence of the material remaining after extraction.

Keyword(s): prediction theories, influence function, prediction, coal mining, longwall, empirical model, computer

Location(s): United Kingdom

Bell, F. G., J. C. Cripps, M. G. Culshaw, M. A. Lovell. A Review of Ground Movements Due to Civil and Mining Engineering Operations. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 3-32.

Human activity frequently causes ground movements that may later cause problems. The most notable examples of ground movements are provided by the mining industry in the form of subsidence. Mining in the broad sense includes removal of material from the ground and that material may be solid, liquid, or gas. Indeed some of the largest subsidences recorded have been in association with the abstraction of oil and ground-water, instances having occurred where the ground surface has been lowered by several meters over large areas. The construction industry is also responsible for generating ground movements, admittedly usually on a small scale. For example, deep excavation causes a reduction in the vertical and horizontal pressure in the ground and thereby can induce heave of the base of the excavation, together with inward and vertical movements, both up and down. Ground movements may develop as a result of tunnelling, particularly in soft ground, and may resemble those associated with longwall mining of coal. Induced seismicity is another example. In this case, some of the most note-worthy examples have been provided by reservoir loading and the permeation of water into the ground. Small scale seismic events also have been associated with mining activity.

Keyword(s): coal mining, tunnelling, fluid extraction, oil extraction, construction, longwall, seismic, soils, room-and-pillar

Location(s): United Kingdom

Bell, F. G., M. G. Culshaw, J. C. Cripps, M. A. Lovell, eds. Engineering Geology of Underground Movements. Geological Society Engineering Geology Special Publication No. 5, 1988, 455 p.

This book is concerned with those ground movements caused by human activity. It includes movements due to construction operation, notably deep excavations due to mining activity and the abstraction and injection of fluids, and due to induced seismicity. Prediction monitoring and control and related design measures run as a common thread throughout.

Keyword(s): engineering, tunnelling, soils, boundary element, prediction, fluid extraction, coal mining, abandoned mines, non-metal mining, influence function, roof stability, monitoring methods, shortwall, seismic, metal mining

Location(s): United Kingdom, Singapore, Poland

Bell, F. G., B. Mortimer. Subsidence Due to Abandoned Mines: Risk, Evaluation and Mitigation. IN: Proceedings 6th Australia-New Zealand Conference on Geomechanics, Christchurch, February 3-7, 1992, New Zealand Geomechanics Society, p. 215-220.

Shallow underground workings cause significant problems during redevelopment of old mining regions. Detailed information on the location of old mines is not always available. Thematic geological maps have been produced for some areas, and they can be used as an initial aid to hazard avoidance. It is still necessary to locate and ascertain the state of abandoned mines before development. This can be done using a combination of direct and indirect techniques. A site can then be zoned according to degree of risk. Stabilization by filling or special foundation structures may be used in certain cases.

Keyword(s): abandoned mines, land-use planning, coal mining, foundations, backfilling

Bell, F. G., M. G. Culshaw, B. S. P. Moorlock, J. C. Cripps. Subsidence and Ground Movements in Chalk. Bulletin of International Association of Engineering Geology, 1992, no. 45, Paris, p. 75-82.

Subsidences that occur within, or near, the outcrop of the Chalk are due to the collapse either of solution features or of old mine workings. Only the latter are considered here. Mine workings in the Chalk extend back into the distant past, the most ancient workings being those of Stone Age man in his quest for flint. The collapse of old mine workings is unpredictable and, to make the situation worse, most old workings are unrecorded and are therefore a potential hazard in areas scheduled for development.

Keyword(s): abandoned mines, non-metal mining, historical, overburden, remote sensing, photography, geophysical, backfilling, land mitigation, surface structural damage, land-use planning

Location(s): United Kingdom

Bell, F.G. Ground Subsidence: A General Review. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 1-20.

Mining has gone on in many parts of the world for centuries. Consequently, in many areas there are abandoned workings at shallow depth beneath the ground surface, which are frequently not recorded. This is especially the case in western Europe and North America where old room-and-pillar workings in coal may present a potential hazard when areas are developed or redeveloped. Subsidence consequent upon longwall mining can be regarded as more or less contemporaneous with the mining activity. Obviously, measures must be taken to avoid significant damage to structures due to mining activity. Such measures differ according to the type of subsidence problem, that is, whether it is generated by the existence of old workings or by present day extraction.

Keyword(s): abandoned mines, active mines, surface structural damage, longwall, room-and-pillar, pillar strength, remote sensing, geophysical, seismic, land-use planning, foundations, backfilling, grouting, coal mining, geologic features, prediction, modeling, influence function, zone area, National Coal Board, structural mitigation

Location(s): Europe, United States

Bell, F. G., ed. Methods of Treatment of Unstable Ground. Newnes-Butterworths, London, 1975.

Keyword(s): ground control

Bell, F. G., ed. Site Investigations in Areas of Mining Subsidence. Newnes-Butterworths, London, 1975, 168 p.

Keyword(s): coal mining

Bell, F. G., ed. Foundation Engineering in Difficult Ground. Newnes-Butterworth, 1978.

Keyword(s): foundations, engineering

Bell, S. E. Successful Design for Mining Subsidence. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 562-578.

The CLASP system of building is designed to withstand the effects of mining subsidence. The author inquires as to how CLASP-designed buildings have withstood mining subsidence over a 16-year period.

Keyword(s): mine design, surface structural damage, land-use planning, engineering, coal mining

Location(s): United Kingdom

Belous, Y. I. Effect of Transverse Walls on Total Rigidity of Undermined Buildings. Soil Mechanics and Foundation Engineering, v. 18, no. 1, January-February, 1981 (translated from Russian).

This paper describes investigations to establish the effect of transverse walls and their foundations on the preservation of buildings undermined in the territory of the Lvov-Volyn coal basin.

Keyword(s): surface structural damage, subsurface structural damage, construction, soil mechanics, foundations, coal mining, architecture

Location(s): Soviet Union

Ben-Hassine, J., E. C. Drumm, J. D. Hoskins III, R. M. Bennett. Mechanistic Approach for the Prediction of Structural Response Due to Subsidence. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 373-390.

In the past, the satisfactory prediction of structural damage due to subsidence has been limited, and has been primarily empirical. Mechanistic analysis methods such as the finite element method allow the representation of the soil-structure system by the respective mechanical properties and geometries. Such a representation provides a rational means for the prediction of not only structural damage, but the complete structural response during a specified subsidence event. These methods also permit the economical evaluation of different types of construction, and various damage mitigation measures.

Keyword(s): structural mitigation, modeling, finite element, prediction, surface structural damage, foundations, construction, longwall

Location(s): Illinois, Illinois Coal Basin, United States

Bennett, H. B., H. E. Sanford, R. W. Stahl. Continuous Mining with Solid Pneumatic Stowing at Dornisthrope Colliery. Transactions, Institute of Mining Engineers, v. 114, 1954, p. 625; also Colliery Guardian, v. 189, no. 4896, December, 1954, p. 811.

Keyword(s): pneumatic backfilling, stowing

Location(s): United Kingdom

Bennett, R. M., E. C. Drumm, D. C. Johnson. Behavior of Linear Foundations Subjected to Longwall Subsidence. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 121-128.

Twelve linear test foundations were constructed over an advancing longwall panel in southern Illinois. Various mitigation techniques were incorporated into the footings. From the results of the study, preliminary recommendations are made regarding construction of footings and foundations over mining areas.

Keyword(s): active mines, coal mining, foundations, construction, longwall, structural mitigation, economics, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Benson, J. B., H. E. Sanford, R. W. Stahl. Conditions and Practices of Coal Mines in the Ruhr District of Western Germany. U.S. Bureau of Mines IC 7549, 1950, 48 p.

Following World War II, a 1-year investigation was made of safety conditions and operating practices in German mines.

Keyword(s): backfilling, mine safety, coal mining

Location(s): Germany

Benson, R. C. Assessment of Localized Subsidence (Before the Fact). IN: Proceedings, International Conference on Evaluation and Prediction of Subsidence, Pensacola Beach, FL, January, 1978, S.K. Saxena, ed., American Society of Civil Engineers, New York, 1979, p. 47-57.

Keyword(s): prediction

Location(s): United States

Benson, R. C., L. B. Yuhr. Assessment and Long Term Monitoring of Localized Subsidence Using Ground Penetrating Radar. IN: Karst Hydrogeology: Engineering and Environmental Applications, Proceedings, 2nd Multidisciplinary Conference on

Sinkholes and the Environmental Impacts of Karst, Orlando, FL, 1987, B.F. Beck and W.L. Wilson, eds., p. 161-169.
Keyword(s): monitoring methods, monitoring equipment

Benzley, E., R. D. Krieg. A Continuum Finite Element Approach for Rock Failure and RUBBLE Formation. SAND80-227, Sandia National Laboratories, Albuquerque, New Mexico, August, 1980, 23 p.
Keyword(s): modeling, finite element
Location(s): United States

Benzley, S. E., R. D. Krieg. A Continuum Finite Element Approach for Rock Failure and RUBBLE Formation. International Journal for Numerical and Analytical Methods in Geomechanics, v. 6, 1983, p. 277-286.
Keyword(s): finite element, modeling

Benzley, S. E. SCRUBS.BYU, A Finite Element Formulation for Underground Resource Removal. College of Engineering Sciences and Technology, Brigham Young University, Provo, UT, December, 1983, 101 p.
Keyword(s): finite element, modeling
Location(s): United States

Benzley, S. E., D. W. Basinger. SCRUBS.BYU, Application of Combined Jointed Media and Discrete Media Plane Characteristics to Subsidence Prediction. College of Engineering Sciences and Technology, Brigham Young University, Provo, UT, December, 1984, 218 p.
Keyword(s): modeling, finite element, prediction
Location(s): United States

Berbower, R. F. Subsidence Problem in the Long Beach Harbor District. ASCE Journal of the Waterways, Harbors, and Coastal Engineering Division, v. 85, no. WW2, June, 1959, p. 43-80.
The author discusses subsidence of the ground surface due to oil extraction and salt water injection to repressure depleted formations.
Keyword(s): surface water, oil extraction, fluid extraction
Location(s): United States

Berbower, R. F. Effects of Ground Surface Subsidence in the Long Beach Harbor District. IN: American Society Testing and Materials Proceedings, v. 64, 1965, p. 903-921.
Keyword(s): fluid extraction
Location(s): California, United States

Bergstrom, R. E., K. Piskin, L. R. Follmer. Geology for Planning in the Springfield-Decatur Region. Illinois State Geological Survey, Circular 497, 1976, Champaign, IL, 76 p.
Keyword(s): land-use planning, coal mining, historical, abandoned mines, geologic features, surface structural damage
Location(s): Illinois, Illinois Coal Basin, United States

Berry, D. S. Theoretical Investigations of Ground Movement Due to Mining Operations. Annual Report for the National Coal Board, Department of Mining Engineering, University of Nottingham, 1961.
Keyword(s): coal mining, modeling, National Coal Board, phenomenological model, elastic model, prediction
Location(s): United Kingdom

Berry, D. S. Ground Movement Considered as an Elastic Phenomena. The Mining Engineer, v. 37, 1963, p. 28-39.
Keyword(s): phenomenological model, elastic model, modeling

Berry, D. S., T. W. Sales. An Elastic Treatment of Ground Movement Due to Mining. Journal of Mechanics and Physics of Solids, pt. 1, v. 8, 1960, p. 280-292; pt. 2, v. 9, 1961, p. 52-62; pt. 3, v. 10, 1962, p. 73-83; pt. 4, v. 11, 1963, p. 373-375.
Keyword(s): modeling, phenomenological model, elastic model

Berry, D. S. The Ground Considered as a Transversely Isotropic Material. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 1, 1964, p. 159-167.
Keyword(s): continuum mechanics, rock mechanics, modeling, phenomenological model, elastic model

Berry, D. S. Ground Movement Considered as an Elastic Phenomenon. The Mining Engineer, London, v. 123, no. 41, 1964, p. 28-41.
Keyword(s): continuum mechanics, modeling, phenomenological model, elastic model

Berry, D. S. A Theoretical Elastic Model of the Complete Region Affected by a Mining Seam. IN:

Proceedings 6th U.S. Symposium on Rock Mechanics, 1964, E.M. Spokes and C.R. Christiansen, eds., University of Missouri at Rolla, p. 310-329.

The author proposes an elastic model theory to describe subsidence resulting from longwall mining with complete or nearly complete caving. This model is considered applicable to the final deformed state when movement has ceased, even though previous movement is considered to be viscoelastic. The ground is treated as a transversely isotropic medium.

Keyword(s): rock mechanics, longwall, phenomenological model, elastic model, modeling

Berry, D. S. A Discussion of the Stochastic Theory of Ground Movement. Felsmechanik und Ingenieurgeologie (Rock Mechanics and Engineering Geology) II/3-4, 1964, p. 213-227.

Keyword(s): modeling, empirical model, stochastic model

Berry, D. S., G. J. Marshall. Calculation of the Stress Around an Advancing Longwall Face in Viscoelastic Ground. IN: First Congress, International Society of Rock Mechanics, v. 2, 1966, p. 379-384.

The large scale behavior of the ground is assumed to be transversely isotropic and viscoelastic. The seam is supposed to be deep and sufficiently thin, in comparison with other significant measurements, that it can be considered to be of infinitesimal thickness, and the face advances at a constant rate. The resulting stress distribution and displacement field in the surrounding rock mass are computed with the aid of a computer for a number of viscoelastic materials.

Keyword(s): prediction, longwall, modeling, phenomenological model, elastic model, viscoelastic model, rock mechanics

Berry, D. S. Progress in the Analysis of Ground Movements due to Mining. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 781-811.

This paper is intended as a historical review as well as an account of current ideas on analytical methods of estimating ground movements resulting from mining

Keyword(s): modeling, phenomenological model, elastic model, historical, prediction, angle of draw, empirical model, prediction theories, National Coal Board, coal mining, profile function, influence function, stochastic model, continuum mechanics, finite element, time factor

Location(s): United Kingdom

Beshai, J. Subsidence Monitoring. Geos (Canada), v. 14, no. 3, 1985, p. 22-25.

CANMET developed a system to monitor ground movement and provide a means of predicting when ground failures would occur. The integrated monitoring system incorporates tiltmeters, photogrammetry, and geodetic survey techniques. The tiltmeter system uses computerized radiotelemetry to determine the time required for caving to migrate to the surface, aerial photogrammetry delineates the extent of the subsidence area, and electro-optical distance techniques provide accurate measurements in easily accessible areas.

Keyword(s): monitoring methods, monitoring design, monitoring equipment, coal mining, geologic features, photography, survey methods, active mines

Location(s): Canada

Beyer, F. On Predicting Ground Deformations Due to Mining Flat Seams. Thesis presented to the Technical University of Berlin, 1945 (in German).

Keyword(s): surface subsidence damage, prediction, modeling, empirical model, influence function

Beyer, L. Bergschadenssicherung von Gasleitungen (Protecting Gas Pipelines from Damage by Mining). Gas-Wasserfach, Gas-Erdgas, v. 122, no. 4, 1981, p. 181-186.

Keyword(s): pipelines, utilities

Bezuidenhout, C. A., J. F. Enslin. Surface Subsidence and Sinkholes in the Dolomitic Areas of the Far West Rand, Transvaal, Republic of South Africa. International Association Hydrological Sciences Publication 89, 1970, p. 482-495.

Keyword(s): geologic features

Location(s): South Africa

Bhattacharya, S., M. M. Singh, C. Y. Chen. Proposed Criteria for Subsidence Damage to Buildings. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, June, 1984, C.H. Dowding and M.M. Singh, eds., Northwestern University, Evanston, IL, p. 747-755.

United States federal and state regulatory authorities require underground mine operators to adopt adequate measures to minimize material damage to the surface caused by mine subsidence. This paper presents an approach to define and determine the extent of material damage due to subsidence from underground coal mining. The basic steps involved in the development of adequate criteria have been enumerated together with the approaches and methodologies used.

Keyword(s): surface structural damage, engineering, rock mechanics, literature search

Location(s): United States

Bhattacharya, S., M. M. Singh, N. N. Moebs. Mine Subsidence Hazard Detection Technique for Pennsylvania's Anthracite Coalfields. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 977-984.

This paper presents a methodology to screen potential sites in the anthracite coalfields to determine which sites would be most appropriate to monitor for impending subsidence activity. It provides an integrated monitoring plan for subsidence detection using surface geophysical techniques.

Keyword(s): abandoned mines, anthracite, coal mining, land mitigation, monitoring design, monitoring equipment, instrumentation, geophysical, room-and-pillar, land-use planning

Location(s): Pennsylvania, Appalachian Coal Region, United States

Bhattacharya, S., M. M. Singh. Development of Subsidence Damage Criteria. Report on U.S. Office of Surface Mining Contract J5120129, Engineers International, Inc., Westmont, IL, October 1985, 226 p. (NTIS PB90-147356)

Federal and State regulatory authorities require underground mine operators to adopt adequate measures to minimize material damage (MD) to the surface caused by mine subsidence. However, what constitutes MD to surface structures and renewable resource lands has not been clearly defined. The report proposes criteria for determining MD to a wide range of surface structures and renewable resources based on observed trends of selected data on surface effects of underground coal mining from major coal-producing regions in the United States and abroad. Guidelines are provided to determine time span for post-mining subsidence damage.

Keyword(s): coal mining, surface subsidence damage, government, land mitigation, structural mitigation, rock mechanics, soil mechanics, engineering, prediction, soils, surface structural damage, roads, railroads, pipelines, room-and-pillar, longwall, profile function, National Coal Board

Location(s): Illinois, Illinois Coal Basin, United States, United Kingdom

Bhattacharyya, A. K., D. M. Shu. Mathematical Modelling of Surface Subsidence in the Coal-Fields of New South Wales Using a Back Analysis Technique. IN: Proceedings International Symposium on Land Subsidence, Dhanbad, 1989, p. 20-29.

Keyword(s): modeling, mathematical model, coal mining

Location(s): Australia

Bhattacharyya, A. K., M. A. Pattinaja. Mathematical Modelling of the Convergence and Vertical Stress Patterns Around a Longwall Panel in New South Wales. IN: Proceedings, Symposium on Ground Movement and Control Related to Coal Mining, Illawarra, Australia, August, 1986, N.I. Aziz, ed., Australasian Institute of Mining and Metallurgy, p. 175-181.

Mathematical modeling was carried out to determine the probable convergence and vertical stress patterns around a retreating longwall panel in an underground coal mine in New South Wales. An "Electrical Resistance Analogue" and a program called "THREED" based on the displacement of discontinuity method were used for the modeling. Parts of the obtained results are presented here and compared with some measurements of convergence at the site. The modelled and measured data agree better qualitatively than quantitatively.

Keyword(s): modeling, mathematical model, longwall, coal mining, vertical displacement

Location(s): Australia

Bickley, D., T. Keptner, E. Eisenbise, F. Carlson, R. Springman. The Development of Environmental Guidelines for Land Use Policy, Applicable to Floodprone and Mine-Subsidence-Prone Areas in Pennsylvania. Department of Environmental Resources, Harrisburg, PA, June 1975, 229 p. (NTIS PB 249 532)

Keyword(s): surface water, land-use planning, environment

Location(s): Pennsylvania, Appalachian Coal Region, United States

Bieniawski, Z. T. In-Situ Strength and Deformation Characteristics of Coal. Engineering Geology, v. 2, no. 5, 1968, p. 325-340.
Keyword(s): pillar strength, ground control, in situ testing, coal mining

Bieniawski, Z. T. Note on In Situ Testing of the Strength of Coal Pillars. Journal of the South African Institute of Mining and Metallurgy, v. 68, May, 1968, p. 454-464.
The uniform load and uniform deformation methods are discussed and compared as two possible methods of in situ testing of large coal specimens. Current in situ tests using the uniform load method are described and a pillar strength formula is proposed for design purposes in South Africa. Complete load-deformation characteristics of coal are also discussed.
Keyword(s): pillar strength, in situ testing, coal mining, mine design, rock mechanics, geotechnical
Location(s): South Africa

Bieniawski, Z. T. The Effect of Specimen Size on Compressive Strength of Coal. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 6, no. 4, 1968.
Keyword(s): coal mining, lab testing, pillar strength

Bieniawski, Z. T. In Situ Large Scale Testing of Coal. IN: Proceedings Conference on In Situ Investigations in Soils and Rocks, British Geotechnical Society, 1969, p. 67-74.
Keyword(s): pillar strength, ground control, geotechnical, in situ testing, coal mining
Location(s): England

Bieniawski, Z. T., W. L. Van Heerden. The Significance of In-Situ Tests on Large Rock Specimens. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 12, no. 4, 1975, p. 101-114.
Keyword(s): rock mechanics, ground control, pillar strength, in situ testing

Bieniawski, Z. T., F. Rafia, D. A. Newman. Ground Control Investigations for Assessment of Roof Conditions in Coal Mines. IN: Rock Mechanics: A State of the Art, Proceedings, 21st Symposium on Rock Mechanics, May 28-30, 1980, D.A. Summers, ed., University of Missouri at Rolla, p. 691-700.
This paper presents the results of geotechnical investigations aimed at assessing roof conditions in coal mines. The study included diamond core drilling, borescope observations, borehole and core logging, and engineering geological mapping in two coal mines. The field investigations were accompanied by regional geology studies involving aerial photography and lineament analysis as well as by laboratory testing of rock and coal samples. A bibliography on roof control in coal mines is provided.
Keyword(s): roof stability, coal mining, ground control, in situ testing, lab testing, rock mechanics, geotechnical, photography, remote sensing, modeling
Location(s): West Virginia, Appalachian Coal Region, United States

Bieniawski, Z. T. Improved Design of Coal Pillars for U.S. Mining Conditions. IN: Proceedings 1st Annual Conference on Ground Control in Mining, West Virginia University, July 27-29, 1981, S.S. Peng, ed., Morgantown,WV, p. 13-22.
This paper presents the results of a survey of room-and-pillar dimensions and design practice in U.S. coal mines aimed at improving the design procedures in room-and-pillar mining. A review is given of the current pillar strength formulas, and suggestions are made for better use of research results in engineering practice.
Keyword(s): coal mining, pillar strength, mine design, room-and-pillar
Location(s): United States

Bieniawski, Z. T. An Overview of Ground Support Considerations in Room and Pillar Coal Mining. IN: Proceedings, Conference on Ground Control in Room and Pillar Mining, Southern Illinois University at Carbondale, August 6-8, 1980, Y.P. Chugh, ed., SME-AIME, New York, 1982, p. 95-104.
Ground support requirements for safe and economical design of room-and-pillar coal mining layouts are reviewed. The design methods for mine roof and mine pillars are discussed, and the role of the geotechnical aspects are considered. It is shown that current support design procedures in the United States do not fully use the latest research findings, and the need for more effective technology transfer in coal mine ground control is emphasized. Promising new developments in ground support are identified, and possible research areas are suggested.
Keyword(s): coal mining, room-and-pillar, ground control, mine design, geotechnical
Location(s): United States

Bieniawski, Z. T. Improved Design of Room-and-Pillar Mining Systems. Final Report to U.S. Department of Energy, June, 1982, 1983.
Keyword(s): mine design, room-and-pillar
Location(s): United States

Bieniawski, Z. T. New Design Approach for Room-and-Pillar Coal Mines in the U.S.A. IN: Proceedings, International Congress on Rock Mechanics, Melbourne, Australia, 1983, p. E27 - E36.
A detailed study has been made of the United States practice and design needs for room-and-pillar coal mining. Although some 90% of underground coal mining in the United States is by the room-and-pillar method, no comprehensive design procedure is available for this purpose. A survey of more than 200 coal mines was conducted and typical mining conditions and room-and-pillar configurations were analyzed during a 3-year research project. Specific investigations were conducted to improve the methods of span selection, roof support and pillar design in the coal mines. In particular, pillar strength formulae for coal mining were studied. An improved procedure for room-and-pillar coal mining in the United States was proposed.
Keyword(s): coal mining, mine design, room-and-pillar, rock mechanics, roof stability, pillar strength
Location(s): United States

Bieniawski, Z. T. Rock Mechanics Design in Mining and Tunneling. 1984, Balkema, 272 p.
Keyword(s): rock mechanics, mine design, tunnelling

Bieniawski, Z. T. Strata Control in Mineral Engineering. John Wiley & Sons, New York, 1986, 240 p.
This book covers the state-of-the-art of strata control practice in the United States and abroad, including rock bolting, longwall mining technology, and energy development. The stability of rock pillars, rockbursts, shaft design, and rock engineering are described. Mineral and energy needs in the United States are also detailed.
Keyword(s): ground control, longwall, roof stability, roof support, pillar strength
Location(s): United States

Bieniawski, Z. T. Towards A Creative Design Process in Mining. Mining Engineering, November 1988, v. 40, no. 11, p. 1040-1043.
After many significant advances in mining, including development of sophisticated methods for strata characterization and numerical modeling analyses, the engineering design process in mining strata control is as primitive as it was two decades ago. Yet, major advances in design methodologies have occurred in other branches of engineering. Is creative design in mining a myth only? Are we deluding ourselves when we talk about innovative mining design of today? Did you know that most design experts are often unaware of their own decision-making processes? This paper explores the methodology of creative engineering design as a newly recognized discipline.
Keyword(s): ground control, mine design, engineering, geotechnical, rock mechanics, mine waste

Bischke, R. E., P. S. Getty. A Method for Assessing the Potential of Mine Subsidence at Abandoned Mine Sites Through the Assistance of Finite Element Modeling. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds. SME-AIME, New York, p. 722-726.
The analysis of subsidence prone sites reveals the importance of understanding and applying all of the parameters influencing mine subsidence Finite element modeling is capable of incorporating the parameters specific to each site, which is an important shortcoming of empirical methods. The finite element model's usefulness in interpreting the in situ stresses within mines and the surface subsidence anticipated over mined regions is exemplified in the increased efficiency and effectiveness of subsidence prevention programs.
Keyword(s): modeling, finite element, coal mining, prediction, abandoned mines, bituminous, anthracite, multiple-seam extraction
Keyword(s): Pennsylvania, Appalachian Coal Region, United States

Bise, C. J. Pennsylvania's Subsidence-Control Guidelines: Should They Be Adopted by Other States? Mining Engineering, v. 33, November, 1981, p. 1623-1628.
This paper analyzes the Pennsylvania Bituminous Mine Subsidence Act of 1966--the only comprehensive subsidence act passed by any state. The applicability of this law to other states is also discussed.
Keyword(s): ground control, law
Location(s): Pennsylvania, Appalachian Coal Region, United States

Black, R. A., A. N. Brown. The Measurement and Analysis of Strata Movements Connected with the Extraction of a Shaft Pillar at Depth. Association of Mine Managers of South Africa, Papers and Discussion, 1960-61, p. 231-313.
Keyword(s): pillar extraction, monitoring methods
Location(s): South Africa

Blair, B. E. Physical Properties of Mine Rock. Part 3. U.S. Bureau of Mines RI 5130, 1955, 69 p.
Keyword(s): rock mechanics, lab testing
Location(s): United States

Blair, B. E. Physical Properties of Mine Rock. Part 4. U.S. Bureau of Mines RI 5244, 1956, 69 p.
Keyword(s): rock mechanics, lab testing
Location(s): United States

Blevins, C. T. Horizontal Stress Problems in Illinois Basin Coal Mines. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, August 8-10, 1990, Mt. Vernon, IL, Y.P. Chugh, ed., Southern Illinois University, Carbondale, 1990, p. 92-97.
In situ directional horizontal stresses are evident in underground mines throughout the Illinois Coal Basin. Evidence of these stresses exists in mines in Indiana, Western Kentucky and Illinois. These stresses normally cause ground control problems in north-south headings, ranging from minor inconveniences to extremely serious problems that become the primary reason for mine closures. This paper covers the following areas relating to horizontal stresses: geological features, mining methods to minimize horizontal stress problems during development of entries and cross cuts, and mining methods to minimize horizontal stress problems during pillar recovery.
Keyword(s): coal mining, roof stability, ground control, geologic features, mine operation, roof support, roof bolting
Location(s): Illinois, Illinois Coal Basin, Kentucky, Indiana, United States

Bloemsma, J. P., E. Shackley, W. D. Claeys. The Effects of Total Extraction Mining Methods on the Stability of Roads at New Denmark Colliery. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 145-155.
The results of extensive research at New Denmark Colliery into the caving characteristics of the overburden strata and the development of surface subsidence above longwall and shortwall panels are presented. The results are compared with other, industry-wide research; empirical methods for predicting future subsidence are highlighted. On a number of occasions public roads were undermined and the resulting minor damage correlated to the influencing subsidence parameters, such as induced ground strains and tilts. This paper describes how confident predictions can be made by relating the extent of anticipated damage to road alignments and surfaces to expected subsidence and planned total extraction mining layouts.
Keyword(s): coal mining, longwall, shortwall, prediction, roads, law, surface structural damage, vertical displacement, horizontal displacement, geologic features
Location(s): South Africa

Bodus, T. M. Relationship Between the Clay Fabric of Roof Shales and Roof Collapse in Mines of the Herrin Coal, Southern Illinois. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 605-612.
The strength of roof shales is, in part, a function of the preferred orientation of clay minerals within them. Therefore, analysis of clay fabric under both air-dried and hydrated conditions should be helpful in understanding roof shale failure. Core samples were collected from the Energy, Anna, and Lawson shales, which are locally present as roof shales of the Herrin No. 6 coal of southern Illinois. The Clay Fabric Index (CFI) was measured for 30 core samples, using X-ray diffractometry, to investigate the relationship between clay fabric and roof collapse in coal mines. Greater CFI values indicate a weaker preferred orientation among clay minerals, which generally results in a weaker inter-grain bond.
Keyword(s): roof stability, coal mining, geologic features, lab testing
Location(s): Illinois, Illinois Coal Basin, United States

Bodziony, J., J. Litwiniszyn, A. Smolarski. New Research Into Rock Masses Treated as Media Characterized by Stochastic Equations. IN: Proceedings, International Conference on Strata Control, Paris, 1960, p. 137-150.
Keyword(s): modeling, empirical model, stochastic model

Bojarski, Z., A. Szczurowski. Report Prepared for the Coal Committee, U.N. Economic Commission for Europe on "The Exchange of Experiences in the Field of Coal Working Under Buildings and Industrial Plants." Central Mining Institute, Research Center for the Deposit and Surface Protection, Katowice, Poland, December 1978, 27 p.

This report contains detailed information on the mining of safety pillars.

Keyword(s): vertical displacement, horizontal displacement, mine design, prediction, pillar extraction, surface structural damage, coal mining

Location(s): Poland, Europe

Bonell, R. A. UK Longwalls, A Review of Strata Control Experience and Current Trends. IN: Proceedings, 6th International Strata Control Conference, Paper 25, Banff, Canada, 1977.

Keyword(s): longwall, ground control, coal mining

Location(s): United Kingdom

Bonte, A. Mining Subsidence and Geology. Industrie Minerale, St. Etienne, France, v. 61, no. 10, 1979, p. 531-541.

Keyword(s): geologic features

Booth, C. J. The Hydrogeological Impact of Deep Longwall Mining, Appalachian Plateau, Pennsylvania. IN: Proceedings, National Water Well Association Conference on the Impact of Mining on Ground Water, Denver, CO, 1984, p. 360-379.

An investigation of the Barnes and Tucker Company's Lancashire No. 20 Mine, Cambria County, Pennsylvania, was conducted to provide a conceptual model and calibration data for the development of a numerical model of groundwater flow associated with underground coal mining in the Appalachian Plateau. This paper presents some hydrologic results and conclusions relating to the groundwater inflow to the mine and the impact of the mine on overlying aquifers.

Keyword(s): subsurface water, hydrology, longwall, coal mining, modeling, geologic features, inflow

Location(s): Pennsylvania, Appalachian Coal Region, United States

Booth, C. J. A Numerical Model of Groundwater Flow Associated with an Underground Coal Mine in the Appalachian Plateau, Pennsylvania. Ph.D. Dissertation, 1984, The Pennsylvania State University, University Park, 458 p.

Keyword(s): modeling, hydrology, subsurface water, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Booth, C. J. Strata-Movement Concepts and the Hydrogeological Impact of Underground Coal Mining. Ground Water, v. 24, no. 4, 1986, p. 507-515.

A review of mining-engineering concepts and studies in mine hydrology suggests a conceptual model linking the strata-deformation, hydraulic property changes, and groundwater impacts due to underground coal mining. A study of a deep coal mine in the Appalachian Plateau, Pennsylvania, indicated (1) probable hydraulic connections between the mine and shallow aquifers in a principal valley area; (2) no obvious response of water levels in shallow aquifers to undermining by supported headings; and (3) rapid, considerable declines in such water levels in response to nearby longwall mining. These results are consistent with the conceptual model.

Keyword(s): subsurface water, hydrology, coal mining, modeling, overburden, geologic features, inflow

Location(s): Pennsylvania, Appalachian Coal Region, United States

Booth, C. J., J. A. Saric. The Effects of Abandoned Underground Mines on Ground Water, Saline County, Illinois. IN: Proceedings, National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, Springfield, IL, December 7-11, 1987, University of Kentucky, Lexington, UKY BU145, p. 243-248.

The hydrogeological effects of abandoned underground coal mines were studied at the town of Muddy, Saline County, Illinois. Muddy is underlain by two abandoned mines at depths of 300 and 400 feet, and exhibits subsidence features. Water levels were measured in glacial and bedrock aquifer wells in 1985-1986. The water table follows the nearly flat topography. The bedrock piezometric surface exhibits anomalies interpreted as being due to leakage of water from glacial to bedrock aquifers, possibly through well casings and from shallow bedrock aquifers to the mine because of subsidence-induced fracturing. The bedrock heads over the mine itself are anomalously low, indicating that the mine is absorbing the upward regional groundwater discharge. No effects of subsidence were noted on the transmissivities determined from simple pumping tests of wells. The groundwater in the glacial aquifer is of intermediate hydrochemical facies. In the bedrock, it is dominated by Na and HCO3, consistent with a regional-upwelling ground-ater provenance. The chemistry also indicates some mixing between glacial and bedrock waters. The impacts at Muddy are minor but indicate that abandoned underground mines interfere with groundwater flow patterns, and they have the potential for significant impacts on local groundwater resources and the migration of poor quality water into aquifers.

Keyword(s): hydrology, subsurface water, abandoned mines, coal mining, overburden, geologic features, inflow

Location(s): Illinois, Illinois Coal Basin, United States

Booth, C. J., E. D. Spande, D. F. Brutcher, B. B. Mehnert. Hydrogeological Response to Longwall Coal Mining in Illinois. Geological Society of America Abstracts with Programs, 1989, p. A230.

Underground coal mining in the Illinois Basin has been mainly dry, with little impact on the minor aquifers present. Longwall mining, however, which causes rapid subsidence and strata fracturing and is known (in Appalachia) to affect aquifer properties and groundwater flow, has been introduced recently to the area. This study, under the Illinois Mine Subsidence Research Program, is of the aquifer response to longwall mining in this new hydrogeological setting.

Keyword(s): hydrology, subsurface water, coal mining, longwall, overburden, active mines

Location(s): Illinois, Illinois Coal Basin, United States

Booth, C. J., E. D. Spande, D. F. Brutcher, B. B. Mehnert. Effects of Longwall-Induced Subsidence on Groundwater Hydrology in Southern Illinois. An Industry Under Siege: Some Facts About Subsidence, American Mining Congress and Illinois Coal Association Seminar, February 15-16, 1990, Mt. Vernon, IL.

Historically, underground coal mining in Illinois has been dry and had little effect on the minor aquifers present. However, high-extraction mining, which has been observed in Appalachia to considerably affect aquifer properties and groundwater flow, is being increasingly used in the area. This study, under the Illinois Mine Subsidence Research Program, is examining aquifer response to longwall mining in Illinois.

Keyword(s): longwall, hydrology, subsurface water, coal mining, active mines, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Booth, C. J., E. D. Spande. Piezometric and Aquifer Property Changes Above Subsiding Longwall Panels, Southern Illinois. IN: EOS, Transactions of American Geophysical Union Spring Meeting, Baltimore, MD, May 30, 1990, v. 71, no. 17, 1990, p. 506 (abstract of poster session).

Longwall mining, a recent feature in Illinois, creates rapid ground subsidence over the rectangular panels of coal extracted; the associated fracturing changes the aquifer properties and piezometric levels in the overlying strata. In this Illinois Mine Subsidence Research Program study (1988-1990), wells and piezometers were monitored and aquifer properties determined before and after subsidence over a longwall mine 700 feet deep.

Keyword(s): hydrology, subsurface water, longwall, geologic features, monitoring methods, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Booth, C. J., E. D. Spande. Response of Groundwater Hydrology to Subsidence Above a Longwall Mine in Illinois. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, Pittsburgh, PA, C.D. Elifrits, ed., p. 113-118.

This study examined the effects of longwall-related subsidence and fracturing on aquifer properties and potentiometric levels above an active, 725-foot-deep longwall mine in southern Illinois.

Keyword(s): hydrology, overburden, longwall, subsurface water, active mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Booth, C. J., E. D. Spande. Changes in Hydraulic Properties of Strata Over Active Longwall Mining, Illinois, USA. IN: Proceedings, 4th International Mine Water Congress, Portschach, Austria, September, 1991, p. 163-174.

This study examined potentiometric and hydraulic property changes caused by active longwall mining at two sites in Illinois.

Keyword(s): coal mining, active mines, longwall, hydrology, subsurface water, overburden, monitoring methods, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Booth, C. J., P. J. Carpenter, E. D. Spande, J. T. Kelleher, B. B. Mehnert, D. J. Van Roosendaal. Geological Control of the Hydrogeological Effects of Longwall Mining: New Interpretations from Recent IMSRP Studies in Illinois. IN: Geological Society of America, Abstracts with Programs, No. 17783, October, 1991, p. A39.

Illinois Mine Subsidence Research Program studies show that the hydrogeological impact of longwall coal mining is principally mediated by subsidence-induced changes in hydraulic properties, and thus differs with lithologic variations, from unit to unit and between sites. This model is supported by IMSRP results from potentiometric monitoring, pre- and post-subsidence determination of hydraulic properties, and surface and subsurface strain characterization over two active longwall mines.

Keyword(s): hydrology, geologic features, longwall, coal mining, monitoring methods, active mines, vertical displacement, horizontal displacement

Location(s): Illinois, Illinois Coal Basin, United States

Booth, C. J. Hydrogeologic Impacts of Underground (Longwall) Mining in the Illinois Basin. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 222-227.

Hydrogeological impacts of active longwall mining were studied at two sites in Illinois. At the site with the more transmissive sandstone aquifer, aquifer permeabilities increased an order of magnitude due to subsidence. Piezometric levels declined with subsidence due to increased porosity, and ahead of mining due to a transmitted draw-down. Levels recovered rapidly at first and fully over 2 years. At the site with the less transmissive aquifer, impacts were similar except that recovery has been limited. Local aquifer enhancement through increased yield can occur, but only where the aquifer is transmissive enough for recovery.

Keyword(s): longwall, hydrology, subsurface water, geologic features, active mines, coal mining, monitoring methods

Location(s): Illinois, Illinois Coal Basin, United States

Booth, C. J., E. D. Spande. Potentiometric and Aquifer Property Changes Above Subsiding Longwall Mine Panels, Illinois Basin Coalfield. Ground Water Journal, v. 30, No. 3, May-June 1992, p. 362-368.

This study examined the response of potentiometric levels and hydraulic properties to subsidence caused by a 725-foot-deep active longwall mine in southern Illinois.

Keyword(s): hydrology, subsurface water, overburden, coal mining, longwall, active mines, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Boreck, D. L. Increasing the Recovery of Thick and Closely Spaced Coal Seams in the Western US--Some Geologic and Longwall Considerations. Mining Engineering, March 1988, p. 168-173.

This paper examines some of the geologic factors that would affect development of thick or closely spaced seams in the western United States. In an effort to increase future recovery from such deposits, the USBM analyzed the potential for incorporating three thick-seam mining methods into western coal mines. These methods are high-face longwall, multi-slice longwall, and longwall caving.

Keyword(s): geologic features, coal mining, longwall, multiple-seam extraction, roof stability, mine safety

Location(s): Colorado, Wyoming, Utah, Rocky Mountain Coal Region, United States

Borecki, M., A. Kidyibinski. Coal Strength and Bearing Capacity of Coal Pillars. IN: Proceedings, 2nd International Congress on Rock Mechanics, 1970, v. 2, Paper No. 3-21, p. 145-152.

Keyword(s): pillar strength, rock mechanics, coal mining

Born, D. D. Longwall Mining Near An Impoundment Embankment--A Case Study. IN: Proceedings, 2nd Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 231-233.

This paper describes conditions of cover and strata in the Pittsburgh seam where a body of impounded water was safely undermined.

Keyword(s): longwall, surface water, coal mining, inflow

Location(s): West Virginia, Appalachian Coal Region, United States

Boscardin, M. D., E. J. Cording, T. D. O'Rourke. Case Studies of Building Behavior in Response to Adjacent Excavation. Report No. UMTA-

IL06-0043-78-2, U.S. Department of Transportation, Washington, DC, 1978.
Keyword(s): engineering, surface structural damage
Location(s): United States

Boscardin, M. D. Building Response to Excavation-Induced Ground Movements. Ph.D. Thesis, University of Illinois, Urbana-Champaign, 1980, 279 p.
The study showed that the most useful relationships between building damage and distortions could be established when both lateral strains and angular distortions were measured. However, some estimate of the lateral ground strains affecting a structure could be made based upon the settlement slopes if the settlement profile shape and the size and position of the structure with respect to the settlement profile were known. Once a reasonable estimate of the ground movements caused by an excavation was made, the figures and tables presented in this report could be used to estimate the response of a structure and the resulting damage.
Keyword(s): surface structural damage, tunnelling, instrumentation, engineering, architecture, modeling, horizontal displacement, construction
Location(s): United States, District of Columbia, Illinois

Boscardin, M. D., I. Ahmed. Subsidence Effects on Buildings and Buried Pipelines. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 106-112.
This paper reviews subsidence-induced ground movements, how these ground movements are transmitted to and accommodated by buildings and buried pipelines, and how these structures may alter ground movements relative to free field, subsidence-induced ground movements.
Keyword(s): pipelines, surface structural damage, utilities, prediction, structural mitigation, soils, active mines, abandoned mines

Bosworth, R. G. What Duty to Support the Surface Does a Subsidence Owner Owe? AIME Technical Publication No. 116, May, 1928, 44 p.
Keyword(s): surface structural damage, land-use planning, mine operation
Location(s): United States

Boukharov, G. N., M. W. Chanda. A Theoretical Study Into Damage to Pillars Caused by Blasting. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 53-57.
Surface subsidence when mining is dependent on the behaviour of the pillars supporting the overlying strata. Different factors influence pillar strength; one of them is the damage caused to the pillars from cracks induced or propagated in the rock by blasting. This paper presents an attempt to estimate the thickness of a damage zone to the pillar caused by blasting.
Keyword(s): modeling, pillar strength, engineering, mathematical model

Bowders, J., M. Gabr, G. Pigott. Analysis of a Landfill Over a Deep Mined Area: A Case Study. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 146-157.
A case study describing the expansion of a landfill over a deep mined area is described. Finite element analyses were used to predict the surface subsidence and associated tensile strains on the landfill liner of the expansion site. A synthetically reinforced liner system is recommended to minimize the impact of subsurface movements on the integrity of the liner system.
Keyword(s): finite element, prediction, geologic features, coal mining, abandoned mines, overburden, rock mechanics
Location(s): West Virginia, Appalachian Coal Region, United States

Bowders, J. J., Jr., S. C. Lee. Effect of Longwall Mining Subsidence on the Stability of Surface Slopes. IN: Proceedings, 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 314-320.
The stability of surface slopes undergoing subsidence due to longwall mining was investigated to examine the effect of subsidence on the stability of the slopes. Stability analyses were performed on all slopes along both longitudinal and transverse sections of the longwall panel before and after subsidence. Both finite- and infinite-slope analyses were performed with both drained and undrained cases. The results indicated that the changes in the stability of slopes due to subsidence were insignificant for the cases analyzed. Although significant lateral ground movements were

recorded, these were not attributed to slope failure. Explanations for these movements are presented.

Keyword(s): longwall, geologic features, coal mining, active mines, instrumentation, survey methods, soils

Location(s): West Virginia, Appalachian Coal Region, United States

Bowman, C. H., M. G. Karfakis, E. Topuz, C. Haycocks. Backfilling in Coal Mining - A State-of-the-Art Review. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 193-205.

The effect of subsidence can be mitigated by the placement of the correct fill during and/or after the mining operation. Fills, if properly selected and placed for the prevailing geologic and mining conditions, have the potential, during the mining operation, of functioning as alternative ground control measures, increasing coal recovery, and enhancing ventilation control. During post-abandonment, they serve the purpose of minimizing subsidence, preserving the hydrologic regime, minimizing underground fires, and enhancing post-mining surface land use and value.

Keyword(s): coal mining, mine fires, partial extraction, room-and-pillar, longwall, backfilling, active mines, hydraulic backfilling, pneumatic backfilling, stowing, mine waste

Location(s): United States

Boyum, B. H. Subsidence Case Histories in Michigan Mines. IN: Proceedings, 4th Symposium on Rock Mechanics, State College, PA, March 30-April 1, 1961. Bulletin Mineral Industry Experiment Station, v. 76, November, 1961, p. 19-57.

This report covers the cumulative studies on mine subsidence in Michigan underground iron mines, with particular emphasis on the investigations by the Cleveland-Cliffs Iron Company. Most of the information and effort have been related to the Marquette Iron Range, the oldest in the Lake Superior region. A historical summary is presented with a brief description of the geology of Range. Sketches of some early subsidence case histories are related.

Keyword(s): rock mechanics, seismic, metal mining, pillar strength, monitoring methods, monitoring equipment, subsidence research

Location(s): Michigan, United States

Brackley, I. J. A., P. N. Rosewarne, L. A. Grady. A Prediction of Surface Subsidence Caused by Lowering the Water-Table in Dolomite. IN: Proceedings, 3rd International Symposium on Ground Subsidence, Venice, Italy, 1984.

Keyword(s): prediction, subsurface water, geologic features, fluid extraction

Brackley, I. J. A. Numerical Prediction of Dolomitic Subsidence Caused by Mine Dewatering. IN: Proceedings, SANGORM Symposium, October 21, 1986, International Society for Rock Mechanics, South African National Group, Sandton p. 115-121.

The dewatering of hydrological compartments by deep gold mines has resulted in dolomitic sink-holes and subsidence. Great difficulty has been experienced in locating areas of high risk, but certain empirical criteria have been developed.

Keyword(s): subsurface water, prediction, metal mining, surface structural damage

Location(s): South Africa

Brady, B. H. Rock Mechanics and Ground Control for Underground Mining and Construction. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings of the 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 5-17.

Recent improvements are described in several techniques for ground control in underground mining. Promising methods for analysis and mitigation of rockbursts are discussed. Methods of assessing damage to underground excavations from repetitive seismic loading are reviewed. Analysis of mining-induced surface subsidence is discussed.

Keyword(s): rock mechanics, ground control, engineering, longwall, overburden, grouting, geologic features, coal mining, prediction, metal mining, modeling

Location(s): Australia, Finland

Brady, B. T., F. G. Horino, W. I. Duvall. The Use of Rock Belts or Wire Rope to Increase the Strength of Fractured Model Pillars. U.S. Bureau of Mines RI 7568, 1971, 24 p.

Keyword(s): pillar strength

Location(s): United States

Brady, S. D. Subsidence in the Sewickley Bed of Bituminous Coal Caused by Removing the Pittsburgh Bed in Monongalia County, West Virginia. Transactions, AIME, Coal Division, Fairmont Meeting, March 26-27, 1931.

The author concludes that coordination of mine designs and pillar pulling can protect overlying and underlying seams. The upper seam must be developed simultaneously with the lower, but retreat pillaring of the lower should be after pillaring of the upper seam.

Keyword(s): mine design, pillar extraction, multiple-seam extraction, room-and-pillar, pillar strength, coal mining, bituminous

Location(s): West Virginia, Appalachian Coal Region, United States

Branham, K. L. Cavity Detection Using High-Resolution Seismic Reflection Methods. M.S. Thesis, 1984, Southwest Missouri State University, Springfield, 75 p. (NTIS PB90-264565)

Surface collapses due to abandoned coal mines are a problem of great concern in southwest Kansas. A reliable and cost-efficient method for detecting mined cavities is needed to evaluate prospective construction sites. High-resolution reflection was used successfully to detect mined cavities in a 3-foot-thick coal seam at depths of 29 and 43 feet. A dominant frequency of 275 Hz was attained and reflections from the top and bottom of the coal seam were resolved. The reflected event from the top of the coal seam exhibited reduced amplitudes over water and coal ash slurry-filled cavities. The reflected event from the bottom of the coal seam exhibited a velocity pull-up beneath water and slurry-filled cavities.

Keyword(s): seismic, abandoned mines, coal mining, land-use planning

Location(s): Kansas, United States

Branthoover and Richards, Inc. Final Report Mine Subsidence Control Project SL452-102.2, Marion Elementary and Bellmar Junior High Schools, Belle Vernon Area School District, Washington Township, Fayette County, Pennsylvania. Prepared for Commonwealth of Pennsylvania. Department of Environmental Resources, Harrisburg, PA, 1979.

Keyword(s): surface structural damage

Location(s): Pennsylvania, Appalachian Coal Region, United States

Branthoover, G. L., J. W. Richards. Mine Subsidence Control Using Foundation Grouting, Southwestern Pennsylvania. IN: Proceedings 18th Annual Engineering Geology Soils Engineering Symposium, Boise, ID, April 2-4, 1980, Pennsylvania Department of Environmental Resources, p. 323-337.

This paper overviews a subsidence investigation program that includes core borings, borehole television, and rock mechanics. It also describes instrumentation and stabilization of structures.

Keyword(s): surface structural damage, rock mechanics, foundations, structural mitigation, architecture, instrumentation

Location(s): Pennsylvania, Appalachian Coal Region, United States

Brass, J. F. First Modern Longwall in Alabama. Mining Congress Journal, October, 1980, p. 25-30.

At the time of this article, there were around 85 longwall installations operating in this country, so a new one was hardly headline news. However, Jim Walter Resources planned to install 11 longwalls in a part of the country better known for cotton growing than advanced technology mining. Indeed, when the first of these longwall units started up, the next nearest working longwall was about 400 miles away. Described here are some of the considerations involved in introducing the new system, as well as the early operating experience.

Keyword(s): longwall, coal mining, mine operation, active mines

Location(s): Alabama, United States

Brauner, G. Critical Review of Present-Day Theory and Practices in the Prediction of Surface Deformation Caused by Mining. U.S. Bureau of Mines Grant GO100749 MIN-28, Michigan Technological University, December, 1969, 57 p.

The author reviews subsidence prediction methods with an emphasis on European methods; these are divided into two groups, on the basis of mathematical expressions either for the trough profile or for the influence of infinitesimal extraction elements.

Keyword(s): vertical displacement, horizontal displacement, prediction, prediction theories, mathematical model

Brauner, G. Subsidence Due to Underground Mining (In Two Parts). 1. Theory and Practices in Predicting Surface Deformation. U.S. Bureau of Mines IC 8571, 1973, 56 p.

The author details two fundamental methods of predicting mine subsidence: the trough profile and the influence of infinitesimal extraction elements. Also included are analyses of horizontal displacements and deformations, surface displacements over inclined seams, time effects, and physical and abstract models.

Keyword(s): empirical model, vertical displacement, horizontal displacement, prediction, prediction theories, surface structural damage, ground control, profile function, influence function, horizontal displacement, time factor
Location(s): Europe, Soviet Union

Brauner, G. Subsidence Due to Underground Mining (In Two Parts). 2. Ground Movements and Mining Damage. U.S. Bureau of Mines IC 8572, 1973, 53 p.
The author discusses the practical implications of ground movements involving surface structures and shafts, including structural and underground precautions against mining damage.
Keyword(s): surface structural damage, mine design, stowing, room-and-pillar, vertical displacement, horizontal displacement, time factor, ground control, descriptive theories, surface subsidence damage, surface water
Location(s): Soviet Union

Brauner, G. Calculation of Ground Movements in European Coalfields. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute of Mining and Metallurgy, Illawarra Branch, Paper 10, p. 10-1 - 10-8.
The precalculation methods preferred in European coal-mining are classified in three groups, namely direct formulas, the profile function method, and the superposition method. The fundamentals are empirical relationships and theoretical approaches. The calculation parameters that characterize the strata conditions must be found from measured ground movements. The horizontal displacements and strains can be determined from the derivatives of the subsidence curves. The direct formulas can be applied to distinct surface points only, the profile function method to entire trough profiles in cases of simple mining geometries, and the superposition method to any surface point and arbitrary mining geometries. A more general influence function may be employed for the superposition method when the agreement with observed movements appears to be insufficient.
Keyword(s): coal mining, prediction, prediction theories, profile function, horizontal displacement, vertical displacement, influence function
Location(s): Europe

Breeds, C. D. A Study of Mining Subsidence Effects on Surface Structures With Special Reference to Geological Factors. Ph.D. Thesis, University of Nottingham, England, 1976, 250 p.
This is a comprehensive reference on protecting existing surface structures from severe subsidence damage. It includes history and appraisal of early prediction methods and a description of the prediction methods used at the time in England.
Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, structural mitigation, mine design, ground control, monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, foundations, prediction, prediction theories, historical, geologic features
Location(s): England

Breeds, C. D., C. Haycocks, M. Karmis, E. Topuz. Design Optimization in Underground Coal Systems Sections 1, 2, 3, and 4. Virginia Polytechnic Institute, Department of Mining and Mineral Engineering, November, 1979, 66 p. (NTIS FE-1231-18)
Keyword(s): mine design, coal mining
Location(s): United States

Breeds, C. D., M. Karmis, C. Haycocks. Subsidence - Prevention or Control. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, Southern Illinois University, August 22-24, 1979, Carbondale, IL, 1980, p. 283-296.
This paper examines a solution for subsidence damage that is readily accepted in other foreign coalfields. That is the concept of control, or accommodation of subsidence movements. Both underground and surface methods of lessening the effects of mining subsidence are discussed. In addition, two case studies are presented to illustrate the success of one surface and one underground method.
Keyword(s): ground control, surface subsidence damage, surface structural damage, stowing, structural mitigation, geologic features, shortwall, room-and-pillar, longwall, mine design
Location(s): United States, United Kingdom

Briggs, H., J. Morrow. An Attempt at the Rationale of Faulting and Subsidence. Transactions, Institute of Mining Engineering, London, v. 73, 1926-27, p. 465-505.
Keyword(s): geologic features
Location(s): England

Briggs, H. Mining Subsidence. Edward Arnold & Co., London, 1929, 215 p.

This book provides a comprehensive study of mine subsidence, with information on British laws, historical theories, partial extraction mining and backfilling. It contains observations from England, India, and the United States.

Keyword(s): surface structural damage, law, historical, backfilling, partial extraction

Location(s): England, India, United States

Briggs, H. Flexure of Undermined Strata. Colliery Engineering, v. 9, 1932, p. 247-251.

Keyword(s): overburden, time factor, rock mechanics

Briggs, H., W. Ferguson. Investigation of Mining Subsidence at Barbauchlaw Mine, West Lothian. Transactions, Institute of Mining Engineering, London, v. 85, 1932-33, p. 303-334.

Location(s): England

Brink, D., F. von M. Wagener. The Construction of Tailings Dams on Areas Mined by High Extraction Mining Methods. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May, 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 243-247.

High extraction mining methods result in surface subsidence. Ultimately, a point of equilibrium is reached where the resistance of the compressed rubble that fills the mining void equals the weight of the overburden strata. At this point no further surface subsidence should occur. If a tailings dam is constructed on a subsided area, the overburden pressure increases and secondary subsidence will occur. This paper covers the aspect of the prediction of secondary settlement induced by additional loading of a mined area and gives practical recommendations for the design and operation of tailings dams on subsided areas.

Keyword(s): coal mining, longwall, pillar extraction, prediction

Location(s): South Africa

British Geotechnical Society. Settlement of Structures. Halsted Press, New York, 1975, 811 p.

Keyword(s): geotechnical, surface structural damage

Location(s): England

Broms, B. B., A. Frederickson. Land Subsidence in Sweden Due to Water Leakage into Deep-Lying Tunnels and its Effects on Pile Supported Structures. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976.

Keyword(s): subsurface water, tunnelling

Location(s): Sweden

Brook, D., K. W. Cole. Subsidence of Abandoned Limestone Mines of West Midlands of England. IN: Land Subsidence, Proceedings, 3rd International Symposium on Land Subsidence, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication No. 151, 1986, p. 675-685.

Abandoned limestone mines in the West Midlands of England present potential problems of subsidence under urban areas. A study was made to (1) discover the extent of information that remains, (2) investigate the extent of the mines and physical characteristics of the mines and the rocks surrounding them, (3) establish the degree of risk, if any, of ground movement occasioned by the collapse of the mines, and (4) consider and recommend remedial and other works for dealing with the assessed risk.

Keyword(s): abandoned mines, non-metal mining, coal mining, surface structural damage, literature search, geologic features, backfilling, land-use planning

Location(s): United Kingdom

Brook, G. A., T. L. Allison. Fracture Mapping and Ground Subsidence Susceptibility Modeling in Covered Karst Terrain: The Example of Dougherty County, Georgia. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association Hydrological Sciences Publication No. 151, 1986, p. 595-606.

Subsidence susceptibility maps of a covered karst terrain in southwest Georgia have been developed using a geographic information system. Five variables were used in the model: sinkhole density, sinkhole area, fracture density, fracture length, and fracture intersection density. Broadly similar subsidence susceptibility models were developed from the data.

Keyword(s): geologic features, modeling

Location(s): Georgia, United States

Brown, A., F. L. Casey. An Investigation Into Surface Subsidence Associated With the Extraction

of Coal Seams. Canada Department of Energy, Mines, and Resources, Mining Research Centre International Report MR 71/88-10, 1971, 39 p.

Keyword(s): surface subsidence damage, coal mining

Location(s): Canada

Brown, A., J. Murphy, H. Bartell. Slurry Backfilling of an Underground Coal Mine. IN: Conference on Hydraulic Fill Structures, Colorado State University, Fort Collins, August 15-18, 1988, D.J.A. Van Zyl and S.G. Vick, eds., ASCE Geotechnical Special Publication No. 21.

The Wyoming Abandoned Mine Lands program is remediating the impacts resulting from mining conducted over the last century. An important part of that program calls for the control of subsidence over abandoned underground coal mines. This paper describes the planning, performance, and effectiveness of a subsidence control project conducted in Hanna, Wyoming, in which 800,000 tons of remotely placed hydraulic backfill was used as a supporting medium for part of an underground coal mine that underlies the main part of the town. This project is the first fully successful application of this technology in the western United States.

Keyword(s): abandoned mines, coal mining, land mitigation, hydraulic backfilling, surface structural damage

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Brown, D. F., D. S. Buist. Mine Workings and Their Treatment on the Unstone-Dronfield By-Pass. Department of the Environment Construction, v. 17, 1976, p. 23-25.

Keyword(s): roads, land-use planning

Brown, E. O. F. Packing Excavations in Coal Seams by Means of Water. Transactions, Institution of Mining Engineers, v. 28, 1905,.

This article discusses hydraulic sand backfilling in Poland.

Keyword(s): hydraulic backfilling, mine fires, coal mining

Location(s): Poland, Europe

Brown, E. T., E. Hoek. Trends in Relationship Between Measured In-Situ Stresses and Depth. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 15, 1978, p. 211-215.

Keyword(s): rock mechanics, in situ testing

Brown, R. E. A Multi-Layered Finite Element Model for Predicting Mine Subsidence. Ph.D. Thesis, Carnegie-Mellon University, Pittsburgh, PA, 1968.

Results of a finite element model of subsidence movements were compared with British field data, and showed good agreement for the cases studied.

Keyword(s): modeling, prediction, finite element, phenomenological model, elastic model

Location(s): England

Brown, R. L., R. R. Parizek. Shallow Ground-Water Flow Systems Beneath Strip and Deep Coal Mines At Two Sites, Clearfield County, Pennsylvania. The Pennsylvania State University Special Research Report SR-84, May 1, 1971, Contract No. CR-66.

The objective of this study was to describe the groundwater flow systems in rock units associated with coals so that acid mine drainage could be more effectively prevented, treated, isolated, or diluted as conditions require. The physical groundwater flow systems for two sites near Kylertown, Pennsylvania, were approximated by flow net construction. The flow nets cannot give a unique solution to the flow problem because all of the parameters were not completely defined. In particular, the influence of joints on horizontal and vertical permeabilities could not be specifically measured.

Keyword(s): hydrology, subsurface water, coal mining, geologic features, monitoring methods, abandoned mines

Location(s): Pennsylvania, Appalachian Coal Region, United States

Bruhn, R. E. The Tolerance of Structures to Ground Movements - Some Considerations. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 83-93.

This paper considers several cases where structural behavior and site specific details had to be taken into account in assessing the relationship between damage and ground movements.

Keyword(s): surface structural damage, prediction, engineering, abandoned mines, active mines, longwall, coal mining, structural mitigation

Bruhn, R. W., M. O. Magnuson, R. E. Gray. Subsidence Over the Mined-Out Pittsburgh Coal. American Society of Civil Engineers National Spring Convention and Continuing Education, Pittsburgh, PA, April 24-28, 1978, ASCE Preprint 3253, 1978, p. 26-55.

This paper discusses subsidence as it occurs above abandoned mines in the Pittsburgh Coal of western Pennsylvania. In particular, it dentifies two principal types of subsidence of subsidence features (sinkholes and troughs), presents data from 354 incidents of subsidence, and discusses the costs of subsidence to the public.

Keyword(s): economics, room-and-pillar, prediction, abandoned mines, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Bruhn, R. W. Mine Subsidence in the Pittsburgh Area. IN: 45th Annual Field Conference of Pennsylvania Geologists, Pittsburgh, October 3-4, 1980, Pittsburgh Geological Society, p. 25-35.

Keyword(s): surface subsidence damage

Location(s): Pennsylvania, Appalachian Coal Region, United States

Bruhn, R. W., M. O. Magnuson, R. E. Gray. Subsidence Over Abandoned Mines in the Pittsburgh Coalfield. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 142-156.

This paper discusses subsidence above abandoned mines in the Pittsburgh Coal based on data from 354 documented incidents that took place in western Pennsylvania and West Virginia in the period of 1955 to 1976. Past mining practice is related to subsidence and available information regarding the geometry of subsidence features, and their time of occurrence is summarized. Practical inferences are drawn, and several cases are cited where human activities have apparently hastened the onset of subsidence above abandoned mines.

Keyword(s): abandoned mines, coal mining, surface structural damage, overburden

Location(s): Pennsylvania, West Virginia, Appalachian Coal Region, United States

Bruhn, R. W., W. S. McCann, R. C. Speck, R. E. Gray. Damage to Structures Above Active Underground Coal Mines in the Northern Appalachian Coal Field. IN: Proceedings 1st Conference on Stability in Underground Mines, Vancouver, British Columbia, Canada, August 16-18, 1982, AIME, 21 p.

This paper presents the results of a characterization study of subsidence damage to 134 homes. It proposes a uniform subsidence-damage classification system for structural damage.

Keyword(s): surface structural damage, active mines, coal mining

Location(s): Appalachian Coal Region, United States

Bruhn, R. W., R. C. Speck, W. S. McCann, O. S. Cecil. Survey of Ground Surface Conditions Affecting Structural Response to Subsidence. Final Report to U.S. Bureau of Mines, OFR 12-84, Contract JO295014, June, 1983, by GAI Consultants, Inc., Monroeville, PA, 601 p. (NTIS PB 84-155860)

The objective of the study is to examine the apparent influence of soil and near-surface rock strata on the severity of damage experienced by surface structures subjected to mine subsidence. The report discusses (1) modes of ground movement that might complicate or be confused with mine subsidence; (2) prevailing concepts concerning mine subsidence in the Northern Appalachian Coal Field and Illinois Basin; (3) apparent influences of soil and near-surface rock strata on the character of subsidence-related ground movements; (4) classifications and criteria for characterizing damage due to ground movements; and (5) types of subsidence damage experienced by homes above active mines in western Pennsylvania. Presented is a damage classification system incorporating a severity index for characterizing subsidence damage to homes with basements above active mines. A series of case histories illustrate subsidence damage to structures above active and abandoned mines.

Keyword(s): surface structural damage, soils, active mines, abandoned mines, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, Illinois, Illinois Coal Basin, United States

Bruhn, R. W., R. C. Speck, R. E. Thill. The Appalachian Field: Damage to Structures Above Active Underground Mines. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., Coal Extraction and Utilization Research Center, Southern Illinois University at Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, 1983, p. 657-670.

This paper reviews four major topics concerning subsidence over active mines: the character of subsidence damage experienced by conventional homes, including typical repair costs, methods of predicting subsidence damage, the frequency of occurrence of subsidence damage, and techniques of mitigating subsidence damage.

Keyword(s): surface structural damage, active mines, structural mitigation, coal mining

Location(s): Appalachian Coal Region, United States

Bruhn, R. W., R. C. Speck. Ground Movements Associated with Pillar Extraction Coal Mining in Northern West Virginia. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 727-736.

An investigation was made of ground response to pillar retreat mining in a 1.7-meter-thick seam at a depth of 108 meters at a site in northern West Virginia. This paper describes mining-related stress changes and movements at mine level, displacements within the overburden, ground surface subsidence and groundwater level variations. Subsidence approached 40% of the mine height and continued for more than a year after mining. Water levels declined in some of the deep-lying strata.

Keyword(s): pillar extraction, coal mining, high-extraction retreat, overburden, subsurface water, active mines, instrumentation, monitoring methods

Location(s): West Virginia, Appalachian Coal Region, United States

Bruhn, R. W. Case Report: Coal Mine Subsidence in Farmington, West Virginia. Underground Space, v. 9, no. 5-6, 1985, p. 261.

The town of Farmington, in Marion County, West Virginia, was visited by consulting geotechnical engineers to determine the cause of ground movements that had become prominent the preceding year.

Keyword(s): utilities, surface structural damage, geotechnical, abandoned mines, room-and-pillar, pillar strength, reclamation, backfilling, coal mining

Location(s): Appalachian Coal Region, United States, West Virginia

Bruhn, R. W. Influence of Deep Mining on the Ground Water Regime at a Mine in Northern Appalachia. IN: Proceedings, 2nd Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 234-248.

Findings concerning groundwater effects presented in this paper indicate that total extraction mining produced significant water level declines in deep-lying strata, but had little effect on water levels at shallower depths. Post-mining values of hydraulic conductivity were typically somewhat higher than pre-mining values. Changes in water chemistry associated with mining were not sufficient to render the water unfit for human consumption.

Keyword(s): subsurface water, hydrology, instrumentation, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Bruhn, R. W., G. W. Luxbacher, J. R. Ferrell, T. A. Gray. The Structural Response of a Steel Lattice Transmission Tower to Mining-Related Ground Movements. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 301-306.

A 125-foot-high steel lattice frame tower supporting a 500-kV EHV transmission line and located over the gateroads of a longwall mining operation was subjected to ground movements from the mining of adjacent longwall panels.

Keyword(s): surface structural damage, longwall, finite element, prediction, horizontal displacement, utilities, coal mining, active mines, instrumentation

Location(s): West Virginia, Appalachian Coal Region, United States

Brummer, R. K. A Simplified Modelling Strategy for Describing Rockmass Behaviour Around Stope Faces in Deep Hard-Rock Gold Mines. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 113-120.

Gold mines in South Africa working at depths of up to 3,600 m have mining layout designed on the basis of numerical models that assume elastic behavior of the rockmass.

Keyword(s): rock mechanics, mine design, metal mining, modeling, elastic model, boundary element

Location(s):S outh Africa

Brutcher, D. F., B. B. Mehnert, D. J. Van Roosendaal, R. A. Bauer. Rock Strength and Overburden Changes Due to Subsidence Over a

Longwall Coal Mining Operation in Illinois. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 563-570.

The overburden above an active underground longwall coal mining operation was characterized before and after subsidence using core drilling, geotechnical instrumentation, and in situ testing. The analysis of mining-induced changes in the overburden provides a better understanding of the mechanisms leading to the surface expression of subsidence and hydrologic changes.

Keyword(s): longwall, coal mining, overburden, rock mechanics, instrumentation, monitoring methods, active mines, lab testing, in situ testing, subsurface water, hydrology, monitoring equipment

Location(s): Illinois, Illinois Coal Basin, United States

Bryan, A., J. G. Bryan, J. Fouche. Some Problems of Strata Control in Pillar Workings. The Mining Engineer, London, v. 123, no. 41, 1964, p. 238-266.

This paper discusses possible causes for a mine collapse in South Africa in which 437 people were killed; the collapse covered at least 75 acres. Topics covered include geologic conditions, failure mechanisms, and coal pillar strength.

Keyword(s): room-and-pillar, ground control, mine safety, pillar strength

Location(s): South Africa

Bucherer, L. Hydraulic Filling in European Mines. Mines and Minerals, v. 32, 1912, p. 715.

Early mining of multiple coal levels used hydraulic backfilling. Difficulties concerning pipe abrasion, fluid mixtures, sorting of fill, and relative cost are discussed.

Keyword(s): hydraulic backfilling, multiple-seam extraction, coal mining, historical

Location(s): Europe

Buck, W. A. Geological Environment in Relation to Longwall Operation in the U.S.A. The Mining Engineer, London, v. 137, no. 199, 1978, p. 363-371.

Keyword(s): longwall, geologic features

Location(s): United States

Bucky, P. B. Use of Models for the Study of Mining Problems. AIME Technical Publication No. 425, 1931, p. 3-28.

This paper discusses and compares modeling methods.

Keyword(s): prediction, modeling, mathematical model

Location(s): United States

Bucky, P. B., A. L. Fortress. Applications of Principles of Similitude to Design of Mine Workings. Transactions, American Institute of Mining and Metallurgical Engineers, v. 109, 1934, p. 25-50.

Samples from natural mine arches were tested for strength according to their size and shape.

Keyword(s): mine design, roof stability, rock mechanics, lab testing

Location(s): United States

Bucky, P. B., A. J. Toering. Mine Roof and Support Design as Applied to Flat-Lying Beds Stressed Within the Elastic Limit. Engineering and Mining Journal, v. 106, 1935, p. 178-181.

Formulas based on laws of mechanics are derived for calculating the safe span allowable between pillar center lines, pillar size, and percent extraction.

Keyword(s): mine design, pillar strength, roof stability

Bucky, P. B. Roof Control Problems in High Speed Mechanization Answered by Barodynamics. Coal Age, v. 43, January, 1938, p. 61-66.

Barodynamics deals with the behavior of weighty structures and applies laws of mechanics to determine the behavior of the structure and/or the application of similitude to the behavior of small-scale models to determine how the prototype will behave.

Keyword(s): roof support, modeling

Bucky, P. B., R. V. Taborelli. Effects of Immediate Roof Thickness in Longwall Mining as Determined by Barodynamic Experiments. Transactions, AIME, v. 130, Coal Division, 1938, p. 314-332.

There is available an accumulation of experience regarding longwall mining but coordination of experience is lacking and this series of experiments was undertaken to help serve this purpose. Model experiments were used for reasons of safety, cost, and time, and because it has been previously shown that a scalar model built of the same material as the prototype will behave in a manner similar to that of the prototype, with time effects the same, if the effective weight of the model is increased in the same proportion as its linear dimensions are decreased.

Keyword(s): longwall, coal mining, lab testing, modeling

Budavari, S., E. L. J. Potts. Rock Deformation Measurements for Evaluating Mine Stability. Transactions, Institution of Mining and Metallurgy, Section A, Mining Industry, v. 79, 1970, p. A37-A42.
Keyword(s): rock mechanics, mine design

Building. NHBC Plans to Reduce £3.5m Annual Claims, 29 April, 1977, p. 41.
Faced with claims of £3.5 million a year on its 10-year new house guarantee insurance, the National House-Building Council is introducing a five-point plan to ensure that houses built in 1977 are the best yet. The article shows two pictures of structures damaged by mine subsidence.
Keyword(s): surface structural damage, architecture, foundations, construction, coal mining, insurance
Location(s): United Kingdom

Buist, D. S., P. F. Jones. Potential Instability of Permian Strata in the Pleasley By-Pass Area, Derbyshire. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 427-448.
Excavations for a new highway scheme encountered intensive fracturing of the Magnesian Limestone. Further problems were posed by a "hidden" fault at the site of a proposed bridge. The possibility of reactivation of the fault by future coal mining subsidence, and the consequent deleterious effect that this would have on the stability of the bridge necessitated a very careful reassessment of the proposed structure. Eventually the design of the bridge was radically altered. This paper investigates the origin and engineering implications of fracturing in the Magnesian Limestone. The paper also describes methods undertaken to calculate the magnitude of future subsidence and to ensure that resultant structural damage is kept to a minimum.
Keyword(s): surface structural damage, roads, coal mining, engineering, geologic features, lab testing, in situ testing
Location(s): United Kingdom

Bull, W. B. Causes and Mechanics of Near-Surface Subsidence in Western Fresno County, California. Short Papers in the Geologic and Hydrologic Sciences, U.S. Department of the Interior, Geological Survey Professional Paper 424-B, 1961, p. B187-B189.
Keyword(s): fluid extraction
Location(s): California, United States

Bull, W. B. Prehistoric Near-Surface Subsidence Cracks in Western Fresno County, California. Geological Society of America, Special Paper 115, 1968, p. 314-315.
Keyword(s): fluid extraction, historical
Location(s): California, United States

Bull, W. B. Subsidence Due to Artesian-Head Decline in the Los Banos-Kettleman City Area, California. Geological Society of America, Special Paper 101, (abstract), 1968, p. 29-30.
Keyword(s): fluid extraction, subsurface water
Location(s): California, United States

Bull, W. B. Prehistoric Near-Surface Subsidence Cracks in Western Fresno County, California. USGS Professional Paper 437-C, 1972, 85 p.
The thousands of clay-filled tension cracks found in the alluvial fans of the San Joaquin Valley, California, during the excavation of the California Aqueduct raised the possibility of postconstruction tensional rupture of the canal. In western Fresno County, the cracks were the result of subsidence caused by compaction due to wetting.
Keyword(s): surface water, subsurface water, engineering
Location(s): California, United States

Bull, W. B. Geologic Factors Affecting Compaction of Deposits in a Land Subsidence Area. Bulletin of the Geological Society of America, 84, 1973, p. 3783-3802.
Keyword(s): geologic features

Bull, W. B. Land Subsidence Due to Ground-Water Withdrawal in the Los Banos-Kettleman City Area, California; Part 2, Subsidence and Compaction of Deposits. U.S. Department of the Interior, Geological Survey Professional Paper 437-F, 1975, 90 p.
Keyword(s): fluid extraction
Location(s): California, United States

Bull, W. B., J. F. Poland. Land Subsidence Due to Ground-Water Withdrawal in the Los Banos-Kettleman City Area, California; Part 3, Inter-relations of Water-Level Change, Change in Aquifer-System Thickness and Subsidence. U.S.

Department of the Interior, Geological Survey Professional Paper 437-G, 1975, 62 p.

Keyword(s): fluid extraction, hydrology
Location(s): California, United States

Bull, W. B., R. E. Miller. Land Subsidence Due to Ground-Water Withdrawal in the Los Banos-Kettleman City Area, California, Part 1, Changes in the Hydrologic Environment Conducive to Subsidence. Geological Survey Professional Paper 437-E, 1975, U.S. Government Printing Office, Washington, D.C.

Keyword(s): fluid extraction, subsurface water, surface subsidence damage
Location(s): California, United States

Bullock, K. P. The Measurement of Coal Mining Subsidence--An Example. Mining Magazine, April, 1984, p. 379-385.

The equipment and methods used in measuring the subsidence over a particular longwall coal mining face are described in this article, together with details of the results obtained. The Electronic Distance Measurement system employed allows accurate results to be obtained with a minimum of time spent in field observation.

Keyword(s): monitoring methods, monitoring equipment, survey methods, survey design, coal mining, longwall, vertical displacement, horizontal displacement
Location(s): United Kingdom

Bullock, W. D., R. L. Brittain, G. A. Place. Mining and the Environment. Exploration Update '75, Calgary, Alberta, May, 1975.

The requirements of recent environmental legislation enacted in Canada and the United States have made mining operations increasingly complex. This paper briefly reviews the extent of mining activity in both countries and lists its major environmental impact. Pending legislation of concern to mine operation is reviewed.

Keyword(s): environment, law, mine operation
Location(s): United States, Canada

Bumm, H., G. Schweden, G. Finke. The Mining Subsidences in the Harbours of Duisburg-Ruhrort. Bulletin of the Permanent International Association of Navigation Congress, Brussels, v. 3, no. 21, 1966, p. 3-29.

This paper discusses mining-extraction methods used to control subsidence effects on the Rhine River in the Federal Republic of Germany; valuable coal deposits under the River had not been mined previously because of possible damage to shipping channels.

Keyword(s): surface structural damage, surface water, mine design, economics, coal mining
Location(s): Germany

Buntain, M. E. Longwall Growth in the U.S. May Depend on How Well Subsidence is Controlled. Coal Mining and Processing, v. 12, no. 12, 1976, p. 71-74, 88-89.

This paper discusses factors affecting subsidence resulting from longwall mining, including angle of draw, geology, width of extraction, and rate of advance; it also contains information on subsidence-control techniques.

Keyword(s): mine design, backfilling, law, longwall, partial extraction, coal mining, angle of draw, geologic features
Location(s): United States

Bur, T. R., B. Berson. A Review of Foreign Subsidence Laws and a Presentation of Mining Laws Within the U.S. that are Applicable to Subsidence. U.S. Bureau of Mines Twin Cities Research Center Project Report, 29 p. (date unknown).

This USBM report presents laws pertinent to subsidence related to underground mining. Included are a brief history of the development of subsidence laws in Europe and the United States, recent regulation of the U.S. Department of the Interior, and laws of the 21 states comprising the major part of the deep coal reserve for underground mining.

Keyword(s): law, coal mining, active mines, abandoned mines
Location(s): United States, Europe

Bur, T. R., A. A. Allen. Preliminary Investigation of Subsidence in the Cleveland Street Area, Eveleth, Minnesota. U.S. Bureau of Mines, Division of Minerals Environmental Technology, Branch of Applied Technology and Demonstration, January, 1980.

This report concerns subsidence and settlement problems in a residential area covering about 2 acres in Eveleth, Minnesota. The area was mined for iron ore by surface or a combination of surface and underground methods. The pit was backfilled, and construction began in the mid-1920s.

Keyword(s): abandoned mines, metal mining, surface structural damage, soils, land-use planning, structural mitigation
Location(s): Minnesota, United States

Burdick, R. G., L. E. Snyder. Use of Automated Resistivity System to Locate Potential Subsidence Areas Over Old Mines. IN: Proceedings, 2nd Conference on Ground Control in Mining, Morgantown, WV, July 19-21, 1982, S.S. Peng and J.H. Kelly, eds., West Virginia University, 1982, p. 214-221.

This paper describes the automated resistivity method and discusses sites in Colorado, Wyoming, and Illinois where the SBM has used this method to locate abandoned mines and potential subsidence areas.

Keyword(s): abandoned mines, computer, surface structural damage, surface subsidence damage

Location(s): Colorado, Wyoming, Rocky Mountain Coal Region, Illinois, Illinois Coal Basin, United States

Burdick, R. G., L. E. Snyder, W. F. Kimbrough. A Method for Locating Abandoned Mines. U.S. Bureau of Mines RI 9050, 1986, 27 p.

Problems presented by old mine workings affect both present-day mining and land development. This report describes six mining areas in the United States that were investigated with the Bureau's automated resistivity method; results showed a high rate of success in detecting old mines. Field measurement techniques and data analysis procedures are described.

Keyword(s): abandoned mines, coal mining, land-use planning, land values, monitoring methods, survey methods, survey data processing

Location(s): United States

Burley, J. D., A. H. Drowin. Solution to Ground Subsidence Problems in Casing Strings and Wellheads. Journal of Petroleum Technology, v. 23, June 1971, p. 654-660.

Keyword(s): subsurface water, fluid extraction

Burns, K. Prediction of Delayed Subsidence. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, Morgantown, March, 1982, p. 220-223.

In planning insurance or restitution measures, a predictive model is of value in estimating the magnitude of the problem and the size of long-term budgetary commitments. Only one model is known, and it was developed for the USBM by GAI Consultants of Monroeville. The GAI model is presented in qualitative terms. This report develops a formal basis for the model and tests a numerical implementation on one of the best-described study areas, Allegheny County in Pennsylvania.

Keyword(s): prediction, modeling, abandoned mines, survey data processing, stochastic model

Location(s): Pennsylvania, Appalachian Coal Region, United States

Burton, A. N., P. I. Maton. Geophysical Methods in Site Investigations in Areas of Mining Subsidence. IN: Site Investigations in Areas of Mining Subsidence, 1975, F.G. Bell, ed., Newnes-Butterworths, London, p. 75-102.

Keyword(s): geophysical

Burton, D. A Three Dimensional System for the Prediction of Surface Movements Due to Mining. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 209-228.

This text is concerned with an understanding of surface movement above mine workings, with particular reference to the type of three-dimensional system that the observer can create and use in connection with the subsidence of important surface structures and installations.

Keyword(s): prediction, vertical displacement, horizontal displacement

Burton, D. The Introduction of Mathematical Models for the Purpose of Predicting Surface Movements Due to Mining. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 50-64.

Although an observer could begin with the assumption that a mathematical model will prevent anyone from keeping a sensible balance between the general description of mining subsidence and the peculiarities of each case, the actual effect of introducing such a model is quite different. By taking advantage of the memory and the speed of the computer, the investigator gains control over predictions in particular situations. For practical purposes, the process of subsidence prediction is divided into two parts: the construction of a suitable model required to generate the numbers for prediction, and the subsequent control of the predictions with a feedback of information.

Keyword(s): mathematical model, prediction, modeling, railroads
Location(s): United Kingdom

Burton, D. Ground Deformation Above Longwall Panels Geometry of the Three Dimensional System. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 30-35.
The paper describes the purpose of a three-dimensional variable geometry beginning with an illustration involving the strains measured in a vertical section across a longwall face, and showing certain features of rock movement that could be related to geology, and the particular case, are features of geometry. The paper continues with a description of the general application of the variable geometry.
Keyword(s): longwall, geologic features, computer, modeling
Location(s): United Kingdom

Burton, D. A Program in BASIC for the Analysis and Prediction of Ground Movement Above Longwall Panels. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 338-353.
This paper contains a program (using BASIC as the formal language) that will calculate the displacement of any surface point in the x, y, z dimensions of space at any time, whether the face of the panel is static or moving.
Keyword(s): computer, prediction, longwall, coal mining

Bushnell, K., J. R. Peak. Map of the Upper Freeport Coal Bed: its Outcrop, Overburden, mining Activity and Related Surface Subsidence, Allegheny, Washington, and Westmoreland Counties, Pennsylvania. U.S. Geological Survey Miscellaneous Field Studies Map MF-693B, 1975.
Keyword(s): surface subsidence damage, overburden, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Bushnell, K. O. Map Showing Areas That Correlate With Subsidence Events Due to Underground Mining of the Pittsburgh and Upper Freeport Coalbeds; Allegheny, Washington and Westmoreland Counties, Pennsylvania. U.S. Geological Survey, MF-693C, 1975.
Keyword(s): surface subsidence damage
Location(s): Pennsylvania, Appalachian Coal Region, United States

Bushnell, K. O. Map Showing: Depths to the Pittsburgh Coalbed, Mining Activity, and Related Surface Subsidence; Allegheny, Washington, and Westmoreland Counties, Pennsylvania. U.S. Geological Survey, MF-693A, 1975.
Keyword(s): surface subsidence damage
Location(s): Pennsylvania, Appalachian Coal Region, United States

Bushnell, K. O. Mine Subsidence. "Lots" of Danger: Property Buyer's Guide to Land Hazards of Southwestern Pennsylvania, J.L. Freedman, ed. Pittsburgh Geological Society, Inc., Pittsburgh, 1977, p. 9-16. (NTIS Accession No. 78-15992)
Surface subsidence because of underground mines abandoned decades ago is one of the most vexing problems faced by home owners in western Pennsylvania. This chapter covers the laws affecting surface subsidence and reviews the steps a land owner can take to appraise his own situation. The geology and mining practices of the region are discussed in relation to surface subsidence. The work and services of various government agencies on behalf of the property owner are described.
Keyword(s): surface structural damage, coal mining, abandoned mines, foundations, law, overburden, geologic features, land-use planning, engineering, government, backfilling, grouting
Location(s): Pennsylvania, Appalachian Coal Region, United States

Butler, D. Detection of Abandoned Coal Mine Workings and Underground Voids by Microgravity. Mining Engineering, April, 1989, v. 41, no. 4, p. 245-247.
Subsurface density changes can be detected by very precise surface gravity measurements. A feasibility study, combined with field experience using modern instruments, will indicate the probability of success. In addition to projected anomaly parameters, surface conditions that affect the survey precision must be evaluated. Examples with excavated zones at a depth of 9 meters (30 ft) and plus or minus 22 microgal error are compared with the same model at 30 meters (98 ft). The figures illustrate anomaly detectability. The survey

error is a function of surface topography and lateral density variation in the very near surface.
Keyword(s): abandoned mines, coal mining, modeling, geologic features

Butler, P. E. Utilization of Coal Mine Refuse in Highway Embankment Construction. SME-AIME Preprint No. 75-F-81, SME-AIME Annual Meeting, New York, NY, February 16-20, 1975, 32 p.
Since early 1973, the Pennsylvania Department of Transportation has been actively engaged in the utilization of coal mine refuse in the design and construction of highway embankments. The program includes field investigations, laboratory testing, engineering evaluation, planning, coordination, implementation, construction control, and review of construction performance.
Keyword(s): mine waste, coal mining, roads, land-use planning, engineering, anthracite, bituminous, lab testing
Location(s): Pennsylvania, Appalachian Coal Region, United States

Butler, R. A., D. Hampton. Subsidence Over Soft Ground Tunnel. ASCE Journal of Geotechnical Engineering Division, v. 101, 1975, p. 35-49.
Keyword(s): tunnelling

Cady, G. H. Coal Resources of District I (Longwall). Illinois State Geological Survey, Mining Investigation Bulletin 10, 1915, 149 p.

This report discusses the geology and economics of coal mining in the "longwall district" in north-central Illinois.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Cady, G. H. Coal Resources of District VI. Illinois State Geological Survey, Mining Investigation Bulletin 15, 1915, 94 p.

This report discusses geology and economics of coal mining in Jefferson, Franklin, and part of Williamson Counties in Illinois.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Cady, G. H. Coal Resources of District II (Jackson County). Illinois State Geological Survey, Mining Investigation Bulletin 16, 1917, 55 p.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Cady, G. H. Coal Resources of District V (Saline and Gallatin Counties). Illinois State Geological Survey, Mining Investigation Bulletin 19, 1919, 135 p.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Cady, G. H. Coal Resources of District IV. Illinois State Geological Survey, Mining Investigation Bulletin 26, 1921, 247 p.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Cambefort, H. The Principles and Applications of Grouting. Quarterly Journal of Engineering Geology, 1977, v. 10, p. 57-95.

Keyword(s): grouting

Cameron-Clarke, I. S. The Distribution and Nature of Surface Features Related to Shallow Undermining on the East Rand. IN: Proceedings, SANGORM Symposium, October 21, 1986, International Society for Rock Mechanics, South African National Group, Sandton, South Africa, p. 33-38.

Developments over areas undermined at shallow depths are severely restricted because of the potential for subsidence or sudden collapse of the ground surface. To facilitate planning, it is advantageous to have some idea of the location of the undermined areas as well as a general understanding of the actual conditions underground.

Keyword(s): abandoned mines, coal mining, metal mining, land-use planning, photography, historical, surface subsidence damage

Location(s): South Africa

Cameron-Clarke, I. S., A. J. Barrett, G. E. Blight. Support of Areas Undermined by Shallow Coal Workings for Road Corridors. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 193-198.

Developments over areas of shallow undermining are restricted because of the potential for surface subsidence. There are several different ways of protecting surface structures. One, which is particularly applicable to the protection of roads, is to incorporate a layer of welded steel mesh into the road structure.

Keyword(s): surface structural damage, coal mining, metal mining, roads, structural mitigation, geologic features, engineering, abandoned mines

Location(s): South Africa

Cameron, D. W. G. Menace of Present Day Subsidence Due to Ancient Mineral Operations. Journal of Royal Institution of Chartered Surveyors, (Scottish Supplement), 1956, v. 19, Part 3, p. 159-171.

Keyword(s): abandoned mines

Location(s): United Kingdom

Camp, C. L. Filling Mine Workings Under Railway Bridges with Concrete at Scranton. Engineering News, January 11, 1912, p. 60.

Subsurface reinforcement of bridge footings was achieved by constructing concrete columns within abandoned mines.

Keyword(s): abandoned mines, grouting, multiple-seam extraction, railroads

Location(s): Pennsylvania, Appalachian Coal Region, United States

Campbell, J. A. L., L. J. Petrovic, W. J. Mallio, C. W. Shulties. How to Predict Coal Mine Roof Conditions Before Mining. Mining Engineering, October 1975, p. 37-40.
Keyword(s): roof stability, coal mining

Campoli, A., T. Barton, F. Van Dyke, M. Gauna, M. DeMarco. Gate Design Key to Bump Control. Coal, September, 1990, p. 54-58.
Full extraction retreat mining, during both longwall and room-and-pillar operations, leads to the concentration of stresses in nearby support pillars. When this occurs at great depth and between unyielding roof and floor strata, portions of these highly stressed pillars often fail rapidly and violently. Such failures, commonly called bumps, vary from minor vibrations without significant strata movement, to notable earth tremors that may eject thousands of tons of coal and rock into the workings.
Keyword(s): bumps, coal mining, mine design
Location(s): West Virginia, Virginia, Appalachian Coal Region, United States

Canace, R., R. Dalton. A Geological Survey's Cooperative Approach to Analyzing and Remedying a Sinkhole Related Disaster in an Urban Environment. IN: Sinkholes: Their Geology, Engineering and Environmental Impact, Proceedings 1st Multidisciplinary Conference on Sinkholes, Orlando, October 15-17, 1984, B.F. Beck, ed., Balkema, Rotterdam, p. 343-348.
A sinkhole resulting from the break of an underground water main severely undermined the foundation of a private residence in densely populated Phillipsburg, New Jersey. Subsurface borings revealed the presence of a deeply dissected dolomitic bedrock surface and, more importantly, significant voids in the stiff, silty to gravelly clay overbruden; some voids were in excess of 10 feet in height.
Keyword(s): surface structural damage, geologic features
Location(s): New Jersey, United States

Canadian Institute of Mining and Metallurgy. Mining with Backfill. Proceedings, 12th Canadian Rock Mechanics Symposium, Sudbury, Ontario, May 23-25, 1978 Canada Institute of Mining Special v. 19, 150 p.
Keyword(s): stowing, backfilling
Location(s): Canada

Candeub, Fleissig, and Associates (Newark, NJ) Demonstration of a Technique for Limiting the Subsidence of Land Over Abandoned Mines. Department of Housing and Urban Development Report HUD-WYO D-I, June 1971, 92 p. (NTIS PB 212 708)
This report presents the findings and conclusions of a demonstration project carried out by the city of Rock Springs, WY, in 1970 using the Dowell Process.
Keyword(s): abandoned mines, ground control, coal mining, hydraulic backfilling
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Candeub, Fleissig, and Associates (Newark, NJ) Demonstration of a Technique for Limiting the Subsidence of Land Over Abandoned Mines. Department of Housing and Urban Development Report HUD-WYO D-I, November, 1973, 34 p. (NTIS PB 233 089)
Keyword(s): abandoned mines, ground control, hydraulic backfilling, coal mining
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Cappleman, H. L. Horizontal Movements Related to Subsidence. Discussion, ASCE Journal Soil Mechanics Foundations Division, v. 96, no. SM1, 1970, p. 310-317.
Keyword(s): horizontal displacement
Location(s): United States

Carbognin, L., P. Gatto, G. Mozzi, G. Gambolati, G. Ricceri. New Trend on the Subsidence of Venice. International Association of Hydrological Sciences Publication 121, 1977, p. 65-81.
Keyword(s): surface subsidence damage, surface water, fluid extraction
Location(s): Italy

Carbognin, L. Land Subsidence: A Worldwide Environmental Hazard. Nature and Resources, UNESCO, v. 21, no. 1, 1983, p. 2-12.
Keyword(s): surface subsidence damage, environment

Carbognin, L., P. Gatto. An Overview of the Subsidence of Venice. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication No. 151, 1986, p. 321-328.

A general view of the aspects of the Venice subsidence situation, as studied by the CNR in Venice since 1969, is supplied. A look at the cause and effect relationship is given, along with an illustration of the three factors making up the land elevation loss during the 20th century (namely, natural subsidence, man-induced subsidence, and eustacy).

Keyword(s): surface water, fluid extraction, surface subsidence damage

Location(s): Italy

Carey, S. Cave-ins of Abandoned Coal Mines Present Growing Threat to Life, Land in 30 States. Wall Street Journal, August 21, 1984.

Keyword(s): abandoned mines, coal mining

Location(s): United States

Carlson, E. J. Hydraulic Model Studies for Backfilling Mine Cavities. Bureau of Reclamation Report REC-ERC-73-19, October 1973, 36 p. (NTIS PB 225 613)

This report presents test results from investigation of effects of various backfilling parameters (including slurry concentration, injection velocity, and floor slope) on deposition patterns.

Keyword(s): hydraulic backfilling, modeling

Carlson, E. J. Hydraulic Model Studies for Backfilling Mine Cavities (Second Series of Tests). Bureau of Reclamation Report REC-ERC-75-3, March 1975, 38 p. (NTIS PB 241 510)

This report presents test results from investigation of effects of various backfilling parameters on deposition patterns for five specific mine patterns.

Keyword(s): hydraulic backfilling, modeling

Location(s): United States

Carlson, M. J., L. W. Saperstein. Efficient Use of Additives to Improve Pneumatically Emplaced Backfill Strength. Mining Engineering, June 1989, v. 41, no. 6, p. 462-466.

With the goal of improving the strength characteristics of pneumatically emplaced material used for localized subsidence control, the binding additives fly ash, bentonite, and portland cement were examined for their effect on the support capabilities of coal refuse. It was found that, within certain concentration ranges, all three offered some increase in the ultimate strength of the backfilling mixture; portland cement gave the greatest percentage increases. Selection of the appropriate backfilling mixture will allow for the most economical and efficient subsidence control when pnuematic stowing is employed.

Keyword(s): longwall, horizontal displacement, pneumatic backfilling, room-and-pillar, ground control, coal mining, lab testing, stowing

Location(s): Appalachian Coal Region, United States

Carmen, C. O. Understanding Roof Action is Imperative in Longwall Mining. Coal Mining and Processing, March, 1965, p. 38-41.

Keyword(s): mine design, roof stability, longwall, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Carpenter, G. W., J. D. Rockaway, R. W. Stephenson, R. C. Speck. Geotechnical Evaluation of Sub-Coal Strata for Coal Pillar Support. IN: Proceedings Illinois Mining Institute Annual Meeting, October 13-14, 1977, Springfield, IL, p. 92-102.

Foundation failures in underground coal mines frequently occur in mines where the strata under the coal includes underclays or clay shales with poor strength characteristics. An investigation carried out at the University of Missouri-Rolla evaluated the strength and stability parameters of strata underlying coal in the Illinois Basin.

Keyword(s): coal mining, floor stability, geotechnical, pillar strength, rock mechanics, finite element, modeling, computer, roof stability

Location(s): Illinois, Illinois Coal Basin, United States

Carpenter, G. W. Areas of Coal Mine Floor Heave Predicted by Bearing Capacity Analysis. M.S. Thesis, University of Missouri-Rolla, Rolla, MO, 1978.

Keyword(s): floor stability, coal mining, prediction, lab testing

Location(s): United States

Carpenter, M. C., M. D. Bradley. Legal Perspectives on Subsidence Caused by Groundwater Withdrawal in Texas, California, and Arizona, USA. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication 151, 1986, p. 817-828.

Damages from subsidence caused by groundwater withdrawal include shoreline submergence, well-casing failures, and changes in gradients of canals, sewers, irrigation ditches, and streams.

Potential damages from subsidence-related earth fissuring include structural damage to roads, railroads, and buildings, ruptured sewers and pipelines, and aquifer contamination. This paper covers legal methods of controlling and managing subsidence in Texas, Arizona, and California.

Keyword(s): fluid extraction, law, surface subsidence damage, subsurface water, hydrology, government, surface water

Location(s): Texas, California, Arizona, United States

Carpenter, P. J., M. A. Johnston. Monitoring Fracture Development Over a Subsiding Longwall Mine Panel Using Electrical Resistivity. North-Central Section Geological Society of America 25th Annual Meeting, Toledo, OH, April 18, 1991, Abstracts with Programs, v. 23, p. 6-7.

Keyword(s): seismic, monitoring methods, geophysical, overburden, longwall, active mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Carpenter, P. J., M. A. Johnston, C. J. Booth, M. P. Matheney. Geophysical Identification of Fractures and Associated Hydrological Effects Over a Collapsing Longwall Mine Panel. IN: Geological Society of America Annual Meeting, Abstracts with Programs, San Diego, CA, October, 1991, p. A39.

Geophysical methods were employed to characterize fracturing and water level changes in the upper portion of a 120-meter bedrock and drift section overlying two collapsing longwall coal panels in Illinois. Resistivity soundings, profiles, and azimuthal surveys were made over panel centers before, during and after subsidence.

Keyword(s): geophysical, hydrology, subsurface water, active mines, longwall, coal mining, seismic, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Carrera, G. H., P. Vanicek. Review of Techniques for Determining Vertical Ground Movements from Levelling Data. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication No. 151, 1986, p. 195-202.

A review of existing mathematical models to obtain the spatial and temporal representation of vertical ground movements from relevellings is presented. Models are classified in terms of their design, spatial data distribution, and temporal data distribution.

Keyword(s): mathematical model, vertical displacement

Carter, H. W. N. A Review of Strata Control Experiences in Longwall Workings in Great Britain. IN: Proceedings 3rd International Conference on Strata Control, Paris, 1960, p. 471-485.

Keyword(s): mine design, ground control, longwall, roof stability

Location(s): England

Carter, P., D. Jarman, M. Sneddon. Mining Subsidence in Bathgate, A Town Study. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 101-124.

This paper deals with Bathgate's history of mining and mining subsidence; the investigations that have been carried out, and the proposals evolved for designing new structures and making existing structures safe, in the zones of potential mining subsidence.

Keyword(s): surface structural damage, coal mining, abandoned mines, surface subsidence damage, subsurface subsidence damage, land-use planning, foundations, structural mitigation, construction, backfilling

Location(s): United Kingdom

Carter, T. G., C. M. Steed. Application of Remedial Measures for Stabilization of Abandoned Mine Workings. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 207-221.

Various methods of remediation are applicable for use in safely stabilizing old, hazardous, thin or unstable crown pillar conditions. Examples of the application of five different remediation approaches are presented: bridge-deck style concrete capping, roller compacted concrete crown reinforcement, conventional gravity backfilling, pneumatic stowing, and hydraulic backfilling.

Keyword(s): abandoned mines, pneumatic backfilling, hydraulic backfilling, economics, surface structural damage, roads, metal mining, non-metal mining

Location(s): Canada, New York, United States

Cartwright, K., C. S. Hunt. Hydrogeology of Underground Coal Mines in Illinois. ISGS reprint 1978-N, 1978. Reprinted from Proceedings International Symposium on Water in Mining and Underground Works, Granada, Spain, September 17-22, 1978, 20 p.

Little is known about the hydrogeology of the groundwater systems around underground coal mines. Illinois mines are generally "dry," with notable exceptions, despite their location in water-saturated rocks well below the water table. Reported pumpages of water from the mines vary from occasional pumping of sumps to pumpage in excess of 5,000 cubic meters per day. Most mines, however, report pumpages of less than 100 cubic meters per day. Some mines are reported to be "dry" even many years after being abandoned. These small volumes of water reported from the mines are directly related to the extremely low hydraulic conductivity of the rock associated with the coal.

Keyword(s): subsurface water, hydrology, coal mining, geologic features, active mines, abandoned mines, inflow

Location(s): Illinois, Illinois Coal Basin, United States

Cartwright, K., C. S. Hunt. Hydrogeology of Underground Coal Mines in Illinois. IN: Proceedings World Congress of Water in Mining and Underground Work (SIAMOS), September 18-22, 1978, R. Fernandez-Rubio, ed., Granada, Spain, p. 61-84.

Keyword(s): subsurface water, coal mining, hydrology

Location(s): Illinois, Illinois Coal Basin, United States

Cartwright, K., C. S. Hunt. Hydrogeologic Aspects of Coal Mining in Illinois: An Overview. Illinois State Geological Survey, Environmental Geology Note 90, January 1981, 19 p. (NTIS PB 81-190126)

Water has generally not been a significant problem in Illinois mining, although most Illinois coal mines (both surface and underground) lie partly or completely below the water table. Water-related problems in and around mines are likely to increase as it becomes economically feasible to open or expand surface mines in areas with thicker and more permeable overburden and to place underground mines at greater depths. Detailed study of the hydrogeology of mining areas before, during, and after mining can help prevent problems that may occur.

Keyword(s): surface water, subsurface water, hydrology, coal mining, inflow

Location(s): Illinois, Illinois Coal Basin, United States

Castle, M. J., J. W. Hewitt, P. F. Suine. Mining Subsidence in Relation to Roads. IN: Collected Case Studies in Engineering Geology, Hydrogeology, and Environmental Geology, M.J. Knight, E.J. Minty, and R.B. Smith, eds., Engineering Geology Specialist Group of the Geological Society of Australia, Inc., Sydney, p. 377-397.

A subsidence bowl forms due to mining of coal seams where the thickness is small in relation to the depth of cover. Movement is gradual and the surface does not necessarily fracture or fissure. Subsidence movements can be predicted and an application of techniques developed outside Australia will provide guidance to the amount of subsidence and the design parameters of roadways and bridges.

Keyword(s): coal mining, roads, prediction, geologic features, time factor

Location(s): Australia

Castle, R. O., R. F. Yerkes. Surface Deformation Associated With Oil-Field Operations in the Baldwin Hills, Los Angeles County, California. Geological Society of America, Special Paper 121 (abstract only), 1969, p. 49-50.

Keyword(s): oil extraction

Location(s): California, United States

Castle, R. O., R. F. Yerkes, F. S. Riley. A Linear Relationship Between Liquid Production and Oil Field Subsidence. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 88, v. 1, p. 162-173.

Keyword(s): fluid extraction, oil extraction, prediction

Catron, W., C. V. Colledge. Controlling Subsidence of a Large Inverted Cone Above the Ore Body, Colorada Mine, Cananea Consolidated Copper Company. Transactions Society Mining Engineers AIME, Technical Publication 938, 1938, 7 p.

Keyword(s): metal mining, ground control

Location(s): United States

Caudle, R. D. Mine Roof Stability. IN: Proceedings Bureau of Mines Technology Transfer Seminar, Lexington, KY, March, 1973, Ground Control Aspects of Coal Mine Design, U.S. Bureau of Mines IC 8630, 1974, p. 79-85.

Structural analysis methods can be used to predict the stability of coal mine roof in entry/room-and-pillar systems and headgate/longwall/tailgate systems. The behavior of the roof reflects the interaction of roof, pillar, and floor elements. Local roof stability is strongly influenced by the proximity of other openings in the mine system (other entries and/or panels).

Keyword(s): mine design, ground control, roof stability, coal mining

Location(s): United States

Caudle, R. D. Multiple Entry Design. IN: Ground Control Aspects of Mine Design, Proceedings Bureau of Mines Technology Transfer Seminar, Lexington KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 49-55.

The design of multiple entries makes use of parametric data from structural analyses of multiple mine openings. These data can be used to deduce the influence of layering, pillar width, and rock properties upon the behavior of rock, rib, and floor. When used in conjunction with a knowledge of the stress field, the properties of coal measure rocks, and the geologic structure, design problem areas can be identified and design changes implemented to alleviate problems.

Keyword(s): mine design, ground control, coal mining

Location(s): United States

Caudle, R. D. Panel Design Problems. IN: Ground Control Aspects of Coal Mine Design, Proceedings, Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 14-21.

Panel design, from a ground control viewpoint, proceeds in a manner similar to that employed in the design of surface structures.

Keyword(s): mine design, active mines, ground control, coal mining, pillar strength

Location(s): United States

Caudle, R. D., Y. P. Chugh, H. Albarracin, K. Chandrashekhar, C. Liang. Effects of Soft Floor Interaction on Room-and-Pillar Mining - A Progress Report. IN: Proceedings Annual Mineral Technology Center, Mine Systems Design and Ground Control, University of Alabama, Tuscaloosa, 1987, p. 23-24.

Keyword(s): floor stability, room-and-pillar

Location(s): Illinois, Illinois Coal Basin, United States

Cavinder, M. Longwall Mining with Shield Supports at Old Ben. Mining Congress Journal, June, 1978.

Keyword(s): longwall, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Cervantes, J. A., Y. C. Kim, I. W. Farmer. Statistical Prediction of Subsidence Events Above Abandoned Room and Pillar Workings in Penn Hills Area. IN: Proceedings 8th Annual Workshop Generic Mineral Technology Center Mine Systems Design and Ground Control, Reno, November 5-6, 1990, E. Topuz and J.R. Lucas, eds., Virginia Polytechnic Institute and State University, Blacksburg, p. 145-156.

Many subsidence events have occurred over the Pittsburgh coal seam. A statistical technique is presented to predict risk of future subsidence. It is based on the following features: geostatistical estimates of key parameters likely to affect ground stability, multiple regression analysis to determine the most significant variables, and discriminant analysis to develop rules to classify areas as likely or unlikely to suffer subsidence. Subsidence probabilities can be used to produce risk maps. Results are consistent with those of an independent study.

Keyword(s): abandoned mines, coal mining, room-and-pillar, prediction, modeling, surface subsidence damage, land-use planning, surface structural damage, rock mechanics, geotechnical

Location(s): Pennsylvania, Appalachian Coal Region, United States

Chandrashekhar, K. An Analysis of Subsidence Movements and Structural Damage Related to an Abandoned Room-and-Pillar Coal Mine. M.S. Thesis, Department of Mining Engineering, Southern Illinois University, Carbondale, May, 1985.

Keyword(s): abandoned mines, room-and-pillar, coal mining, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Chandrashekhar, K., R. Nath, S. Tandon. Design of Coal Pillars Under Weak Floor Conditions. IN: Proceedings 28th U.S. Rock Mechanics Symposium, Tucson, AZ, June 29-July 1, 1987, I.W. Farmer et al., eds., Balkema, Rotterdam, p. 1037-1081.

A coal pillar on weak floor strata may be considered as a shallow foundation on cohesive soil or rock. The theory of bearing capacity and settlement of shallow foundations may therefore be

applied for designing isolated pillars. However, design of multiple coal pillars and evaluation of mine stability requires an additional consideration of interaction among the roof, coal pillar, and floor elements.

Keyword(s): mine design, pillar strength, floor stability

Location(s): Illinois, Illinois Coal Basin, United States

Chang, C-Y., K. Nair. Analytical Methods for Predicting Subsidence Above Solution-Mined Cavities. IN: Proceedings 4th International Symposium on Salt, Houston, TX, April 8-12, 1973. Northern Ohio Geological Society, Cleveland, v. 2, p. 101-117.

Keyword(s): prediction, non-metal mining

Channing, J. P. Subsidence at Miami, Arizona. Transactions AIME, v. 69, 1923, p. 394-397.

This paper discusses mining methods, geologic features, and mining operations during copper mining using block caving methods.

Keyword(s): metal mining, surface subsidence damage, geologic features

Location(s): Arizona, United States

Chapman, T. Concrete Bulkheads for Pillar Extraction. Engineering and Mining Journal, v. 97, 1914, p. 1145.

To allow pillar removal, concrete columns are constructed for roof support. The columns are poured through 6-inch boreholes from the surface and timber supports are later added between columns.

Keyword(s): pillar extraction, roof support, grouting

Charman, J. H., C. E. Cooper. The Frindsbury Area, Rochester: A Review of Historical Data and Their Implication on Subsidence in an Urban Area. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw et al., eds., The Geological Society, London, 1987, p. 115-124.

A sudden subsidence under a footpath, which led to the tragic death of a pedestrian, was followed by a series of further subsidences over a period of years, all incidents apparently located within an area no more than approximately 1 km square. The probable cause of the incidents at Frindsbury has been attributed to the existence of chalk mines associated with the brickfields (from production at the turn of the century) and further investigation is now taking place to locate these. Clues to all of the features were available as open file information in public records. This paper describes how the information was acquired and assimilated and emphasizes the importance of the role of the desk study in the initial stages of any development project.

Keyword(s): land-use planning, land values, engineering, geologic features, surface subsidence damage, surface structural damage, non-metal mining

Location(s): United Kingdom

Charmbury, H. B., G. E. Smith, D. R. Maneval. Subsidence Control in the Anthracite Fields of Pennsylvania. American Society of Civil Engineers Preprint 721, Annual and National Meeting on Structural Engineering, Pittsburgh, PA, September 30-October 4, 1968, 22 p.

Hydraulic flushing projects in Scranton, PA, used mine waste as the filling material.

Keyword(s): ground control, surface structural damage, economics, hydraulic backfilling, mine waste, anthracite, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Chase, F. E. Clay Veins: Their Physical Characteristics, Prediction, and Support. IN: Proceedings, 4th Conference on Ground Control in Mining, West Virginia University, 1985, Morgantown, p. 212-219.

Keyword(s): floor stability, coal mining

Location(s): United States

Chekan, G. J., R. J. Matetic, J. A. Galek. Strata Interactions in Multiple-Seam Mining--Two Case Studies in Pennsylvania. U.S. Bureau of Mines RI 9056, 1986, 17 p.

The authors discuss investigations performed by the USBM to improve development in mining of multiple coalbeds. Two common interactions that occur between adjacent coalbeds are subsidence and pillar load transfer. Underground measurements obtained from both mine sites correlate with theoretical and photoelastic multiple-seam models.

Keyword(s): multiple-seam extraction, pillar strength, modeling, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Chekan, G. J., R. J. Matetic, J. A. Galek. Multiple-Seam Mining Problems in the Eastern United States. IN: Eastern Coal Mine Geomechanics, Proceedings, Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, November 19, 1986, U.S. Bureau of Mines IC 9137, p. 27-43.

Strata interactions between adjacent coalbeds occur frequently in the Appalachian coalfields and can have unfavorable effects on both product cost and worker safety. Two common interactions that occur between adjacent coalbeds are subsidence and pillar load transfer. At two mine sites where such ground interactions were present, the Bureau conducted geologic studies and gathered various geotechnical information on pillar and entry stability using rock mechanics instrumentation.

Keyword(s): multiple-seam extraction, coal mining, active mines, mine safety, geologic features, geotechnical, room-and-pillar, instrumentation

Location(s): Pennsylvania, West Virginia, Appalachian Coal Region, United States

Chekan, G. J., R. J. Matetic, D. L. Dwyer. Effects of Abandoned Multiple Seam Workings on a Longwall in Virginia. U.S. Bureau of Mines RI 9247, 1989, 15 p.

To reduce waste and improve resource conservation, mine planning, and development, the USBM is investigating multiple seam interactions associated with longwall mining. Longwall gate entry and panel stability have been influenced by previous mining in coalbeds above and below a mine in Virginia that operates in the Lower Banner Coalbed. Directly superjacent, approximately 115 feet, the Upper Banner Coalbed has been partially worked by room-and-pillar mining. Directly subjacent, approximately 730 feet, the Tiller Coalbed has been worked by partial room-and-pillar retreat mining. The study mine has experienced problems during development of gate entries in areas of over- and undermining. It is anticipated that stress fields associated with adjacent mining may further affect gate entry stability and face advancement during the extraction of the longwall panel. To assess overmining and undermining effects on ground stability, the Bureau gathered geotechnical information at the site.

Keyword(s): multiple-seam extraction, longwall, coal mining, room-and-pillar, abandoned mines, active mines, geotechnical, instrumentation, monitoring equipment, pillar strength

Location(s): Virginia, Appalachian Coal Region, United States

Chekan, G. J. Design Aspects in Multiple-Seam Mining: Case Studies. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 12-21.

Developing a coal seam that has been influenced by previous mining in seams either above or below can result in severe ground control problems. In many instances, interactions between operations are inevitable, but improvements in ground stability can usually be achieved by predicting potential problem areas in advance and adjusting the mining plans accordingly. This report investigates four case studies involving interactions between operations that used both room-and-pillar and longwall methods.

Keyword(s): geologic features, multiple-seam extraction, coal mining, room-and-pillar, longwall, mine design, instrumentation, geotechnical

Location(s): Appalachian Coal Region, United States

Chen, C. Y., Y. N. Chen, D. V. Goffney. Architectural Measures to Minimize Subsidence Damage. Appalachian Regional Commission Report ARC-73-111-2551, 1974, 130 p. (NTIS PB 242 466)

This report evaluates proposed guidelines, rules, and suggested practices to be used in the design and construction of surface structures and underground utilities to minimize subsidence damage due to underground mining.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, ground control, architecture, utilities, prediction, engineering, construction, coal mining, structural mitigation

Location(s): Appalachian Coal Region, United States

Chen, C. Y., D. E. Jones, D. K. Hunt. Government Regulation of Surface Subsidence Due to Underground Mining. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, SME-AIME, Y.P. Chugh and M. Karmis, eds., September, 1982, p. 245-252.

Following a brief discussion of the technical aspects and the effects of subsidence on man and his environment, this paper presents a historical overview of how rules and regulations are used to govern subsidence related problems. The development of the regulations of subsidence under Public Law 95-87, the Surface Mining Control and Reclamation Act of 1977 (SMCRA) are also

discussed, including the new regulations being developed under the regulatory reform program.
Keyword(s): law, government, economics
Location(s): United States

Chen, C. Y. Subsidence Control Measures. Mining Engineering, v. 35, November, 1983, p. 1547-1551.
This paper discusses the mechanics of subsidence and the effects of subsidence on ground features. It also summarizes some measures used to minimize the possibility of damage to structures as a result of subsidence due to underground coal mining.
Keyword(s): ground control, coal mining, surface structural damage, structural mitigation, longwall, room-and-pillar, overburden, pillar strength, partial extraction, backfilling, law
Location(s): United States

Chen, C. Y., S. S. Peng. Underground Coal Mining and Attendant Subsidence Control: Some History, Technology, and Research. Mining Engineering, February, 1986, p. 95-98.
Surface subsidence is a critical issue facing the coal industry today. Several states have issued regulations requiring subsidence control plans and several others are in the process of issuing their own. The industry needs to look at current technologies available for subsidence control and improve on them.
Keyword(s): historical, ground control, mine operation, surface structural damage, utilities, mine design, longwall, room-and-pillar, prediction, modeling, finite element, law, subsidence research, coal mining
Location(s): United States

Chen, G., Y. P. Chugh. Application of Short-Term Time-Dependent Plate Loading Tests for Estimation of In-Situ Elastic and Viscous Parameters of Weak Floor Strata. IN: Proceedings 9th International Conference on Ground Control in Mining, West Virginia University, June 4-6, 1990, S.S. Peng, ed., Morgantown, p. 238-249.
This paper explores the possibility of using short-term time-dependent plate loading tests to estimate the elastic and viscoelastic parameters of the weak floor strata typically associated with coal seams in Illinois. Plate loading tests with incremental loads, similar to incremental creep experiments, were conducted until the floor failure occurred.
Keyword(s): floor stability, coal mining, in situ testing, time factor, room-and-pillar, longwall
Location(s): Illinois, Illinois Coal Basin, United States

Chen, G., Z. Yu, Y. P. Chugh, G. Hunt. A Study of Bedrock Movements Associated with Room-and-Pillar Mining in A Central Illinois Mine. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 129-147.
This paper discusses the instrumentation of the bedrock at an active room-and-pillar mine in Illinois. Two boreholes were drilled into the bedrock from the surface, one on a pillar and the other over an entry. Inclinometer guide pipes and settlement anchors were installed to monitor horizontal and vertical displacements of the bedrock at different depths. Geotechnical properties of the bedrock samples were also determined in the laboratory.
Keyword(s): instrumentation, monitoring methods, monitoring equipment, room-and-pillar, coal mining, lab testing, in situ testing, geotechnical, horizontal displacement, vertical displacement
Location(s): Illinois, Illinois Coal Basin, United States

Chlumecky, N. A Method for Testing the Bearing Capacity of Floor Strata. Mining Engineering, v. 20, no. 3, 1968.
Keyword(s): floor stability, in situ testing

Choi, D. S., D. L. McCain. Design of Longwall Systems. IN: SME-AIME Mini Symposium Series No. 79-07, 1979, p. 15-26.
A method of estimating the chain pillar size required to support the wide working faces of longwall or shortwall coal mining is presented. The pillar size is determined through the use of coal strength, entry geometry, panel width, and overburden pressure. Design analysis is focused on a three-entry development system in the Pittsburgh Seam but can be used for other development plans and other seams by substitution of the proper geometric and strength data.
Keyword(s): longwall, mine design, coal mining, shortwall, pillar strength
Location(s): Appalachian Coal Region, United States

Choi, D. S., H. D. Dahl. Measurement and Prediction of Mine Subsidence Over Room and Pillar Workings in Three Dimensions. IN: Proceedings Workshop on Surface Subsidence Due to Underground Mining, November 30-December 2, Morgantown, WV, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 34-47.

This paper contains a subsidence measurement taken over a room-and-pillar panel of a mine located in northern West Virginia. A total of 72 monuments were used to determine a three-dimensional view of mine subsidence. In addition, the results of measurements were used to compute ground strains with the use of a numerical model. Also included are short discussions on geology, mining method, the survey network, and observation procedures.

Keyword(s): vertical displacement, horizontal displacement, monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, room-and-pillar, prediction, modeling, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

Choi, D. S., H. D. Dahl, D. L. McCain. Rock Mechanics Application to Room and Pillar Mining. IN: Ground Control in Room-and-Pillar Mining, Proceedings of the Conference,Southern Illinois University at Carbondale, August 6-8, 1980, Y.P. Chugh, ed., SME-AIME, New York, 1982, p. 65-80.

This paper examines current room-and-pillar mining practice in the United States from the standpoint of rock mechanics. Consideration is given to the deformation characteristics of the roof formation and the coal seam as determined in the laboratory as well as in the field. The results can be used by the practicing mining engineer to improve current mine design practice.

Keyword(s): mine design, room-and-pillar, rock mechanics, partial extraction, pillar strength, finite element

Location(s): United States

Choi, D. S., D. L. McCain. Ground Control Aspects of Longwall Coal Mining. IN: Proceedings Rapid Excavation and Tunneling Conference, Chicago, IL, June 12-16, 1983, H. Sutcliffe and J.W. Wilson, eds., SME-AIME, New York, p. 178-190.

This paper presents some results of ground control work carried on in Consol's mines. Application of these results has improved the safety and productivity of the underground mines. In addition, some other mines in the region have also successfully implemented the longwall mining method, resulting in the same benefit. Most of the tests mentioned in the paper require repeated observations to confirm their results over long mining cycles.

Keyword(s): coal mining, longwall, ground control, mine safety, room-and-pillar, vertical displacement, horizontal displacement

Location(s): United States

Choi, D. S. Theoretical Analysis of Breaking Strength of Mine Pillars and Test Specimens. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 953-962.

This paper presents a theoretical analysis of the effect of shape and size on strength of geologic materials. The results indicate that the shape effect is caused by the development of confining pressure at the interfaces. The linearization of the obtained formula is of the same form determined by experiments. The size effect is attibuted to the fact that the geologic materials contain discontinuities in the form of fractures, bedding planes, and cleats. The maximum reduction factor for the size effect is the one-sixth power of the volume of a cubic test specimen. These results are useful in determining the strength of pillars in underground mines.

Keyword(s): geologic features, pillar strength, coal mining, rock mechanics, lab testing, in situ testing

Christiaens, P. Clastic Behaviour of Main Roof Beds by Deep Mining. IN: Proceedings International Congress on Rock Mechanics, Aachen, 1991, W. Wittke, ed., v. 1, p. 689-692.

Beringen Colliery is working at a depth of 800 m beneath a 630-m waterbearing overburden. Serious exploitation problems are caused by strata control failures (face breakdown). No mathematical rock pressure model has ever been able to account for water pressure or the existence of faults. A measuring campaign has proved that the behaviour of the main roof beds is not elastic. These beds do not subside according to a right line, corresponding to prestressed beams of a length of at least 23 m, and their stability is particularly influenced by the shear resistance at their support point, determined mostly by the geologic and geometric configuration.

Keyword(s): coal mining, roof stability, geologic features, subsurface water, longwall, inflow

Location(s): Belgium

Chrzanowski, A., A. Szostak Chrzanowski. A Comparison of Empirical and Deterministic Prediction of Mining Subsidence. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., IAHS Publication No. 151, 1986, p. 137-147.

All theories for predicting ground subsidence in mining areas are based either on empirical (statistical) models obtained through fitting of selected displacement functions into observed deformations or on deterministic modeling of the load-deformation relationship. The authors have been involved in a study of surface subsidence produced by extraction of a steeply inclined coal seam in difficult geological and topographical conditions of the Canadian Rocky Mountains. Actual displacements were compared with predicted values obtained from an empirical model and from a deterministic finite element model.

Keyword(s): coal mining, modeling, empirical model, finite element, geologic features, survey methods, survey data processing, monitoring methods, computer, active mines

Location(s): Canada

Chrzanowski, A., T. Poplawski, C. Y. Qi, J. Leal. Use of the Global Positioning System in Ground Subsidence Studies. IN: Proceedings VIII Congress International Society for Mine Surveying, September 22-27, 1991, University of Kentucky, Lexington, UKY BU154, p. 203-209.

Since 1985, the Engineering Surveys Research Group at the University of New Brunswick in Canada have used the Global Positioning System in several deformation measurement projects including ground deformation studies in oil fields in Venezuela and in a potash mining area in Canada.

Keyword(s): oil extraction, non-metal mining, survey methods, survey equipment, monitoring methods, vertical displacement

Location(s): Venezuela, Canada

Chudek, M., K. Podgorski, Z. Szczepaniak. Badanie Zachowania Sie Kabli Telekomunikacyjnych, Ukladanuch na Terenach Szkod Gorniczych (Investigation of Behavior of Telecommunication Cables Laid in Areas Affected by Mining Subsidence). Przeglad Gorniczy, v. 24, no. 9, 1968, p. 403-411.

Keyword(s): utilities

Chudek, M., A. Pach, R. Zylinski, W. Olaszowski. Problmy Utrzymania Rorgiagow na Terencah Gorniczych (Problems of Pipeline Maintenance in Mining Areas). Przeglad Gorniczy, v. 25, no. 3, 1969, p. 119-124.

Keyword(s): pipelines

Chudek, M. Size and Shape of the Protecting Pillars Under Surface and Underground Structures for the Conditions of Great Depths. IN: Strata Control in Deep Mines: Proceedings 11th Plenary Scientific Session of the International Bureau of Strata Mechanics, World Mining Congress, Novosibirsk, June 5-9, 1989, Balkema, Rotterdam, p. 61-72.

When mining in the vicinity of surface structures, it is necessary to define protecting pillars beneath the structures to prevent damage due to settlement. The size and shape of these pillars depends on strength of the rock massif, mining depth, angle of inclination of beds, thickness of overburden, and whether faults are present. The basis of design of protecting pillars, taking these factors into account is discussed with particular reference to mining and geological conditions of Poland.

Keyword(s): geologic features, overburden, mine design, pillar strength

Location(s): Poland

Chugh, Y. P., K. Chandrashekahr, R. Missavage, S. Ober. An Analysis of Subsidence Movements Associated with an Abandoned Shallow Room-and-Pillar Coal Mine. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 194-203.

An area in the midwestern United States overlying abandoned room-and-pillar mine workings at shallow depth has been experiencing subsidence movements with associated damage to surface structures. Other coal companies in the area have also been having similar experience. A 16-month cooperative study between a mining company and the Department of Mining Engineering at Southern Illinois University, Carbondale, was developed

Keyword(s): abandoned mines, room-and-pillar, geologic features, hydrology, surface structural damage, rock mechanics, instrumentation, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., A. Van Besien, eds. Proceedings, First Conference on Ground Control Problems in the Illinois Coal Basin. Southern Illinois University at Carbondale, 1980, 301 p.

The Conference consisted of five sessions on geology of the Illinois Basin and geologic factors affecting mining, ground control in the room-and-pillar mining system, artificial supports, longwall mining, and subsidence. The primary objectives of the conference were to compile and disseminate available information and experience related to ground control, and to present current operating problems and ongoing ground control research pertinent to basin mines.

Keyword(s): ground control, coal mining, mine operation, subsidence research, active mines, abandoned mines, room-and-pillar, longwall, geologic features, floor stability, modeling, roof bolting, mine design

Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., R. A. Missavage. Effects of Moisture on Strata Control in Coal Mines. IN: Proceedings 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 70-88.

Moisture has been known to influence strata failures in coal mines for a long time. A concise review of what is known about effects of moisture on strata control with emphasis on the Illinois Basin Coal mines is presented in this paper.

Keyword(s): coal mining, ground control, lab testing, roof stability, roof bolting

Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., J. Bauer, C. Bandopadhay, C. Bollier. Subsidence Prediction Due to Auger Mining of Coal Pillars. IN: Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, 1981.

Keyword(s): prediction, coal mining

Chugh, Y. P., A. Okunola, M. Hall. Moisture Absorption and Swelling Behavior of the Dykersburg Shale. Transactions Society of Mining Engineers, v. 268, 1981, p. 1808-1812.

Effects of moisture absorption on the behavior of the Dykersburg shale overlying the Harrisburg coal seam in southern Illinois are presented in this paper.

Keyword(s): roof stability, lab testing, coal mining, rock mechanics

Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., J. Bauer, C. Bandopadhay. Effect of Weak Floor Interaction on Stability of Mine Openings. IN: Proceedings, Meeting of Petroleum Society of the Canada Institute of Mining and the Canadian Symposium on the Engineering Application of Mechanics, June, 1982, National Research Council of Canada, Ottawa, Ontario, p. 37-43.

This paper presents the results of weak floor interaction on the stability of coal pillars and mine openings. The results are based on analytical studies using a two-dimensional (plane strain) elastic-plastic finite element model. The effects of varying soft floor thickness, lateral stress field, and depth of mining were the primary variables investigated.

Keyword(s): floor stability, mine operation, coal mining, finite element, modeling

Location(s): United States

Chugh, Y. P., M. Karmis, eds. State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence. Proceedings of Symposium, Society of Mining Engineers of the American Institute of Mining, Metallurgical and Petroleum Engineers Fall Meeting, September, 1982, 271 p.

Keyword(s): ground control, longwall, coal mining

Location(s): United States

Chugh, Y. P., R. D. Caudle, C. Bandopadhay. Analysis of Soft Floor Interaction in Underground Mining at an Illinois Basin Coal Mine. IN: Proceedings, International Society for Rock Mechanics Symposium on Design and Performance of Underground Excavations, Cambridge, England, September, 1984, E.T. Brown and J.A. Hudson, eds., British Geotechnical Society, London, p. 383-390.

This paper presents the results of analytical and field studies to analyze the effects of soft floor on underground room-and-pillar mining. Two-dimensional finite element analyses were used to analyze the effect of soft floor on stress distribution in and around mine openings and coal pillars during mine development and retreat mining. Field studies involved measurement of convergence and sag in roadways and intersections during mine development and retreat mining, bearing capacity of floor, and measurement of pillar deformations ahead of retreat mining. The analytical and field studies data were used to prepare (1) design charts for determining the safe percentage of coal extraction to minimize floor heave for varying soft floor thickness and strength of underclay, and (2) guidelines to contain floor heave.

Keyword(s): rock mechanics, floor stability, coal mining, mine design
Location(s): Illinois Coal Basin, Illinois, United States

Chugh, Y. P., R. Missavage, R. D. Caudle, S. Ober, K. V. K. Prasad. Effect of Pillar Extraction on Roof Control. Annual Meeting of the American Mining Congress and International Coal Show, Chicago, May, 1984.
Keyword(s): roof stability, roof support, pillar extraction, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., P. Singh. A Study of the Long-Term Strength of Herrin Coal from a Southern Illinois Mine. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 46-54.
This paper attempts to develop the long-term strength data from Herrin Seam coal from a selected site in southern Illinois. Unconfined compressive strength tests were conducted on about 3.0-inch cubical model coal pillars to study changes in their mechanical behavior with increasing stress and to identify critical stress levels for long-term stability. Two creep tests were also conducted on model coal pillars to study their time-dependent behavior and to determine if their time to failure could be predicted.
Keyword(s): coal mining, rock mechanics, pillar strength, modeling, lab testing
Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P. In-Situ Strength Characteristics of Coal Mine Floor Strata in Illinois. U.S. Bureau of Mines OFR 16-87, 1986, contract JO256002, 160 p.
This report presents data on bearing capacity and in-place shear strength characteristics of immediate floor strata. An attempt was made to correlate the field data with laboratory-determined strength-deformation characteristics and engineering index properties of floor strata from ongoing studies.
Keyword(s): in situ testing, floor stability, coal mining, active mines
Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., K. Chandrashekhar, R. D. Caudle, S. Shankar, R. Nath. Effects of Soft Floor Interaction in Room-and-Pillar Coal Mining. IN: Proceedings 4th Annual Workshop Generic Mineral Technology Center Mine Systems Design and Ground Control, Moscow, ID, October 21-26, 1986, Department of Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, p. 33-43.
This paper presents results of geotechnical studies to analyze the effects of weak floor on the stability of mine openings and coal pillars in a room-and-pillar coal mine in central Illinois. Immediate floor strata cores were studied in the laboratory for engineering index properties. Ultimate bearing capacity tests were conducted in the field under as-mined and soaked-wet conditions. Borehole shear tests were performed to determine in-place cohesive strength and angle of internal friction. Floor substrata movements, differential roof strata movements, pillar load changes and surface subsidence were also being monitored over a mining panel.
Keyword(s): coal mining, room-and-pillar, floor stability, lab testing, in situ testing, geotechnical, pillar strength, computer, monitoring methods, monitoring equipment, surface subsidence damage, survey methods, finite element
Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., R. Nath, S. Shankar. Time-Dependent Behavior of Immediate Weak Floor Strata from an Illinois Coal Mine. IN: Proceedings 6th International Conference on Ground Control in Mining, June 9-11, 1987, Department of Mining Engineering, West Virginia University, Morgantown.
The paper discusses laboratory and field studies to analyze time-dependent deformation behavior of immediate weak floor strata in an Illinois coal mine. In the laboratory, core samples of the immediate floor strata were subjected to incremental creep tests under unconfined compressive stress. Both axial and lateral creep deformations were recorded. A linear viscoelastic model was developed to represent the laboratory time-dependent behavior of immediate floor strata. Such a model may be acceptable for the design of partial extraction mining systems having extraction ratios of 40% to 60%. Field observations of roof-floor convergence at the mine also indicated a time-dependent behavior similar to that observed in the laboratory.
Keyword(s): coal mining, lab testing, in situ testing, time factor, floor stability, rock mechanics,

modeling, partial extraction, finite element, geotechnical, viscoelastic model
Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., K. Chandrashekhar, R. D. Caudle. A Field Geotechnical Study of the Effects of Weak Floor Strata on Underground Coal Mining in Illinois. IN: Key Questions in Rock Mechanics, Proceedings 29th U.S. Symposium, Minneapolis, MN, June 13-15, 1988, P.A. Cundall, R.L. Sterling, and A.M. Starfield, eds., Balkema, Rotterdam, p. 681-690.
This paper details results to date of a geotechnical field study in a room-and-pillar mine. The primary objective of the study was to acquire data on roof/pillar/weak floor interactions so data could be compared with results of analytical studies.
Keyword(s): coal mining, floor stability, rock mechanics, geotechnical, room-and-pillar, finite element, lab testing, in situ testing, instrumentation, monitoring methods
Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., S. Kuscu, A. Atri, R. Sweigard. Subsidence Monitoring at a Shallow Partial Extraction Room-and-Pillar Mine in Midwestern United States. 13 p.
Trough or sag type surface subsidence may be observed above partial extraction shallow (less than 100 m deep) room-and-pillar mines particularly where the coal seam is associated with weak and thick underclays in the floor. This paper presents results of subsidence studies at such a mine. The specific objectives of the study were to (1) analyze subsidence movements for vertical and horizontal displacements and strain profile characteristics and (2) correlate subsidence movements with observed underground movements.
Keyword(s): room-and-pillar, coal mining, partial extraction, active mines, floor stability, agriculture, monitoring methods, monitoring design, monitoring equipment, survey data processing, vertical displacement, horizontal displacement
Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., A. Atri, J. Dougherty. Laboratory and Field Characterization of Immediate Floor Strata in Illinois Basin Coal Mines. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings of 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 47-54.
Laboratory and field geotechnical characterization studies of weak floor strata were conducted at six mines during the period from 1985 to 1988. Correlation analysis among engineering index properties and laboratory and field determined strength-deformation properties were conducted to identify simple tests that can be used to estimate ultimate bearing capacity and deformation properties of immediate floor strata. It was concluded that the ultimate bearing capacity and strength-deformation properties of weak floor strata can be estimated from tests of natural moisture content, atterberg limits, and axial swelling strain. Indirect tensile strength was found to be a better estimator of UBC than unconfined compressive strength.
Keyword(s): floor stability, coal mining, active mines, lab testing, in situ testing, geotechnical, rock mechanics
Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., A. Atri. Subsidence Monitoring at a Shallow Partial Extraction Room-and-Pillar Mine in Midwestern United States. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 715-722.
Subsidence may be observed above partial extraction shallow room-and-pillar mines where the coal seam(s) is associated with weak and thick claystone in the floor. This paper presents results of subsidence studies at such a mine.
Keyword(s): monitoring methods, partial extraction, room-and-pillar, coal mining, floor stability, time factor, vertical displacement, angle of draw, horizontal displacement, active mines
Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., W. M. Pytel, O. Pula. A Modified Approach for Design of Coal Pillars for Weak Floor Strata Conditions. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 111-124.
This paper briefly describes and illustrates a modified approach for design of coal pillars under weak floor strata conditions considering UBC as well as pillar settlement. The approach is based on an approximate solution for estimation of the UBC for a shallow foundation on a two-layered rock system. Similarly, deformability underneath a full-

size pillar is estimated from deformability calculated from the plate loading tests. The effect of adjacent pillars on the UBC and deformability of coal pillars in a panel is also considered using foundation engineering analysis techniques. Design of pillars based on limiting settlements considers both differential settlements as well as mean settlement of pillars in a panel.

Keyword(s): mine design, coal mining, pillar strength, room-and-pillar, pillar extraction, floor stability, modeling, in situ testing, prediction

Location(s): United States

Chugh, Y. P., C.-C. Lia, X.-H. Weng, K. Chandrashekhar. An Analysis of the Effect of Augering of Coal Pillars on Mine Stability and Surface Subsidence. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 191-207.

Mine stability and subsidence effects of auger mining coal pillars during retreat mining are analyzed with finite element techniques. The analyses show that auger mining is possible and should not cause the remnant structure to be unstable if the first auger hole is located at least 3.5 feet away from the coal rib and spacing between auger holes is at least 2 feet. Results presented in this paper should also be valid if auger holes are developed on all four sides of a pillar.

Keyword(s): coal mining, finite element, pillar extraction, pillar strength, room-and-pillar, geologic features, floor stability, modeling

Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., M. E. Phillips, K. Chandrashekhar, A. K. Atri, S. E. Haq. Identification of Mine Characteristics, Conditions, and Procedures for Design of Stable Partial Extraction Room-and-Pillar Mines in Illinois. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y. P. Chugh, ed., Southern Illinois University, Carbondale, p. 1-17.

Stability of partial extraction room-and-pillar mines depends on a number of interrelated geological, geotechnical and engineering (mine design) parameters. Identification and correlation of these parameters is a logical first step in understanding the causes of mine instabilitities and developing design guidelines. This paper discusses an attempt to identify and subsequently develop commonly encountered roof lithologic sequences associated with the No. 6 coal seam in Illinois. The association of these lithologic sequences with observed mine stability and artificial roof support performance is presented. Based on an analysis of specific instabilities such as roof falls, floor squeezes and surface subsidence for different geological and mining conditions, an attempt is made to identify appropriate safety factors for mine design in Illinois.

Keyword(s): coal mining, room-and-pillar, partial extraction, roof stability, roof support, floor stability, geologic features, mine design, geotechnical, engineering, pillar strength, roof bolting

Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., Z. Yu, P. E. Miller. A Ground Control and Subsidence Study of a Longwall Mine in Southern Illinois. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 195-216.

This paper presents the results of an ongoing field geotechnical study in a longwall mine in southern Illinois. The study includes both surface and underground instrumentation and monitoring. Surface subsidence monitoring includes vertical and horizontal deformations of monuments along and across the study panel, and underground instrumentation includes measurement of changes with face retreat in vertical pressure and horizontal deformation of chain pillars, and roof-floor convergence, roof sag, and floor heave in entries. An attempt is made to correlate the surace and in-mine ground movements. A hyperbolic tangent equation appears to fit changes in pillar deformation, convergence, and surface subsidence data as a function of face position.

Keyword(s): longwall, monitoring methods, active mines, instrumentation, in situ testing, monitoring equipment, survey methods, survey data processing, modeling, floor stability, roof stability, mine design, coal mining, pillar strength

Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., W. M. Pytel. Analysis of Alternate Room-and-Pillar Mining Geometries Using the SIU Panel.2D Model. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 71-91.

This research is an attempt to develop alternate mine geometries with variable size pillars along and across a panel based on safety factors and pillar settlement considerations.

Keyword(s): floor stability, modeling, room-and-pillar, mine design, active mines, pillar strength

Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., Z. Yu, P. E. Miller. A Ground Control and Subsidence Study of a Longwall Mine in Southern Illinois. IN: Proceedings, Illinois Mining Institute, Centennial Year, 1992, p. 4-25.

This paper presents the results of an ongoing field geotechnical study in a longwall mine in southern Illinois. The study includes both surface and underground instrumentation and monitoring. Surface subsidence monitoring included vertical and horizontal deformations of 65 monuments along and across the study panel. Underground instrumentation included measurement of changes with face retreat in vertical pressure and horizontal deformation of chain pillars, and roof-floor convergence, roof sag, and floor heave in entries. An attempt was made to correlate the surface and in-mine ground movements. A hyperbolic tangent equation appears to fit changes in pillar deformation, convergence, and surface subsidence data as a function of face position. The developed equations may be used by the mining industry to plan additional supports in entries, vacating surface structures, and in planning land use over mined-out areas.

Keyword(s): longwall, geotechnical, coal mining, instrumentation, monitoring methods, monitoring equipment, vertical displacement, horizontal displacement, survey design, survey methods

Location(s): Illinois, Illinois Coal Basin, United States

Chugh, Y. P., ed. Ground Control in Room-and-Pillar Mining. Proceedings Conference on Ground Control in Room-and-Pillar Mining, August, 1980, Southern Illinois University, Carbondale, SME-AIME, 1982, 157 p.

This proceedings contains 26 technical papers on ground control practices in coal and noncoal mines.

Keyword(s): room-and-pillar, coal mining, mine design, mine safety, ground control, roof stability, bumps, metal mining, rock mechanics, roof support, pillar strength, modeling, monitoring methods, abandoned mines, monitoring equipment, backfilling

Location(s): Appalachian Coal Region, Illinois, Illinois Coal Basin, United States

Chugh, Y. P., ed. Proceedings, Second Conference on Ground Control Problems in the Illinois Coal Basin, May 29-31, 1985, Southern Illinois University, Carbondale, 158 p.

Falls of roof, ribs, and sides account for more than 50% of fatal and non-fatal injuries in the U.S. and Illinois underground coal mines. The need for better control of the ground from a safety point of view is therefore quite apparent. Additionally, uncontrolled surface and subsurface movements due to ground failures can significantly impact agricultural lands, water resources, and fish and wildlife habitats and cause damage to surface structures. Therefore, control of the ground during mining is also imperative from social, economic, and environmental points of view. The papers presented in this volume represent research advances and industry experience in ground control since the similar conference held in 1980. Surface subsidence and its control has drawn considerable public attention in Illinois in the recent past, and several papers on the subject are included.

Keyword(s): ground control, coal mining, subsidence research, geologic features, mine safety, agriculture, wildlife, environment, hydrology

Location(s): Illinois, Illinois Coal Basin, United States

Ciesielski, R., M. Czosnowski. The Construction of a Passenger Chairlift in a Mining Subsidence Area and its Protection. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 597-605.

A recreational chair lift was constructed in the territory of the Park of Culture and Recreation at Chorzow, in the center of the Silesian industrial district of Poland. The area in which the park is located is not suitable for general building purposes since it is subjected to large mining subsidence movements which are on a continuing basis.

Keyword(s): construction, surface structural damage, coal mining, engineering, horizontal displacement, monitoring methods

Location(s): Poland

Ciesielski, R. Dynamic Mining Influences on Surface Structures - Analysis and Methods of Evaluation. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, J.D. Geddes, ed., July 8-11, 1991, Pentech Press, London, 1992, p. 305-337.

These investigations into the problem of dynamic mining influences in two regions of Poland according to current practice, show that this problem can be serious for buildings in these regions, and can lead to damage or deterioration of buildings, particularly old ones.

Keyword(s): surface structural damage, active mines, abandoned mines

Location(s): Poland

Cifelli, R. C., H. W. Rauch. Dewatering Effects from Selected Underground Coal Mines in North-Central West Virginia. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 249-263.

This study documented the effects of underground coal removal on groundwater levels at selected mine sites in northern West Virginia, as observed from water wells, springs, and streams. This research should be useful to coal companies and regulatory agencies as an aid in recommendations for future water well locations and specifications in areas of existing or proposed underground coal mines

Keyword(s): subsurface water, surface water, hydrology, coal mining, active mines, abandoned mines, inflow

Location(s): West Virginia, Appalachian Coal Region, United States

Cizek, K. Packing Goaf with Sand and Granulated Slag by the Flushing Process. Colliery Guardian, v. 85, 1903, p. 1274.

This article gives a general description of sand and granulated slag flushing, under German towns. Benefits included a substantial increase in coal extraction, no subsidence at the surface, and prevention of fire.

Keyword(s): hydraulic backfilling, stowing, mine fires, historical

Location(s): Germany

Clark, R. G., E. T. Haws, M. Stephen. Mining Subsidence Beneath PFA Disposal Lagoons at Brotherton Ings, Yorkshire. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, J.D. Geddes, ed., 1984, Pentech, London, 1985, p. 281-297.

This paper sets out the background and operational problems associated with a major ash disposal complex. Ground conditions are somewhat unusual, with periglacial effects exacerbated by past mining subsidence. Continued mining beneath the site has necessitated the adoption of special constructional and operational procedures to enable safe and economic ash disposal to continue without interruption.

Keyword(s): mine waste, abandoned mines, active mines, surface subsidence damage, engineering, coal mining

Location(s): United Kingdom

Cleary, E. T. Robbing Mine Supports May Have Caused Shenandoah Subsidence. Engineering News Record, v. 124, 1940, p. 358-380.

This article describes the area and the damages at the scene of a large subsidence event; it covers how utility companies met the problem.

Keyword(s): coal mining, utilities, surface structural damage, pillar extraction

Location(s): Pennsylvania, Appalachian Coal Region, United States

Clemens, J. M. Monterey No. 1, A Modern Coal Mine. Mining Follows the Quadrant Plan. Coal Mining and Processing, v. 9, no. 6, 1972, p. 38-43.

The operations at the Monterey coal project, an underground working in southern Illinois, are described. It was decided to extract only 50% of the seam leaving pillars of adequate size to provide overburden support. Continuous mining machines and belt transportation are employed. Details of the roof support are given.

Keyword(s): roof support, mine design, mine operation, pillar strength, room-and-pillar, coal mining, active mines

Location(s): Illinois, Illinois Coal Basin, United States

Coal. Longwall Use Could Collide With Tighter Subsidence Controls. July 1990, v. 96, no. 7, p. 9.

The coal industry's increased use of longwall systems appears on a collision course with the federal government's move toward tighter controls over subsidence.

Keyword(s): longwall, active mines, coal mining, law, government, environment, structural mitigation

Location(s): United States

Coal. Virginia Court Upholds Longwalling. v. 95, no. 12, December, 1990, p. 78-80.

A coal mine in southwestern Virginia came close to being permanently barred from longwalling in a January 1990 decision by the Virginia Supreme Court.

Keyword(s): law, longwall, coal mining, government

Location(s): Virginia, Appalachian Coal Region, United States

Coal Age. Anthracite Mine-Cave Situation. v. 14, no. 13, 1918, p. 598-601.

Early development of coal mining in Scranton, Pennsylvania, is described, including agreements between coal companies and townspeople regarding compensation for and protection against surface structural damage as a result of subsidence.

Keyword(s): surface structural damage, anthracite, coal mining, historical

Location(s): Pennsylvania, Appalachian Coal Region, United States

Coal Age. Hydraulic Stowage at Home and Abroad. v. 25, 1924.

This article is a general discussion of hydraulic stowing methods and application in various countries. It includes a detailed discussion, by Charles Enzian, of Griffith's proposal to blast the roof down and blast the floor up to form supporting pillars.

Keyword(s): hydraulic backfilling, stowing, coal mining

Coal Age. Longwall Mining. McGraw-Hill, New York, 1965.

Longwall mining equipment and procedure is described, including a series of pictures. The article also discusses the advantages and disadvantages of longwall mining and its application in United States coalfields.

Keyword(s): longwall, mine design, mine operation, coal mining

Location(s): United States

Coal Mining and Processing. Can Mining Operations be Planned to Minimize Subsidence? v. 4, no. 9, 1967, p. 38-41, 47.

This article discusses the use of underground measures (mine design methods) as a means of minimizing subsidence.

Keyword(s): mine design, longwall, coal mining, active mines

Location(s): United Kingdom, United States

Coal Mining and Processing. How to Calculate Factors in Mining Subsidence. v. 4, no. 5, May, 1967, p. 28-33 (first of a three-part series).

With the extension of mining beneath residential and industrial areas, it is becoming increasingly important to work minerals in such a way that subsidence damage is kept to a minimum and that as little mineral as possible is sterilized in pillars of support. This dual aim can only be achieved with a knowledge of ground movement and its relation to mine workings. For many years little was known about the nature of ground movement, and subsidence calculations were therefore very approximate. In recent years, affected areas have been carefully measured and observed, and the principles of ground movement caused by extraction of stratified deposits are now more fully understood.

Keyword(s): mine design, backfilling, stowing, mine waste, time factor, coal mining, longwall, prediction

Location(s): United Kingdom, United States

Coal Mining and Processing. What Happens When the Ground Subsides? v. 4, no. 7, July, 1967, p. 20-23.

This article discusses the components involved in the vertical and horizontal movement within a subsidence trough. The paper also discusses strain, which is the extension or compression of the ground within the subsidence zone per unit of length; also, the degree and direction to which any surface site will tilt depending on the subsidence; and finally, the choice that may be made in designing structures so they will be able to withstand subsidence.

Keyword(s): vertical displacement, horizontal displacement, coal mining, surface structural damage, longwall, active mines, structural mitigation

Location(s): United Kingdom, United States

Coal Mining and Processing. Illinois to Conduct Subsidence Study. v. 19, no. 10, 1982, p. 17.

Keyword(s): coal mining, subsidence research

Location(s): Illinois, Illinois Coal Basin, United States

Coal News. States Can Determine Subsidence Liability, Supreme Court Rules. No. 5039, April 1, 1991, National Coal Association, Washington, D.C., p. 1-2.

In a ruling of major significance, a federal appeals court has reversed a lower court decision

and upheld a U.S. Interior Department regulation that leaves to state law the extent of subsidence liability of underground coal mining operations.
Keyword(s): law, government, coal mining, structural mitigation, surface structural damage, active mines
Location(s): United States

Coates, D. F. Pillar Loading. Research Report, Department of Mines and Technical Surveys, Ottawa, Canada, 1965-1966.
This paper describes laboratory experiments and field measurements used to derive new hypotheses for determining pillar loads. The report includes a series of equations including such factors as span of mining zone, height and breadth of pillars, position of pillars in the mining zone, variations between deformability of pillars and wall rocks, and the effects on both normal and transverse field stresses.
Keyword(s): pillar strength, mine design, room-and-pillar, rock mechanics, lab testing, in situ testing
Location(s): Canada

Coates, D. F., A. Ignatieff. Prediction and Measurement of Pillar Stresses. Canadian Mining Journal, v. 87, January, 1966, p. 50-56.
The author presents a new hypothesis for predicting the loading of pillars, taking into account the structural features of the system. Included are measurements of pillar stresses in underground iron mines in Canada and Sweden, and uranium mines in Canada.
Keyword(s): prediction, pillar strength, metal mining
Location(s): Canada, Sweden

Coates, D. F. Rock Mechanics Principles. Mines Branch, Canadian Department of Energy, Mines, and Resources, Monograph 74, Ch. 4, 1970, p. 4-1 - 4-25.
The mechanics of pillars is discussed from three aspects: the load applied to the pillar, the strength of the pillar, and the reaction of the roof and floor to pillar stresses.
Keyword(s): rock mechanics, pillar strength

Coates, D. F., M. Gyenge. Incremental Design in Rock Mechanics. Mining Research Centre, Mines Branch, Department of Energy, Mines and Resources, Canada, Mines Branch Monograph 880, 1973, p. 5-1 - 5-15.
The authors formulate mathematical subsidence-prediction methods for underground mining operations. These methods can be used to calculate subsidence over flat-lying ore bodies, steeply dipping veins, and massive ore bodies that lead to cover caving.
Keyword(s): vertical displacement, horizontal displacement, rock mechanics, prediction, modeling, mathematical model, metal mining
Location(s): Canada

Coates, D. F. Rock Mechanics Principles. Canadian Department of Energy, Mines and Resources, Mine Branch Monograph 74, 1970, rev. 1974.
The mechanics of pillars is discussed from three aspects: pillar load, pillar strength, and the reaction of the roof and floor to pillar stresses.
Keyword(s): rock mechanics, pillar strength, ground control, mine design
Location(s): Canada

Coates, D. R. Large Scale Land Subsidence. IN: Mega-Geomorphology, R. Gardner and H. Scoging, eds., Oxford University Press, Oxford, 1983, p. 212-233.
Keyword(s): geologic features, surface subsidence damage

Cochran, W. Mine Subsidence--Extent and Cost of Control in a Selected Area. U.S. Bureau of Mines IC 8507, 1971, 32 p. (NTIS PB 236 093)
The USBM investigated subsidence caused by recent underground mining, estimated the extent of damages, and formulated a procedure for evaluating subsidence costs.
Keyword(s): mitigation, economics, ground control, active mines
Location(s): Pennsylvania, Appalachian Coal Region, United States

Coe, C. J., S. M. Stowe. Evaluating the Impact of Longwall Coal Mining on the Hydrologic Balance. IN: Proceedings Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, December 2-7, 1984, University of Kentucky, Lexington, p. 395-403.
An approach has been developed to evaluate changes in the hydrologic balance associated with land subsidence above longwall mining operations in the Appalachian Coal Basin. This method consists of developing hydrogeologic cross sections to define specific aquifers and aquitards which exist within the overburden. The cross sections can be used to define the premining hydrologic flow

pattern wihin the mine overburden and the lithologic composition of a well, spring, or pond where no previous data were available. Then the water sources are mapped in relationship to the mine development plan. Hydrographs are developed to evaluate changes in water level in a well or the flow characteristics of a spring or stream with respect to the passing of the longwall mine face. Two site case histories are presented.

Keyword(s): subsurface water, hydrology, longwall, coal mining

Location(s): Appalachian Coal Region, United States

Coe, C. J., S. M. Stowe. Evaluating the Impact of Longwall Coal Mining on the Hydrologic Balance. IN: Proceedings, National Water Well Association Conference on the Impact of Mining on Ground Water, Denver, CO, 1984, p. 348-359.

Keyword(s): longwall, coal mining, hydrology, subsurface water, active mines

Cohen, S. Taking the Surprises Out of Subsidence. Landmarc, July/August, 1989, p. 4-13.

This article discusses various coal companies' efforts to cooperate with landowners and repair surface properties during and after longwall mining. An accompanying sidebar covers USBM subsidence prediction models and foundation monitoring studies.

Keyword(s): longwall, structural mitigation, surface structural damage, coal mining, land mitigation, law, subsurface water, foundations, monitoring equipment, prediction

Location(s): Ohio, Pennsylvania, Appalachian Coal Region, United States

Colaizzi, G. J., R. H. Whaite, D. L. Donner. Pumped-Slurry Backfilling of Abandoned Coal Mine Workings for Subsidence Control at Rock Springs, Wyoming. U.S. Bureau of Mines IC 8846, 1981, 100 p.

This report describes a pumped-slurry backfilling demonstration project for abandoned mine workings. It also contains background information on other hydraulic backfilling methods.

Keyword(s): hydraulic backfilling, economics, abandoned mines, coal mining

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Colaizzi, G. J., M. R. Virta, D. L. Groy, M. R. Schmidt. Coal Mine Subsidence Control Case Studies, Colorado Springs, Colorado. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 235-253.

Subsidence of the land surface over abandoned underground coal mines is a continuing problem in Colorado Springs. Subsidence events pose varying problems depending on subsidence type, local geology, and proximity to buildings and other improvements.

Keyword(s): abandoned mines, grouting, hydraulic backfilling, surface structural damage, foundations, coal mining, geologic features

Location(s): Colorado, Rocky Mountain Coal Region, United States

Cole, K., I. Statham. General (Areal) Subsidence Above Partial Extraction Mines - Part 1. Ground Engineering, v. 25, no. 2, March, 1992, p. 45-55.

Isolated examples of trough subsidence above partial extraction mines have been reported in the United Kingdom, crownhole subsidence being more common. General subsidence results from deterioration and ultimate collapse of ground at or above the working level. Categories of collapse condition for partial extraction mines are outlined. Mine pillar collapse mechanisms and the many contributing factors are examined. Pillar stress and strength calculations considering geological and geometric parameters are illustrated.

Keyword(s): partial extraction, pillar strength, engineering, coal mining

Location(s): United Kingdom

Cole, K., I. Statham. General (Areal) Subsidence Above Partial Extraction Mines - Part 2. Ground Engineering, v. 25, no. 3, April 1992, p. 36-40.

Failure processes in coal mines are further examined, with results of tests on coal pillars summarized, comparisons made between strengths of coal and overburden pillars, and failure of overburden pillars in coal mines considered. Effects of quality of overburden rock, mine flooding, uneven pillar loading, and mine layout and mining procedures are discussed. Finally, remedial grouting and assessment of collapse potential are described.

Keyword(s): partial extraction, pillar strength, coal mining, overburden, grouting, engineering

Location(s): United Kingdom

Cole, K. W. Building Over Abandoned Shallow Mines--A Strategy for the Engineering Decisions on Treatment. Ground Engineering, v. 20, no. 4, 1987, p. 14-30.
Keyword(s): abandoned mines, surface structural damage, structural mitigation, engineering, construction, architecture, land-use planning

Colliery Engineering. Flushing Anthracite Workings. v. 33, 1913, p. 537.
This article describes the first uses of hydraulic backfilling of anthracite mines. Both remote and controlled flushing were used for roof support, to prevent subsidence, and allow pillar removal.
Keyword(s): hydraulic backfilling, mine waste, anthracite, coal mining, roof support, pillar extraction

Colliery Engineering. Effect of Coal Mining on the Surface. v. 33, May 1913, p. 548-552; v. 33, June 1913, p. 617-622.
Keyword(s): surface subsidence damage, coal mining

Colliery Engineering. Hydraulic Stowing in Pennsylvania. v. 28, July, 1951, p. 329.
Two methods of controlling surface subsidence are described: (1) hydraulic flushing with comparatively fine-grain material, and (2) manual and mechanical stowage of material.
Keyword(s): hydraulic backfilling, stowing
Location(s): Pennsylvania, Appalachian Coal Region, United States

Colliery Engineering. Power Stowing Installation. v. 31, no. 366, August, 1954, p. 266.
Keyword(s): stowing

Colliery Engineering. Hydraulic Stowing in Poland. v. 31, December, 1954, p. 529 (abstract only).
This abstract describes the status of hydraulic backfilling in Poland at that time.
Keyword(s): hydraulic backfilling, stowing
Location(s): Poland

Colliery Engineering. Crushing Stowing Material. v. 33, no. 388, June, 1956, p. 264.
Keyword(s): stowing

Colliery Engineering. Pneumatic Stowing in Spain. v. 34, no. 396, February, 1957, p. 54.
Keyword(s): pneumatic backfilling, stowing
Location(s): Spain

Colliery Engineering. Steel Bars and Stowing. v. 34, no. 398, April, 1957, p. 176.
Keyword(s): stowing

Colliery Engineering. Stowage Dirt Transport. v. 34, no. 399, May, 1957, p. 221.
Keyword(s): stowing

Colliery Engineering. Stowing in Inclined Seams. v. 34, no. 403, September, 1957, p. 395.
Keyword(s): stowing

Colliery Engineering. Hydraulic Stowing in Poland. v. 35, February, 1958, p. 91 (abstract only).
This abstract describes hydraulic backfilling operations in Poland where seams are up to 79 feet thick.
Keyword(s): hydraulic backfilling, stowing
Location(s): Poland

Colliery Engineering. Preparation of Pit Stone for Stowage. v. 38, no. 450, August, 1961, p. 332.
Keyword(s): stowing

Colliery Engineering. Simultaneous Coal Getting and Stowing. v. 39, no. 459, May, 1962, p. 204.
Keyword(s): stowing, coal mining

Colliery Engineering. Successful Debut of Bien Breaker Stower. v. 41, no. 486, August, 1964, p. 312.
Keyword(s): stowing

Colliery Guardian. Hydraulic Packing in German State Mines. November 1, 1912, p. 903.
This article includes a comparative chart illustrating the purpose of backfilling, increase in production, fill material, and quantity and particle size of fill for the mine.
Keyword(s): hydraulic backfilling
Location(s): Germany

Colliery Guardian. Support of Railways. v. 107, 1914, p. 523 and 1400.
This article discusses the rights of railway owners and mineral owners and the English law of 1845.
Keyword(s): historical, law, railroads
Location(s): England

Colliery Guardian. Mining Subsidence in India. August 11, 1922, p. 330.
A Subsidence Committee noted the following conditions that may be deemed peculiar to India:

(1) absence of packing, except in a few recent cases, none of which were old enough to enable definite conclusions to be drawn; (2) the considerable thickness of the seams; and (3) the high proportion of hard sandstones and low proportion of shales or soft rocks in the strata.
Keyword(s): coal mining, geologic features, stowing, pillar extraction
Location(s): India

Colliery Guardian. Mine Subsidence. v. 179, March 10, 1949, p. 333-335.

Colliery Guardian. The Hydraulic Transport of Coal in Poland. v. 197, October, 1958, p. 542.
Keyword(s): backfilling, coal mining
Location(s): Poland

Colliery Guardian. Hydraulic Stowing. August 8, 1963, p. 185-187.
An example is given of hydraulic sand backfilling under pressure to fill old mine voids in Great Britain.
Keyword(s): abandoned mines, hydraulic backfilling
Location(s): England

Colliery Guardian. Mining Under Coventry. v. 207, September 12, 1963, p. 324-327.
This article describes a partial extraction system to be used in England. The seam is 20 to 30 feet thick, at a depth of 2,100 feet.
Keyword(s): surface structural damage, partial extraction
Location(s): England

Colliery Guardian. Controlling Subsidence. v. 210, August 7, 1964, p. 176.
Keyword(s): ground control, coal mining

Collins, B. J. Measurement and Analysis of Residual Mining Subsidence Movements. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 3-29.
This paper is based upon a research project into the long-term or residual aspects of mining subsidence. The work was carried out in conjunction with the National Coal Board.
Keyword(s): instrumentation, monitoring methods, survey methods, survey data processing, survey equipment, time factor, horizontal displacement, vertical displacement
Location(s): Wales, United Kingdom

Collins, S. L. Coal and Coal Mining. IN: Guidebook for the 45th Annual Field Conference of Pennsylvania Geologists--Land Use and Abuse the Allegheny County Problem, Pittsburgh, Pennsylvania, October 3 and 4, 1980, Department of Environmental Resources, Bureau of Topographic and Geologic Survey, Harrisburg, PA, p. 19-24.
Keyword(s): land-use planning, environment, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Colorado School of Mines. Rock Mechanics Instrumentation Program for Kaiser Steel Corporation's Demonstration of Shield-Type Longwall Supports at York Canyon Mine, Raton, New Mexico. U.S. Department of Energy Contract AC01-74ET12530, 1981, 303 p. (NTIS DOE/ET/12530-1)
Chapter 5 describes the surface instrumentation used to measure vertical and horizontal movement and extent of surface subsidence. Results are then compared with results of predictions made by the National Coal Board of Britain.
Keyword(s): vertical displacement, horizontal displacement, monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, survey data processing, rock mechanics, longwall, National Coal Board, coal mining, instrumentation, prediction
Location(s): New Mexico, Rocky Mountain Coal Region, United States

Concrete and Construction Engineering (London) Large Reservoir Designed for Mine Subsidence. v. 46, no. 12, 1951, p. 353-358.
Keyword(s): construction, surface water, engineering

Concrete and Construction Engineering (London) Foundations to Resist Subsidences. v. 51, no. 9, 1956, p. 491-493.
Keyword(s): construction, foundations

Concrete and Construction Engineering (London) A Tower Liable to Subsidence. v. 51, no. 10, 1956, p. 500-501.
Keyword(s): construction, surface structural damage

Connelly, M. A. The Uses of Geologic Structural Analyses in Predicting Roof Conditions in Coal Mining. IN: Proceedings of Symposium on Stress and Failure Around Underground Openings, University of Sydney, New South Wales, Australia, 1967, paper 13, p. 1-2.

Keyword(s): prediction, roof stability, coal mining, geologic features

Conover, D. P., K. Y. Haramy, K. Hanna. Methods to Determine Pillar Stress Distribution and its Effect on Stability. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 419-424.

The effects of stress distribution on pillar stability were evaluated through rock mechanics studies conducted in three underground room-and-pillar coal mines. Results of the three field instrumentation programs are presented to illustrate the use of borehole pressure cells to determine vertical stress distribution in coal pillars at various stages of mine development. Vertical stresses and stress changes are determined using methods developed at the USBM. Measured stress distributions are compared against theoretical distributions and possible explanations for observed behavior are discussed. Results indicate that stresses and stress changes calculated from pressure cell data are inconsistent with theoretical values; however, the data are useful for qualitative evaluation of trends over time. Calculated values are found to be sensitive to coal properties and initial setting pressures of the cells.

Keyword(s): pillar strength, rock mechanics, room-and-pillar, coal mining, instrumentation

Location(s): United States

Conroy, P. Rock Mechanics Studies, United States Bureau of Mines, Longwall Demonstration, Old Ben Mine No. 24, Benton, Illinois, Phase III. Preliminary report Panel 2, June, 1970, 18 p.

Keyword(s): coal mining, rock mechanics, longwall, monitoring methods

Location(s): Illinois, Illinois Coal Basin, United States

Conroy, P. Rock Mechanics Studies, United States Bureau of Mines, Longwall Demonstration, Old Ben Mine No. 24, Benton, Illinois, Phase III. Preliminary report panel 1, Job No. 7734-002-07, August, 1977, 39 p.

Keyword(s): coal mining, rock mechanics, longwall, monitoring methods

Location(s): Illinois, Illinois Coal Basin, United States

Conroy, P. Rock Mechanics Studies, Longwall Demonstration at Old Ben 24, Benton, IL. Phase I and II Report, submitted to U.S. Bureau of Mines, 1979, 57 p.

Keyword(s): coal mining, rock mechanics, longwall, monitoring methods

Location(s): Illinois, Illinois Coal Basin, United States

Conroy, P. J. Subsidence Above A Longwall Panel in the Illinois No. 6 Coal. Preprint 3293, ASCE Convention and Exhibit, Pittsburgh, PA, April, 1978, p. 77-92.

The mining discussed in this paper was the first successful application of longwall in Illinois. This panel was part of a cooperative agreement between Old Ben Coal Company and the USBM. As part of the agreement, subsidence monitoring (including TDR) was performed on the surface. Instrumentation also monitored the progressive caving of the overlying strata.

Keyword(s): coal mining, longwall, surface subsidence damage, monitoring methods

Location(s): Illinois, United States, Illinois Coal Basin

Conroy, P. J. Longwall Coal Mining. Dames and Moore Engineering Bulletin, no. 52, August, 1980, p. 13-26.

This article outlines experience gained during a feasibility and demonstration study of longwall coal mining in the Illinois Basin. Geotechnical investigations included a premining study to review the previous attempts at longwall mining and to perform in situ rock mechanics tests. Results were used as a basis to formulate recommendations for the longwall supports to be used in the demonstration. TDR (Time Domain Reflectometry) was used in the monitoring program.

Keyword(s): longwall, engineering, rock mechanics, geotechnical, instrumentation, coal mining

Location(s): Illinois, Illinois Coal Basin, Europe, United States

Conroy, P. J., J. H. Gyarmaty, M. L. Pearson. Demonstration of Subsidence Monitoring System. U.S. Department of Energy contract AC01-78ET10029, Dames and Moore, Park Ridge, IL, June, 1981, 435 p. (NTIS DOE/ET/10029-T1)

This study was conducted to provide additional data on coal mine subsidence to serve as a basis for the development of subsidence control technology. The study involved installing, monitoring, and evaluating three subsidence monitoring instrument systems: (1) structure performance, (2) performance of supported systems, and (3) performance of caving systems. Objectives of the instrument program were: (1) to select, test, assemble, install, monitor, and maintain all instrumentation required for implementing the monitoring systems; and (2) to evaluate the performance of each instrument individually and as part of the appropriate monitoring system or systems. Twelve instruments were selected and implemented. The data acquired with each instrument were discussed and evaluated for applicability in terms of quality and effectiveness in characterizing subsidence. Recommendations include the use of an automatic level and rod extensometer for measuring structure performance, and the automatic level, steel tape extensometer, FBPX, FPBI, USBM borehole deformation gauge, and vibrating wire stressmeters for measuring the performance of caving systems. Instruments recommended for measuring the performance of supported systems were identical to that of the caving system. Alternatives are also discussed.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, survey data processing, instrumentation

Location(s): United States

Conroy, P. J., E. A. Curth. Longwall Mining in Illinois. IN: Longwall-Shortwall Mining, State of the Art, 1981, R.V. Ramani, ed., AIME, New York, p. 191-199.

This chapter discusses the history and development of longwall mining in Illinois, including equipment, roof supports, and present practice.

Keyword(s): longwall, mine design, roof support, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Conroy, P. J., J. H. Gyarmaty. Planning Subsidence Monitoring Programs Over Longwall Panels. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, September, 1982, Y.P. Chugh and M. Karmis, eds., SME-AIME, p. 225-234.

This paper presents guidelines and recommendations for the design and implementation of a comprehensive subsidence monitoring program.

Keyword(s): monitoring design, monitoring equipment, monitoring methods, survey methods, survey equipment, horizontal displacement, longwall, economics, ground control, National Coal Board, coal mining

Location(s): Illinois Coal Basin, Appalachian Coal Region, United States

Conroy, P. J., J. H. Gyarmaty. Subsidence Monitoring--Case History. IN: Proceedings Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 148-153.

This paper summarizes subsidence research performed at a mine site in West Virginia, with a generalized geological description of the site to allow comparison of data with those of similar sites.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, instrumentation

Location(s): West Virginia, Appalachian Coal Region, United States

Conroy, P. J. Subsidence Monitoring to Verify Analytical Models. IN: Proceedings Conference on Ground Control in Room-and-Pillar Mining, Southern Illinois University at Carbondale, August 6-8, 1980, Y.P. Chugh, ed., SME-AIME, New York, 1982, p. 127-132.

Most subsidence monitoring to date has been surface monitoring to develop empirical relationships of the magnitude and extent of subsidence effects. Federal regulations are forcing a better understanding of subsidence. Empirical methods of subsidence prediction may not be adequate because these relationships may not be valid between or even within coal fields. A better understanding of the mechanics of subsidence is required to develop and verify analytical models.

Keyword(s): modeling, coal mining, prediction, law, longwall, monitoring methods, monitoring design, geologic features

Location(s): United States

Conroy, P. J., J. H. Gyarmaty. Characterization of Subsidence Over Longwall Mining Panels--Eastern Coal Province. U.S. Bureau of Mines OFR 192-83, Contract JO133920, Dames & Moore, 1983, 165 p.

Keyword(s): longwall, coal mining, monitoring methods
Location(s): Appalachian Coal Region, United States

Conroy, P. J., J. Gyarmaty. The Mid-Continent Field: Results of a Subsidence Monitoring Program. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., Coal Extraction and Utilization Research Center, Southern Illinois University at Carbondale, U.S Department of Energy Contract no. DE AC22 80ET 14146. Elsevier, New York, 1983, p. 681-708.
A subsidence monitoring program was conducted over two longwall panels at the Old Ben Mine No. 24 located near Benton, Illinois, as part of the USBM Longwall Demonstration project. The results of this study may be useful to future longwall mining subsidence monitoring plans for mines located in the Illinois Basin having similar geologic and topographic properties.
Keyword(s): longwall, active mines, monitoring methods, geologic features, vertical displacement
Location(s): Illinois, Illinois Coal Basin, United States

Cook, N. The Design of Underground Excavation. IN: Failure and Breakage of Rock, Proceedings 8th Symposium on Rock Mechanics, University of Minnesota, September 15-17, 1966, C. Fairhurst, ed., AIME, New York, 1967, p. 167-193.
This paper deals with stresses contained within rock masses both before and after excavation, and with energy released as a result of underground excavation. The discussion includes the design of excavations to minimize energy changes and to control rock failure underground with the main emphasis on the calculation of stresses and not with actual physical layouts of mining operations.
Keyword(s): rock mechanics, mine design
Location(s): South Africa

Cook, N. G. W., K. Hodgson, J. P. M. Hojem. A 100-MN Jacking System for Testing Coal Pillars Underground. Journal South African Institute of Mining and Metallurgy, v. 68, 1967, p. 192-195.
Keyword(s): pillar strength, ground control, in situ testing, coal mining
Location(s): South Africa

Cooley, W. C. Survey of Foreign Technology for Stowing in Underground Coal Mines. Final report on U.S. Bureau of Mines Contract JO275041 with Terraspace, Inc., Rockville, MD, Report #TR-420-1, May 30, 1978, 60 p.
This report is a historical summary and bibliography of foreign technology concerning backfilling as a means of limiting subsidence.
Keyword(s): stowing, literature search, coal mining
Location(s): Soviet Union, Poland, Germany, United States

Cooper, R. E. Discussion on Subsidence Due to Coal Workings. IN: Institution of Civil Engineers, Minutes of Proceedings, v. 135, 1898, p. 132-135.
Keyword(s): coal mining, historical

Cope, E. The Progress of Mechanized Packing in North Staffordshire. Transactions, Institute of Mining Engineers, v. 115, 1955, p. 651; also Colliery Guardian, v. 191, no. 4934, September, 1955, p. 351.
Keyword(s): stowing, coal mining
Location(s): United Kingdom

Corapcioglu, M. Y., W. Brutasaert. Viscoelastic Aquifer Model Applied to Subsidence Due to Pumping. Water Resource Research, v. 13, 1977, p. 597-604.
Keyword(s): fluid extraction, modeling, viscoelastic model, phenomenological model, subsurface water, hydrology

Corbett, B. O. Abandoned Mine Workings Beneath Monklands District General Hospital, Airdrie. IN: Mineworkings 84: Proceedings of the International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1984, M.C. Forde, et al., eds., Engineering Technics Press, Edinburgh, p. 52-63.
Keyword(s): abandoned mines, surface structural damage

Corbett, R. G. Effects of Coal Mining on Ground and Surface Water Quality, Monongalia County, West Virginia. The Science of the Total Environment, v. 8, no. 1, July, 1977, p. 21-38.
Keyword(s): surface water, subsurface water, hydrology, coal mining
Location(s): West Virginia, Appalachian Coal Region, United States

Corden, C. H. H. The Recording of Boundary Distortion in Mining Subsidence. Ph.D. Thesis, University of Leeds, UK, 1964, 146 p.
Location(s): United Kingdom

Corden, C. H. H., H. J. King. A Field Study of the Development of Surface Subsidence. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 2, no. 1, 1965, p. 43-55.

The field measurement of surface subsidence presents many difficulties. The use of the usual survey techniques yields a static, or instantaneous picture of the displacements along the axis of measurement. These are not, however, necessarily capable of analysis, especially if the line is either multi-directional or, being uni-directional, is oblique to the developing contours of subsidence. The experience gained in a field scheme for the absolute measurement of tilt and strain was useful in the design and use of the apparatus described in this article.

Keyword(s): rock mechanics, survey methods, survey equipment, monitoring equipment, vertical displacement, survey design, monitoring design

Cording, E. J., T. D. O'Rourke, M. Boscardin. Ground Movements and Damage to Structures. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 516-537.

The results of studies on buildings adjacent to tunnels and excavations are summarized. Measurements of lateral strain, tilt and differential settlement were made in a brick bearing wall structure during excavation of a tunnel adjacent to the structure. For other structures, the available movement data consisted of settlements. In these cases, maximum settlements and slopes were related to observed building damage.

Keyword(s): surface structural damage, tunnelling, foundations, longwall, architecture, horizontal displacement, vertical displacement

Cordova, R. M., R. W. Mower. Fracturing and Subsidence of the Land Surface Caused by the Withdrawal of Ground Water in the Milford Area, Utah. U.S. Department of the Interior, Geological Survey Journal of Research, v. 4, 1976, p. 505-510.

Keyword(s): fluid extraction

Location(s): Utah, United States

Corson, D. R. Field Evaluation of Hydraulic Backfill Compaction at the Lucky Friday Mine, Mullan, Idaho. U.S. Bureau of Mines RI 7546, August, 1971.

Results are given for a 4-year monitoring program of two test sites where normal filling procedures were used and compared to vibratory compaction.

Keyword(s): hydraulic backfilling

Location(s): Idaho, United States

Cortis, S. E. Coal Mining and Protection of Surface Structures Are Compatible. Mining Congress Journal, v. 55, June 1969, p. 84-89.

This paper discusses Pennsylvania's Bituminous Mine Subsidence and Land Conservation Act of 1966. It summarizes the formulas, regulations and standards developed to control mine subsidence and determine surface areas of potential damage above active mines for prevention of damage to surface structures.

Keyword(s): surface structural damage, law, government, bituminous, active mines, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Corwine, J. W. A Longwall Demonstration at Old Ben Mine No. 24, Illinois. IN: Proceedings Illinois Mining Institute, v. 84, 1976, p. 72-79.

This paper is a status report on the longwall demonstration, equipment used, and the initial results.

Keyword(s): longwall, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Cotecchia, V. Subsidence Phenomena Due to Earthquakes: Italian Cases. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication No. 151, 1986, p. 829-840.

Subsidence phenomena may have a more or less slow development or, when triggered by earthquakes, a very rapid evolution. The latter is the case of the modifications in the elevation of entire regions following very violent seismic events. Among the natural causes of the modifications, a basic role is undertaken by the seismo-tectonic component, whose primary effects are tectonic dislocations of the bedrock. In more superficial soils, another not less important consequence is given by minor dislocations caused by various sudden effects of the seismic action.

Keyword(s): geologic features, surface subsidence damage, seismic, soils

Location(s): Italy

Coulomb, C. Application des Regles de Maximis et Minimus a quelques Problemes de Statique Relatifs a l'Architecture. Memiors de Savants etrangers de l'Academie des Sciences de Paris, 1773.
Keyword(s): prediction theories

Coulthard, M. A., A. J. Dutton. Numerical Modelling of Subsidence Induced by Underground Coal Mining. IN: Key Questions in Rock Mechanics, Proceedings of the 29th U.S. Symposium, Minneapolis, MN, June 13-15, P.A. Cundall, R.L. Sterling, and A.M. Starfield, eds., 1988, Balkema, Rotterdam, p. 529-536.
The subsidence induced by single panel coal extractions has been calculated with continuum and distinct element stress analysis. Nonlinear material models in programs FLAC and UDEC, which allow a more realistic representation of the behaviour of the roof strata, reproduce the observed qualitative change in subsidence profiles that occurs in the transition from sub-critical to super-critical panel widths. The programs therefore have the potential to provide reliable subsidence prediction in new geological and mining environments.
Keyword(s): modeling, coal mining, prediction, empirical model
Location(s): Australia

Courtney, W. J., M. M. Singh. Feasibility of Pneumatic Stowing for Ground Control in Coal Mines. Illinois Institute of Technology Research, Report No. D 6068, 1972, 128 p. (Available from USBM Library, Mining Research Center, Spokane, WA.)
Keyword(s): pneumatic backfilling, stowing, ground control, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Cox, D. W. Modelling Stochastic Behaviour Using the Friction Table with Examples of Cracked Brickwork and Subsidence. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 307-328.
The friction table has been widely applied to demonstrate the behaviour of rock slopes. The same methods can be applied to other fissured or discontinuous media such as brickwork or rock in a subsidence zone. The paper demonstrates the effect of different ground deflections on crack patterns in brickwork. The secondary effect of window and door openings on the pattern are also shown. A stereographic method of crack measurement is detailed.
Keyword(s): stochastic model, modeling, surface structural damage

Craft, J., T. Crandall, J. Holbrook, G. Kelley, W. Remy. Madisonville Areawide Subsidence Investigation. Final Report, Office of Surface Mining, Pittsburgh, September, 1986, 175 p. (NTIS PB91-164806)
This report discusses an areawide subsidence investigation, conducted by Office of Surface Mining in Madisonville, KY, to determine mechanisms of abandoned underground mine subsidence and to access potential for future subsidence. Information and data from geotechnical investigations, subsidence damage surveys, borehole camera inspection of conditions in abandoned mines, and previous subsidence investigations are analyzed. Geologic data and damage survey reports, pillar strength calculations, abandoned mine gas information, and a general discussion of available abatement techniques are appended to this report.
Keyword(s): abandoned mines, coal mining, geotechnical, monitoring methods, pillar strength, geologic features
Location(s): Kentucky, United States

Craft, J. L., T. M. Crandall. Mine Configuration and its Relationship to Surface Subsidence. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October 1987, p. 37-50.
Knowledge of the mine configuration is essential to a subsidence investigation and the interpretation of the subsidence mechanism(s). The investigator should obtain all available mine maps in the subsiding area and establish survey control points to accurately tie the mine map to the surface. Once established and confirmed by drilling, mine geometry and the exploratory drilling data can be evaluated to determine the failure mechanism which resulted in the surface disturbance. Only after the failure mechanism has been determined, can an effective stabilization program be implemented.
Keyword(s): abandoned mines, active mines, coal mining, prediction, geologic features
Location(s): West Virginia, Alabama, Pennsylvania, Appalachian Coal Region, United States

Craft, J. L. Classification of Coal Mine Related Subsidence East of the Mississippi River, U.S.A. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 69.

Field investigation of surface subsidence associated with active and abandoned underground coal mine sites in the Eastern United States has established evidence for the classification of mine related surface subsidence. The classification is based on the interrelationship between overburden thickness, geology, topography, and mine plan. The subsidence types are: Pit, Room, Sag, and Cantilever Beam Subsidence.

Keyword(s): overburden, coal mining, surface subsidence damage, surface structural damage, roof stability, pillar strength

Location(s): United States

Crane, W. R. The Use of Concrete for Mine Support. Transactions, Institution of Mining Engineers, v. 37, 1909, p. 560.

This article stresses versatility, strength, and lack of maintenance of concrete versus timber for support.

Keyword(s): roof support

Crane, W. R. Subsidence and its Relation to Drainage in the Red Iron Mines of the Birmingham District, Alabama. Transactions, AIME, v. 75, 1927, New York, p. 837-872.

Cave-ins near the outcrop and fracturing of the surface were the most pronounced manifestations of disturbance by the red-ore mines of the Birmingham District. Because the orebed was overlain by water-bearing formations, fracturing of the top rock was important enough to warrant adoption of protective measures.

Keyword(s): metal mining, subsurface water

Alabama, United States

Crane, W. R. Subsidence and Ground Movement in the Copper and Iron Mines of the Upper Peninsula, Michigan. U.S. Bureau of Mines B 295, 1929, 66 p.

Keyword(s): surface subsidence damage, metal mining

Location(s): Michigan, United States

Crane, W. R. Essential Factors Influencing Subsidence and Ground Movement. U.S. Bureau of Mines IC 6501, 1931, 14 p.

The author assesses joints and faulting in a mining area to predict possible subsidence.

Keyword(s): angle of draw, prediction, geologic features

Location(s): United States

Creveling, J. B. Factors Affecting the Strength of Subcoal Materials and the Prediction of Strength from Index Properties. M.S. Thesis, University of Missouri-Rolla, 1976.

Keyword(s): floor stability, lab testing, coal mining

Crook, J. M., D. P. McNicholl. The Monitoring of Ground Movements Due to Deep Coal Mining and Their Implications for Large-Scale Development Proposals at Warrington New Town (UK). IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 527-544.

Warrington New Town was designated in 1968, and it is planned to increase the population to 190,000 by 1991. Approximately 30% of the New Town area would be subject to underground mining and associated ground movements would represent a constraint both in terms of the timing of development in areas undergoing active subsidence and the type and form of developments in areas to be undermined in the future. To be able to commit development in the mining areas with confidence, a systematic approach to the problem was adopted.

Keyword(s): coal mining, instrumentation, monitoring design, monitoring methods, land-use planning, surface structural damage, abandoned mines, active mines

Location(s): United Kingdom

Crossfield, J. K. Ground Settlement Monitoring by Digital Photogrammetry. IN: Proceedings, 45th Annual Meeting of American Society of Photogrammetry, Washington, D.C., March 18-24, 1979, p. 600-606.

Keyword(s): monitoring equipment, monitoring methods

Location(s): United States

Crouch, S. L., C. Fairhurst. The Mechanics of Coal Mine Bumps and the Interaction Between Coal Pillars, Mine Roof, and Floor. U.S. Bureau of Mines OFR-53-73, February 22, 1973, 97 p. (NTIS PC A05/MF A01)

This report describes research done on the mechanics of coal mine bumps over a 26-month period.

Keyword(s): room-and-pillar, bumps, pillar strength, floor stability, roof stability, coal mining
Location(s): United States

Crouch, S. L. Two-Dimensional Analysis of Near-Surface Single-Seam Extraction. International Journal of Rock Mechanics and Mining Sciences and Geomechanics Abstracts, v. 10, no. 2, March, 1973, p. 85-96.
This paper describes a digital computer method for calculating the stresses and displacements induced by underground excavations in a single flat-lying seam that is arbitrarily near the surface of the earth. The method is developed by superposition from solutions previously given for a displacement discontinuity, or dislocation, in an otherwise continuous, linearly elastic, infinite rock mass. The new solution can be applied to complicated extraction patterns in the plane of a seam in a semi-infinite mass, the surface of which can be subjected to arbitrary prescribed extractions.
Keyword(s): phenomenological model, elastic model, modeling, rock mechanics

Crouch, S. L., C. Fairhurst. Analysis of Rock Mass Deformations Due to Excavations. IN: Rock Mechanics Symposium, Winter Annual Meeting of American Society of Mechanical Engineers, Detroit, November 11-15, 1973, D.L. Sikarskie, ed., American Society of Mechanical Engineers, New York, p. 25-40.
The major difficulty in attempting to calculate stresses and displacements caused by underground excavations is that the material characteristics and detailed geologic structure of the rock mass usually are unknown. The ideas presented in this paper are based on the assumptions that the rock mass can be characterized as a linearly elastic material and that any nonlinear behavior is confined to the immediate vicinity of the excavations or to any known major structural features within the mass.
Keyword(s): geologic features, rock mechanics, engineering, surface structural damage, modeling

Crowell, D. L. Drilling for Mine Subsidence Mitigation. Ohio Mineral Industries Report, 1990, Ohio Department of Natural Resources, Division of Geological Survey, 7 p.
The Ohio Geological Survey completed a 39-hole drilling project as part of a mine-subsidence mitigation investigation. The U.S. Office of Surface Mining provided funding to devise the mitigation plan. Part of this plan required holes to be drilled into the Wellston mine complex to determine the extent of mining activity and the progress of subsidence under that portion of the city with the greatest number of subsidence complaints.
Keyword(s): abandoned mines, mitigation, coal mining, geotechnical, historical, surface structural damage
Location(s): Ohio, United States

Culshaw, M. G., A. C. Waltham. Natural and Artificial Cavities as Ground Engineering Hazards. Quarterly Journal of Engineering Geology, 20, 1987, p. 139-150.
Keyword(s): geologic features, engineering, land-use planning

Culshaw, M. G., F. G. Bell, J. C. Cripps, M. O'Hara, eds. Planning and Engineering Geology. Geological Society Engineering Geology Special Publication No. 4, Proceedings of Conference, 1987, 641 p.
The papers in this symposium review the relationship between planning and engineering geology and its development in response to increasing public awareness of environmental conservation and restoration needs.
Keyword(s): engineering, abandoned mines, land-use planning, coal mining, non-metal mining, remote sensing, geophysical, hydrology, prediction
Location(s): United Kingdom, Jamaica, China

Culshaw, M. G., P. D. Jackson, D. M. McCann. Geophysical Mapping Techniques in Environmental Planning. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 171-177.
Geophysical information can be used to identify geological features, some of which may be a problem during the planning, design, or construction of a new development.
Keyword(s): abandoned mines, geophysical, seismic, roads
Location(s): United Kingdom

Culver, H. E. Coal Resources of District III (Western Illinois). Illinois State Geological Survey, Mining Investigation Bulletin 29, 1925, 128 p.
Keyword(s): coal mining, historical
Location(s): Illinois, Illinois Coal Basin, United States

Culver, H. E. Coal Resources of District III. Illinois State Geological Survey, Mining Investigation Bulletin 29, 1925, 128 p.
    Keyword(s): coal mining, historical
    Location(s): Illinois, Illinois Coal Basin, United States

Cummings, R. A., M. M. Singh. Investigation and Abatement of Subsidence Damage at the Heltsley Residence, Indiana. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 65-71.
    In April 1984 a subsidence depression formed directly beneath a two-story frame residence near Linton, IN, causing 2 ft of separation between the floor and walls, and damaging both the foundation and interior of the building. The Office of Surface Mining undertook the rehabilitation of the area under its emergency response program. This paper describes the investigation performed to determine the cause, severity, and extent of the problem. Abandoned mine workings were found approximately 55 to 60 feet below the house. Based on the findings, remedial measures were prescribed. An abatement program consisting of grouting the mine voids was recommended, and specifications prepared. These were implemented, and the area has been successfully stabilized.
    Keyword(s): surface structural damage, structural mitigation, abandoned mines, grouting, coal mining, geotechnical, geologic features, room-and-pillar, subsurface water, foundations
    Location(s): Indiana, Illinois Coal Basin, United States

Cundall, P.A. A Computer Model for Simulating Progressive Large Scale Movements in Blocky Rock Systems. IN: Proceedings International Symposium on Rock Mechanics, 1971, 8 p.
    Keyword(s): computer, prediction, rock mechanics, modeling

Curth, E. A. Relative Pressure Changes in Coal Pillar During Extraction: A Progress Report. U.S. Bureau of Mines RI 6980, July 1967, 20 p.
    Keyword(s): pillar strength, in situ testing, coal mining
    Location(s): United States

Curth, E. A. Roof Support Problems in Longwall Mining: A Study in the United States and Germany in 1971. IN: Proceedings U.S. Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, Ground Control Aspects of Coal Mine Design, U.S. Bureau of Mines IC 8630, 1974, p. 101-114.
    Observations at 12 selected longwall operations in the United States indicated that roof control at the face was achieved even under adverse conditions. A study in Germany included 25 mine trips and the Essen Research Center's techniques for the evaluation of roof and support.
    Keyword(s): roof support, longwall, roof stability, coal mining
    Location(s): West Virginia, Virginia, Pennsylvania, Appalachian Coal Region, United States, Germany, Europe

Curth, E. A., M. D. Cavinder. Longwall Mining the Herrin No. 6 Coalbed in Southern Illinois. IN: Proceedings, Illinois Mining Institute, 1977.
    In April 1975, the USBM awarded a cost-sharing contract to Old Ben Coal Co. with the objective of demonstrating that the Herrin Coal in southern Illinois can be mined by longwall methods using shield-type roof supports. Earlier attempts at longwalling using chocks ended in failure.
    Keyword(s): longwall, coal mining, geologic features, rock mechanics, roof support
    Location(s): Illinois, Illinois Coal Basin, United States

Curth, E. A. Safety Aspects of Longwall Mining in the Illinois Coal Basin. U.S. Bureau of Mines IC 8776, 1978, 37 p.
    Keyword(s): The USBM and Old Ben Coal Co. participated in a cost-sharing contract to demonstrate longwall mining in the Herrin No. 6 coalbed in southern Illinois. A premining investigation laid the groundwork for specifying a roof-support system designed to control hazardous ground. Lemiscate-type roof shields were selected. A rock mechanics program and geological mapping provided early warning capability and criteria for equipment design. The effect of mining on the surface was monitored by a surface survey to develop subsidence-prediction criteria for the Illinois coal basin. The major adverse condition was the occurrence of limestone concretions, called coal balls, in massive pods. The shields provided adequate roof control even in faulty ground. The accident rate was low.
    Keyword(s): longwall, mine operation, coal mining, mine safety, survey methods
    Location(s): Illinois, Illinois Coal Basin, United States

Curth, E. A. Design of Longwall Mining Systems. IN: Proceedings 1st Conference on Ground Control Problems in the Illinois Coal Basin, Southern Illinois University at Carbondale, August 22-24, 1979, Y.P. Chugh and A. Van Besien, eds., 1980, p. 165-207.

The Illinois Coal Basin contains significant reserves and is one of the important coal-producing provinces in the United States in close proximity to consumers. Room-and-pillar methods are prevalent, with the result that the average coal recovery approximates 50% and roof control is difficult. The alternative is longwall mining, with the potential for better ground control, generally easier compliance with safety standards, improved productivity and higher resource recovery.

Keyword(s): coal mining, longwall, mine design, finite element, economics

Location(s): Illinois, Illinois Coal Basin, Pennsylvania, United States

Cyrul, T., Z. Kleczek, A. Zorychta. Certain Polish Experiences in Controlling and Predicting the Surface Subsidence Due to Mining. SME-AIME Preprint No. 86-82, for presentation at the SME Annual Meeting, New Orleans, LA, March 2-6, 1986, 9 p.

Poland has achieved high coal production despite unfavorable mining and geological conditions by introducing new and original solutions to the mining practice. This paper deals only with surface subsidence and protection against mining influences in the Upper Silesian Coalfield.

Keyword(s): longwall, surface structural damage, mine design, pillar extraction, geologic features, coal mining

Location(s): Poland

Da Costa, A. M., C. Fairhurst. Comparison of Numerical Modeling with Predictions from Laboratory Tests and Field Observations of Deformation in a Potash Mine in Sergipe, Brazil. IN: Proceedings 26th U.S. Symposium on Rock Mechanics, Rapid City, SD, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, 1985, p. 239-249.

This paper examines the application of two numerical methods (the finite element method and the displacement discontinuity method) to practical examples in the simulation of the behavior of mining excavations in the Taquari-Vassouras Mine in Brazil.

Keyword(s): modeling, finite element, computer, rock mechanics, lab testing, in situ testing, non-metal mining

Location(s): Brazil

Daemen, J. The Effect of Protective Pillars on the Deformation of Mine Shafts. Rock Mechanics, v. 4, No. 2, October, 1972.

Keyword(s): pillar strength, mine design, rock mechanics

Daemen, J. J. K., M. Hood. Subsidence Profile Functions Derived from Mechanistic Rock Mass Models. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 124-139.

This paper considers the first phase of an assessment of the use of mechanistic subsidence models, namely the possibilities and problems associated with estimating the large-scale rock parameters needed to use some of the elastic solutions for subsidence calculations by treating the solutions as profile functions.

Keyword(s): vertical displacement, horizontal displacement, empirical model, modeling, profile function

Dahl, H. D. Mine Subsidence as a Problem in Coulomb Plasticity. M.S. Thesis, Pennsylvania State University, State College, 1967, 84 p.

Keyword(s): modeling, phenomenological model, plastic model

Dahl, H. D. A Finite Model for Anisotropic Yielding in Cavity Loaded Rock. Ph.D. Dissertation, Pennsylvania State University, 1969, 155 p.

Keyword(s): modeling

Dahl, H. D., R. C. Parsons. Ground Control Studies in the Humphrey No. 7 Mine of Christopher Coal Division, Consolidation Coal Company. AIME Centennial Annual Meeting, New York, NY, 1971, AIME Preprint 71-AM-101.

A comprehensive research effort was directed toward improving ground stability in the Humphrey and nearby mines having similar roof conditions.

Keyword(s): ground control, roof stability, coal mining

Location(s): United States

Dahl, H. D. Two and Three Dimensional Elastic-Elastoplastic Analyses of Mine Subsidence. IN: Proceedings 5th International Strata Control Conference, 1972, Paper No. 28, 5 p.

The author discusses finite element models used to simulate subsidence phenomena and correlates the results obtained to field data from Britain and the United States. The U.S. data are from observations over mines in western Pennsylvania and West Virginia.

Keyword(s): continuum mechanics, finite element, phenomenological model, elastic model, plastic model, modeling

Location(s): England, Pennsylvania, West Virginia, Appalachian Coal Region, United States

Dahl, H. D., R. C. Parsons. Ground Control Studies in the Humphrey No. 7 Mine, Christopher Coal Division, Consolidation Coal Company. Transactions AIME, v. 252, 1972, p. 211-222.

To improve roof stability, Continental Oil Company's research program, initiated in 1969, was directed toward defining the geological parameters that affect the severity of roof conditions in any particular area of the mine. In addition, the program was seeking to define why roof falls in the Humphrey No. 7 mine (and in northern West Virginia-southwestern Pennsylvania coal mining areas) are oriented so that they occur primarily in north-south rooms or entries. Conclusions and recommendations from this study of roof fall orientation are given.

Keyword(s): coal mining, roof stability, geologic features

Location(s): West Virginia, Pennsylvania, Appalachian Coal Region, United States

Dahl, H. D., D. S. Choi. Measurement and Prediction of Mine Subsidence Over Room and Pillar Workings in Three Dimensions. IN: Proceedings AIME Annual Meeting, Dallas, TX, February 23-28, 1974.

Subsidence data are compiled for a mine practicing modified room-and-pillar extraction in a flat seam, 6 feet thick and 500 to 600 feet deep in the eastern United States. Overlying topography is rugged. A three-dimensional mathematical model was used to duplicate observed effects. The model assumes subsidence is a result of deformation governed by elastic-frictional plastic stress-strain relationships. Good agreement between observed and modeled effects are obtained. Discussion of observed effects is included.

Keyword(s): prediction, modeling, mathematical model, coal mining, room-and-pillar

Location(s): Appalachian Coal Region, United States

Dahl, H. D., D. S. Choi. Some Case Studies of Mine Subsidence and Its Mathematical Modeling. IN: Proceedings, 15th U.S. Rock Mechanics Symposium, Custer State Park, SD, September 17-19, 1973, E.R. Hoskins, Jr., ed., ASCE, 1975, p. 1-21.

Ground movements have been monitored over mines in southwest Pennsylvania in which coal is produced both by room-and-pillar and longwall methods. Three-dimensional contour maps of subsidence have been obtained in which face position is considered an independent variable. These field data are compared with a three-dimensional analytical model incorporating a frictional yield criteria in the constitutive relation. In addition, the effect of topography on subsidence is presented and discussed.

Keyword(s): vertical displacement, mathematical model, prediction, longwall, room-and-pillar, survey data processing, modeling, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Dahl, H. D., H. A. VonSchonfeldt. Rock Mechanics Elements of Coal Mine Design. IN: Site Characterization, Proceedings 17th U.S. Symposium on Rock Mechanics, Snowbird, UT, August 25-27, 1976, W.S. Brown, S.J. Green, and W.A. Hustrulid, eds., University of Utah, Salt Lake City, p. 4A1-4A9.

The purpose of this paper is to outline some of the design techniques being used in industry for improved roof and ground control. The discussion is restricted to coal mining in single, more or less horizontal, seams. It covers a basic analysis concept that can be applied to the design of longwall development headings, to recommend pillar extraction schemes, to the caving properties of the overburden over longwall panels, subsidence prediction and the design of long-term main entries.

Keyword(s): coal mining, rock mechanics, mine design, longwall, pillar extraction, prediction

Location(s): United States

Damberger, H. H. Analysis of Geological Structures That Influence Roof Stability in Room and Pillar Mines in the Herrin (No. 6) Coal Member, Ill. Presented at the 1976 AIME Annual Meeting, Las Vegas, NV, February 24, 1976.

Keyword(s): roof stability, ground control, room-and-pillar, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Damberger, H. H., W. J. Nelson, H.-F. Krausse. Effect of Geology on Roof Stability in Room-and-Pillar Mines in the Herrin (No. 6) Coal of Illinois. Illinois State Geological Survey Reprint 1980-P, 1980. Reprinted from Proceedings of 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Y.P. Chugh and A. Van Besien, eds., Southern Illinois University, Carbondale, 1980, p. 14-32.

Keyword(s): roof stability, room-and-pillar, ground control, coal mining, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Damberger, H. H., W. J. Nelson, H.-F. Krausse. Effect of Geology on Roof Stability in Room-and-Pillar Mines in the Herrin (No. 6) Coal of Illinois. IN: Proceedings 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Y.P. Chugh and A. Van Besien, eds., Southern Illinois University, Carbondale, 1980, p. 14-32.

Roof stability in underground mines in the Herrin Coal is dependent upon the lithology and geologic structure of the rocks overlying the coal.

Keyword(s): roof stability, coal mining, active mines, geologic features, room-and-pillar

Location(s): Illinois, Illinois Coal Basin, United States

Dames and Moore. Rock Mechanics Studies, United States Bureau of Mines Longwall Demonstration, Old Ben Mine, No. 24, Benton, Illinois; Phase III--Preliminary Report, Panel 1. Job No. 07734-002-07, 1977.

Keyword(s): rock mechanics, longwall, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Daniels, J., L. D. Moore. The Ultimate Crushing Strength of Coal. Engineering and Mining Journal, v. 10, August, 1907, p. 263-268.
Keyword(s): pillar strength, coal mining

Darmody, R. G., I. J. Jansen, S. G. Carmer, J. S. Steiner. High Extraction Mining: Effects on Corn Yields. IN: Proceedings National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, Springfield, IL, December 7-11, 1987, Office of Engineering Services, University of Kentucky, Lexington, p. 203-208.
The impact of coal mine subsidence-induced effects on corn yields in 1985 and 1986 in Illinois was investigated. The study areas were photographed from the air, and areas deemed to have subsidence-induced effects were delineated on the photos after photo analysis. Sites for corn yield sampling were harvested in the fall of each year.
Keyword(s): agriculture, coal mining, active mines, longwall, high-extraction retreat, photography, subsidence research
Location(s): Illinois, Illinois Coal Basin, United States

Darmody, R. G., I. J. Jansen, S. G. Carmer, J. S. Steiner. Effects of Coal-Mine Subsidence on Corn Yields in Illinois. IN: Agronomy Abstracts, Proceedings 79th Annual Meeting of American Society of Agronomy, Atlanta, GA, November 29-December 4, 1987 p. 25.
The effect on corn yields of underground coal mine induced subsidence was studied in Illinois. Two types of coal mines with planned subsidence were studied, longwall and high-extraction retreat. Subsided areas were inventoried by means of aerial photography. Areas with obvious increase in soil wetness or with change in topography due to mining were marked on the photos. Corn yields were sampled in the fall of each year. Although the overall reduction in yield was slight, when calculated on a weighted area average basis, areas associated with longwall mining had significantly greater decrease in yield than did areas associated with high-extraction retreat mining.
Keyword(s): agriculture, high-extraction retreat, longwall, photography, soils
Location(s): Illinois, Illinois Coal Basin, United States

Darmody, R. G., J. S. Steiner, I. J. Jansen, S. G. Carmer. Agricultural Impacts of Coal Mine Subsidence: Evaluation of Three Assay Methods. Journal of Environmental Quality, v. 17, No. 3, 1988, p. 510-513.
A microcomputer and spread sheet program were used to store and analyze data from a collection of maps and aerial photographs in a research project concerning the agricultural impacts of underground coal mine induced subsidence. The overall objective of the research project was to assess the damage to agricultural production caused by underground coal mine subsidence. The work reported here details the development and evaluation of the method used to meet the overall objective.
Keyword(s): survey data processing, computer, subsidence research, photography, agriculture
Location(s): Illinois, Illinois Coal Basin, United States

Darmody, R. G., I. J. Jansen, S. G. Carmer, J. S. Steiner. Agricultural Impacts of Coal Mine Subsidence: Effects on Corn Yields. Journal of Environmental Quality, v. 18, no. 3, July-September, 1989, p. 265-267.
Underground coal mining methodology is moving toward techniques that cause immediate planned subsidence of the overlying land. Damage done by subsidence to structures has been documented, but the effects on agricultural productivity are undocumented. This study was conducted to (1) determine the extent of measurable subsidence effects associated with planned subsidence mining, (2) measure the impact of subsidence on corn yield, and (3) compare the effects of longwall and high extraction retreat mining methods. Five locations in southern Illinois were included in the 3-year study.
Keyword(s): agriculture, coal mining, active mines, longwall, high-extraction retreat
Location(s): Illinois, Illinois Coal Basin, United States

Darmody, R. G., F. W. Simmons, T. J. Bicki, S. D. Harding. Coal Mine Subsidence Effects on Soils and Hydrology. IN: Agronomy Abstracts, American Society of Agronomy 81st Annual Meeting, October 15-20, 1989, Las Vegas, NV, p. 261.
Research was undertaken to determine the effects of coal mine subsidence on soils and hydrology in southern Illinois. Areas to be undermined by planned subsidence types of mines were characterized prior to mining. Soil

investigation pits were excavated to allow profile description and collection of samples for bulk density, saturated hydraulic conductivity, particle size, shear strength, and penetrometer resistance. Saturated hydraulic conductivity was also determined in the field by means of a Bouwer double tube hydraulic conductivity device. Piezometers were installed at various depths.

Keyword(s): agriculture, soils, hydrology, active mines, coal mining, longwall, high-extraction retreat

Location(s): Illinois, Illinois Coal Basin, United States

Darmody, R. G., T. J. Bicki. Use of Civil Engineering Fabrics in Pedological Field Research. Soil Science Society of America Journal, v. 53, no. 6, November-December 1989, p. 1912.

During the course of a field research project involving the effects of mine subsidence on soils in southern Illinois, the need to routinely re-examine pedons from soil pits was realized.

Keyword(s): agriculture, soils, in situ testing, coal mining, active mines

Location(s): Illinois, Illinois Coal Basin, United States

Darmody, R. G. Illinois Mine Subsidence Research Program: The Agronomic Contributions. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 119-129.

This paper describes three agronomic projects to investigate the impact of coal mine subsidence on agriculture: an assessment of the impact of coal mine subsidence on corn yields, an evaluation of subsidence mitigation, and an evaluation of the direct impact of subsidence on agricultural soils.

Keyword(s): agriculture, active mines, coal mining, mitigation, soils, hydrology, subsidence research

Location(s): Illinois, Illinois Coal Basin, United States

Darmody, R. G., R. T. Hetzler, F. W. Simmons. Coal Mine Subsidence: The Effect of Mitigation on Crop Yields. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 183-188.

Longwall coal mining in southern Illinois occurs beneath some of the best agricultural land in the United States. This region is characterized by highly productive, nearly level, and somewhat poorly drained soils. Subsidence from longwall mining causes changes in surface topography, which alters surface and subsurface hydrology. These changes can adversely affect agricultural land by creating wet or ponded areas that can be deleterious to crop production. Although most subsided areas showed little impact from subsidence, some areas experience total crop failure. Coal companies are required by law to mitigate subsidence damage to cropland. The objective of this study was to test the effectiveness of mitigation in restoring grain yields to their pre-mined levels.

Keyword(s): agriculture, land mitigation, active mines, longwall, coal mining, hydrology, subsurface water, soils, reclamation

Location(s): Illinois, Illinois Coal Basin, United States

Darmody, R. G., R. T. Hetzler, F. W. Simmons. Coal Mine Subsidence: Effects of Mitigation on Crop Yields. International Journal of Surface Mining and Reclamation, 6, 1992, p. 187-190.

Subsidence from longwall underground coal mining adversely impacts agricultural land by creating wet or ponded areas. Although most subsided areas showed little impact, some areas, usually less than 1.5 ha in size, may experience total crop failure. Coal companies mitigate subsidence damaged cropland by installing drainage waterways or by adding fill material to raise the grade. The objective of this study was to test the effectiveness of mitigation in restoring corn and soybean yields to pre-mined levels. Fourteen sites in southern Illinois were selected for study. Corn and soybean yields from mitigated and nearby undisturbed areas were compared for 4 years. Results varied due to differing weather and site conditions. Mean corn yields overall, however, were significantly lower on mitigated areas. There was no significant difference in overall mean soybean yields. Soil fertility levels were similar and did not account for yield differences.

Keyword(s): agriculture, land mitigation, coal mining, longwall, active mines, soils

Location(s): Illinois, Illinois Coal Basin, United States

Darn, D. Predicting and Evaluating Subsidence with the Carbs Eagle. Lands & Mineral Surveying, v. 5, no. 11, November 1987, p. 594-597.

Predicting the degree of subsidence likely to be caused by mining has always been based on "rule of thumb" calculations using various formulas that relate to the zone of influence and the depth of the workings. Computer aided design now gives much more accurate results. The author explains the development and function of the Carbs Eagle software package, both in general terms and in its application for tracking and predicting subsidence. The program can be used for all types of underground extraction that may affect the surface and also for surface modeling applications in quarrying, tunnelling, and civil engineering.

Keyword(s): prediction, modeling, computer, coal mining, metal mining, tunnelling, survey data processing, geologic features, overburden, active mines, engineering, land-use planning

Location(s): United Kingdom

Darton, N. H. Notes on Sand for Mine Flushing in the Scranton Region. U.S. Bureau of Mines B 25, 1912, p. 72.

This bulletin deals with the history and condition of mining operations in the Scranton, Pennsylvania, area.

Keyword(s): backfilling, coal mining, historical

Location(s): Pennsylvania, Appalachian Coal Region, United States

Das, B., V. Singh. Theoretical Investigation Into the Angle of Break in Relation to the Depth. Journal of Mines, Metals and Fuels, v. 21, April, 1973, p. 110-112.

Keyword(s): modeling

Das, M. N., D. Barat, R. K. Prasad, P. R. Sheorey. Considerations for Influence of Overburden Depth on Coal Strength. IN: Proceedings, International Symposium on Underground Engineering, New Delhi, India, April 14-17, 1988, B. Singh, ed., Balkema, Rotterdam, p. 55-60.

As reported elsewhere, a large number of in situ strength data for Indian coal seams, when plotted against depth, show a downward trend indicating that the in situ strength is underestimated at depth because testing is generally done in the failed rock zone. An increase in the depth of cover increases the failure zone, causing more deteriorated rock to be tested. In the case of small scale laboratory strength, the influence of depth is insignificant except at greater depth. Further systematic investigations were carried out in a single seam at Barmondia Colliery to confirm the findings more conclusively.

Keyword(s): in situ testing, lab testing, pillar strength, coal mining, overburden, rock mechanics

Location(s): India

Daunesse, C., Y. Reimbaud. The Mining Subsidence in the Nord and Pas-de-Callius Coalfield. Ann. Mines, October, 1963, p. 589-633 (in French).

Location(s): France

Davies, B. L., R. Smith. The Influence of Coal Mining on Maintenance, Design and Construction of Highway Bridges and County-Owned Structures in South Yorkshire (UK). IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 545-561.

This paper describes the approach taken by the South Yorkshire County in establishing an internal mining adivsory service. It discusses the evolution of a policy in regard to the protection of the County's interests in those structures, whether highway or building for which the County has a direct responsibility, and gives examples of mining related problems that it has dealt with during the first 3 years of its existence.

Keyword(s): construction, surface structural damage, structural mitigation, coal mining, roads, National Coal Board, active mines, abandoned mines

Location(s): United Kingdom

Davies, J. B. A Novel Method of Conveying Culm into Old Workings to Support the Roof. Colliery Engineering, v. 14, August, 1893, p. 11.

This article describes a method of introducing culm and water at the Black Diamond Colliery, near Kingston, PA.

Keyword(s): backfilling, hydraulic backfilling, mine waste

Location(s): Pennsylvania, Appalachian Coal Region, United States

Davies, J. D. Circular Tanks on Ground Subject to Mining Subsidence. Civil Engineering and Public Works Review, London, v. 55, no. 648, 1960, p. 918-920.

Keyword(s): surface structural damage

Location(s): England

Davis, G. H. Formation of Ridges Through Differential Subsidence of Peatlands of the Sacramento San Joaquin Delta, California. U.S. Geological Survey Professional Paper 475-C, 1963, p. 162-165.

Keyword(s): geologic features

Location(s): California

Davis, G. H. Land Subsidence Related to Head Decline at Baton Rouge, Louisiana. Geological Society of America, Special Paper 101, (abstract), 1968, p. 354.
Keyword(s): fluid extraction, subsurface water
Location(s): Louisiana, United States

Davis, G. H., H. B. Counts. Further Examination of Subsidence at Savannah, Georgia, 1955-1975. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, December 13-17, 1976, International Association of Hydrological Sciences, Publication No. 121, Washington, D.C., 1977, p. 347-354.
Keyword(s): hydrology
Location(s): Georgia, United States

Davis, G. H. Land Subsidence and Sea Level Rise on the Atlantic Coastal Plain of the United States. Environmental Geology and Water Sciences, 10, 1987, p. 67-80.
Keyword(s): surface water, geologic features
Location(s): United States

Davis, P. K. Model Studies for Optimum Hydraulic Backfilling of Underground Coal Mines Through Boreholes for Subsidence Control. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990,Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 345-359.
Research on the feasibility of disposing of a slurried mixture of flue gas desulfurization sludge and fly ash in abandoned underground mines has been ongoing since 1985. In addition to disposing of this waste material in an environmentally acceptable manner, it was anticipated that another significant advantage to this method would be subsidence prevention.
Keyword(s): modeling, hydraulic backfilling, coal mining, mine waste, abandoned mines, literature search
Location(s): Illinois, Illinois Coal Basin, United States

Davis, S. N., F. L. Peterson, A. D. Halderman. Measurement of Small Surface Displacements Induced by Fluid Flow. Water Resource Research, v. 5, 1969, p. 129-138.
Keyword(s): fluid extraction, survey methods

Dawson, R. F. Land Subsidence Problems. IN: Proceedings ASCE Surveying and Mapping Division, v. 89, no. SV2, Paper 3531, June, 1963, p. 1-12.
Regional subsidence occurred in the Texas Gulf Coast area due to oil and groundwater withdrawal, resulting in consolidation of clay strata by increasing intergranular pressure.
Keyword(s): fluid extraction, surface water, subsurface water, hydrology
Location(s): Texas, United States

Dawson, R. F. Land Subsidence Problems. IN: Proceedings ASCE Journal of Surveying and Mapping Division, v. 91, no. SU1, 1965, p. 53-54.

Dean, J. W. Old Mine Shafts and Their Hazards. The Mining Engineer, London, March, 1967, v. 126, no. 78, p. 368-377.
Keyword(s): abandoned mines, historical

Dearman, W. R., A. Strachan, D. P. Roche, C. Vincett. Influence of Mining Subsidence on Pipelines. Bulletin of the International Association of Engineering Geologists, 25, 1982, p. 19-24.
Keyword(s): pipelines, utilities

Decherf, J., A. Vandewalle, A. Caron. Le Probleme des Affaissements Miniers Dams le Bassin du Nord-Pas-de-Calais (Problem of Mine Subsidence in the Nord-Pas-de-Calais Basin). Industrie Minerale, St. Etienne, France, v. 62, no. 5, 1980, p. 295-313.
Location(s): France

Deere, D. U., A. J. Hendron, F. D. Patton, E. J. Cording. Design of Surface and Near-Surface Construction in Rock. IN: Failure and Breakage of Rock, Proceedings 8th Symposium on Rock Mechanics, University of Minnesota, September 15-17, 1966, C. Fairhurst, ed., AIME, New York, p. 237-302.
In designing a structure founded in near-surface rock, the authors think that evaluating the engineering properties of the rock mass is one of the most important steps. This paper emphasizes the determination of the engineering properties of the in situ rock mass, both the deformation modulus and shear strength, although not to the exclusion of other aspects of the problem of rock behavior and engineering design.
Keyword(s): mine design, rock mechanics, geotechnical, tunnelling, lab testing

Deere, D. V. Subsidence Due to Mining--A Case History from the Gulf Coast Region of Texas. IN: Proceedings 4th Symposium on Rock Mechanics, State College, PA, March 30-April 2, 1961, Bulletin

Mineral Industry Experiment Station, v. 76, The Pennsylvania State University, p. 59-64.

Sulfur extraction by the Frasch process from the cap rock of numerous salt domes in the Gulf Coast Region of the United States has produced subsidence of the surface over mining areas. A record of measurements of the surface subsidence and the associated horizontal movements extending over a period of 2.5 years is presented from an operation in Texas.

Keyword(s): non-metal mining, survey data processing, monitoring methods, horizontal displacement

Location(s): Texas, United States

Degirmenci, N., D. J. Reddish, B. N. Whittaker. A Study of Surface Subsidence Behaviour Arising from Longwall Mining of Steeply Pitching Coal Seams. IN: Proceedings, 6th Coal Congress, Zonguldak, Turkey, May, 1988, 27 p.

Keyword(s): longwall, coal mining, vertical displacement, geologic features

Degraff, J. V. Selected Bibliography on Land Subsidence. U.S. Department of Agriculture, R-4 Intermountain Region, G-R-4-78-2, February 8, 1978, 25 p.

Land subsidence associated with extractions of solids or fluids creates serious land management problems. In an effort to provide a source of information on specific aspects of this phenomena, this bibliography was compiled. The citations were compiled from government articles, books, and recent journals. Most of the references are from 1960 to 1977. All references to subsidence due to wetting or applicatiion of fluids were excluded. The bibliography is divided into two sections: (1) extractions of solids and (2) extractions of fluids. This dichotomy reflects the differences in extent and effect of subsidence resulting from these two actions.

Keyword(s): literature search, coal mining, metal mining, non-metal mining, fluid extraction

Location(s): United States

Degroot, H. P., A. MacDonald. Experimental Stoping on the No. 5 Seam, Greenside Colliery. South African Journal Institute of Mine Surveying, v. 21, no. 1, March 1981, p. 120-128.

Keyword(s): backfilling, coal mining

Location(s): South Africa

Dehasse, L. Raising Buildings Sunk by Mine Subsidence. Revue Universelle des Mines, October, 1935; also Colliery Guardian, v. 152, 1936, p. 103.

This paper recommends that buildings constructed in subsidence-susceptible areas should be designed such that they can be readily raised to their original level.

Keyword(s): surface structural damage, structural mitigation, construction

DeJean, M., J. P. Lamy. Utilisation de l'Ordinateur Pour la Prevision des Affaissements Dans les Houilleres du Bassin du Nord et du Pas-De-Calais (Subsidence Prediction by Computer in the Collieries of the North and Pas-De-Calais Coal Basin). Industrie Minerale, St. Etienne, France, no. 3, 1975, Supplement to June 1975, p. 335-338.

Keyword(s): prediction, computer

Location(s): France

DeJean, M. J. P., F. Martin. Amplitude of Subsidence of Underground Openings Subject to the Influence of Mining Adjacent and Below. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute of Mining and Metallurgy, Illawara Branch, Paper 4, p. 4-1- 4-7.

An underground opening situated above a mined seam is subject to subsidence and deformations. This subsidence can only be measured if deformations remain slight, but this only occurs above the worked area. For this reason this study is confined to this aspect of underground work. Two types of models of behavior were considered. Comparison with experimental results shows that actual values lie somewhere between those indicated by the two theories considered.

Keyword(s): multiple-seam extraction, modeling, coal mining, longwall

Location(s): France

DeLong, R. M. Coal-Mine Subsidence in Ohio. Ohio Geology Newsletter, Fall 1988, Ohio Department Natural Resources, Division of Geological Survey, Columbus OH, 4 p.

For more than a century and a half, underground coal mining has been an active industry in eastern Ohio. During this period, about 4,000 underground mines, ranging in size from a few acres to several square miles, have honeycombed the surface. Several generations of coal mining have left us with both a tradition of mining and a legacy of abandoned mines from the "pick and shovel" era. Now, with an expanding population and its demand on space, the problems inherent in this legacy of abandoned mines are being investigated. One of the problems at the forefront is that of mine subsidence--caving or distortion of the ground surface due to collapse of underground mine workings. The cost of repairing damage to homes and other structures due to mine subsidence can total tens of thousands of dollars.

Keyword(s): surface structural damage, coal mining, abandoned mines, room-and-pillar, historical, structural mitigation, reclamation, roads, backfilling, grouting, insurance

Location(s): Ohio, United States

DeMarco, M. J., J. R. Koehler, P. H. Lu. Characterization of Chain Pillar Stability in a Deep Western Coal Mine - Case Study. Preprint no. 88-76, for presentation at the SME Annual Meeting, Phoenix, AZ, January 25-28, 1988, 12 p.

Beginning in late 1985 and continuing through 1987, USBM personnel investigated longwall chain pillar and entry design in two- and three-entry gateroad systems at a deep underground coal mine in central Utah. To evaluate their respective stability characteristics, four chain pillars and two longwall panels within the two separate entry systems were instrumented with USBM hydraulic borehole pressure cells to continuously monitor vertical and horizontal pillar and panel stresses through adjacent panel retreat. In addition, supplemental entry closure information was obtained from sites located in the vicinity of the instrumented pillars. The findings presented in this report demonstrate the practicality of evaluating mine pillar stability using in situ methods.

Keyword(s): pillar strength, coal mining, mine design, mine safety, in situ testing, longwall, instrumentation, monitoring equipment, ground control

Location(s): Utah, Rocky Mountain Coal Region, United States

DeMarco, M. J., J. R. Koehler, P. H. Lu. Characterization of Chain Pillar Stability in a Deep Western Coal Mine--A Case Study. Mining Engineering, December, 1988, p. 1115-1119.

Beginning in late 1985 and continuing through 1987, USBM personnel investigated longwall chain pillar and entry design in two and three-entry gateroad systems at a deep underground coal mine in central Utah. To evaluate their respective stability characteristics, four chain pillars and two longwall panels within the two separate entry systems were instrumented with USBM hydraulic borehole pressure cells to continuously monitor vertical and horizontal pillar and panel stresses through adjacent panel retreat. In addition, supplemental entry closure information was obtained from sites located in the vicinity of the instrumented pillars. The findings presented in this report demonstrate the practicality of evaluating mine pillar stability using in situ methods.

Keyword(s): pillar strength, yielding supports, coal mining, longwall, mine design, monitoring methods, monitoring equipment

Location(s): Utah, Rocky Mountain Coal Region, United States

DeMaris, P. J., R. A. Bauer. Geology of a Longwall Mining Demonstration at Old Ben No. 24: Roof Lithologies and Coal Balls. IN: Proceedings Illinois Mining Institute 85th Annual Meeting, October 13-14, 1977, Springfield, IL.

A longwall mining demonstration in the Herrin Coal involved the extraction of three adjacent panels by the longwall method. The ISGS was involved in the project for two reasons: (1) to detail the geology of the roof and relate the geologic features to the behavior of the roof during mining operations, and (2) to study the nature and occurrence of coal balls (carbonate petrifications of peat) encountered during this demonstration.

Keyword(s): coal mining, longwall, geologic features, roof stability, active mines

Location(s): Illinois, Illinois Coal Basin, United States

DeMaris, P. J., R. A. Bauer. Geology of a Longwall Mining Demonstration at Old Ben No. 24: Roof Lithologies and Coal Balls. Illinois State Geological Survey Reprint 1978-J, 1978, Reprinted from Proceedings of Illinois Mining Institute, 1977, v. 85, p. 80-91.

Keyword(s): longwall, roof stability, geologic features, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

DeMaris, P. J., R. A. Bauer, R. A. Cahill, H. H. Damberger. Geologic Investigation of Roof and Floor Strata: Longwall Demonstration, Old Ben Mine No. 24. Prediction of Coal Balls in the Herrin Coal. Final Technical Report, Part 2. Illinois State Geological Survey Contract/Grant Report C/G 1983-2, 1983, 69 p. (NTIS DE83-011414)

Coal-ball areas, large deposits of mineralized peat in the coal seam, obstructed longwall mining in the Herrin Coal at Old Ben Mine No. 24. In-mine mapping located coal balls under transitional roof, areas where the roof lithology alternates between the Energy Shale and the Anna Shale/Brereton Limestone. Specifically, coal balls occur under eroded exposures or "windows" of the marine Anna Shale/Brereton Limestone in the Energy Shale.

Keyword(s): roof stability, floor stability, longwall, geologic features, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

DeMaris, P. J., R. A. Bauer. Identification of Mine Subsidence on Aerial Photographs in Central Illinois. Illinois State Geological Survey Contract/Grant Report, C/G 1983-7, 1983, 31 p.

This report evaluates the use of stereo pairs of aerial photography over and in the vicinity of a coal mine for the detection of subsidence due to underground coal mining in a glaciated area of central Illinois. The study area chosen was examined on 11 sets of imagery taken between 1939 and 1977. A number of sites where subsidence was previously documented are visible on the photos and were used for comparison with other anomalies found on the photos.

Keyword(s): photography, surface subsidence damage, coal mining, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Denkhaus, H. G. A Critical Review of the Present State of Knowledge Related to the Strength of Mine Pillars. Journal of the South African Institute of Mining and Metallurgy, v. 63, 1962, p. 59-75.

This paper summarizes knowledge concerning mine pillars as in-place support. The author discusses pillar loading, spacing, size, shape, and resulting pillar strength. The article includes a discussion of results and their applications in practical mining problems.

Keyword(s): pillar strength

Location(s): South Africa

Denkhaus, H. G. Critical Review of Strata Movement Theories and Their Applications to Practical Problems. Journal of the South African Institute of Mining and Metallurgy, March, 1964, p. 310-332.

This paper is an attempt to review the various theories of strata movement and stability that have been propounded and to assess their practical significance. With a view to the variety of such theories, the survey cannot claim completeness, but the author is of the opinion that all the threories can be grouped into three major categories, namely the dome theories, the trough theories, and the continuum theories.

Keyword(s): prediction theories, modeling

Department of the Environment. Reclamation of Derelict Land: Procedure for Locating Abandoned Mine Shafts. Planning, Regional and Minerals Directorate, London, 1976.

Keyword(s): reclamation, abandoned mines, land-use planning

Location(s): England

Department of the Environment. Limestone Mines in the West Midlands: The Legacy of Mines Long Abandoned. Department of the Environment, July, 1983.

Keyword(s): non-metal mining, abandoned mines

Location(s): England

Dershowitz, W., I. Miller. Practicality and Sophistication in Subsidence Modeling for Geothermal Systems. IN: Proceedings 22nd U.S. Rock Mechanics Symposium, Massachusetts Institute of Technology, Boston, 1981, p. 131-136.

Keyword(s): modeling, rock mechanics

Location(s): United States

Deutscher Verband Fuer Wasserwirtschaft, E.V. Proceedings International Symposium on Fossil Fuel Production and Water Resources. Duesseldorf, Federal Republic of Germany, September, 1976, 470 p.

Keyword(s): hydrology, coal mining

Devis, R. S. Hydraulic Packing at Ballarpur Colliery. Transactions Mine Geology Institute of India, v. 10, pt. 2, 1916, 53 p.

Keyword(s): hydraulic backfilling, stowing, coal mining, historical

Location(s): India

Dhar, B. B., S. Ratan, C. Amarendra. Environmental Impact as a Result of Large Underground Excavations--A Modeling Approach. IN: Proceedings International Symposium on Large Rock Caverns, Helsinki, August 25-28, 1986, Pergamon Press, v. 1, 1986, p. 771-782.

Mine workings have been simulated in an electric tank analogue, and closure distributions calculated from the voltage distributions as found in the analogue. Surface subsidences have been determined using a numerical model. Predicted and measured subsidences above two Indian coal mines are compared. A number of additional mining and geological factors that should be incorporated into the analysis of subsidence to improve its accuracy are examined.

Keyword(s): modeling, prediction, geologic features, environment, coal mining

Location(s): India

Dhar, B. B., B. K. Shrivastava, S. K. Gupta. Effect of Staggering of Longwall Panels in Contiguous Seams--A FEM Approach. IN: Proceedings, International Symposium on Underground Engineering, New Delhi, India, April 14-17, 1988, B. Singh, ed., Balkema, Rotterdam, p. 195-198.

Mining of contiguous seams has always been a problem, because extraction of one seam affects the extraction of the other. The design of such workings has forced mining engineers to look for effective conservation with safety. General practice has been that with flat or slightly dippping seams, the pillars/panels are designed in such a way that they are vertically above each other. To demonstrate the effect of staggering panels, a FEM program has been developed and used for the present analysis. Three different cases of contiguous workings were considered for simulation. In case one, excavations are assumed to be one above the other, while in the second and third cases they are assumed to be staggered. The analysis has shown that the staggering of panels adversely affects the stability of parting pillar and the coal seam ahead of the face. The results thus demonstrate that while designing contiguous seam workings, a mathematical simulation based on FEM principles is possible for safe extraction design of such coal seams.

Keyword(s): finite element, mathematical model, modeling, multiple-seam extraction, longwall, coal mining

Location(s): India

Di Molfetta, A., G. P. Giani. Numerical Model of Subsidence Phenomena Due to Mining Exploitation. IN: Proceedings International Symposium on Engineering in Complex Rock Formations, November 3-7, 1986, Beijing, China, Pergamon Press.

A numerical model for subsidence phenomena forecasting is presented. The subsidence is caused by mining exploitations, characterized by from both underground excavation and dewatering. The model studies separate the dewatering and the mechanical behavior. The dewatering study is examined with an analytical model that examines this phenomenon, obtaining the lowering of the piezometric heads, on the basis of water flow pumped and vice versa. The subsidence study examines, with the finite element method, the surface settlements on the basis of the dewatering and the underground excavation solutions.

Keyword(s): modeling, subsurface water, finite element, hydrology

Location(s): Italy

Dials, G. Subsidence Control-Underground Mines. Preprint 79-83, for presentation at SME-AIME Fall Meeting, New Orleans, LA, February 18-22, 1979, 2 p.

Keyword(s): ground control

Dickinson, J. Subsidence Due to Colliery Workings. Transactions, Manchester Geological Society, London, v. 25, 1898, p. 600.

Keyword(s): coal mining, historical

Dierks, H. A. Pneumatic Stowage. Coal Age, v. 36, no. 9, September, 1931, p. 466.

This article details the development of two types (low pressure and high pressure) of pneumatic stowage systems in Germany as an alternative to hydraulic backfilling of active mines.

Keyword(s): stowing, pneumatic backfilling, active mines

Location(s): Germany

Dierks, H. A. Hydraulic Backfilling as Europe Practices It. Coal Age, v. 36, no. 7, 1931, p. 351.

This article contains a brief background of hydraulic backfilling as developed in the United States. It describes hydraulic backfilling as conducted in Europe.

Keyword(s): hydraulic backfilling

Location(s): United States, Europe

Dierks, H. A. Pneumatic Stowage Makes Rapid Strides in Mines in Germany. Coal Age, v. 36, no. 9, September, 1931, p. 466.

Keyword(s): pneumatic backfilling, stowing

Location(s): Germany

Dierks, H. A. Backfilling Permits Recovery of Abandoned Pillars While Preserving Surface Improvements. Coal Age, v. 38, no. 8, August, 1933, p. 255-258.

This article describes the use of hydraulic flushing in a mine in Scranton, Pennsylvania, as a means of permitting complete robbing of two coal seams that had been previously mined out.

Keyword(s): hydraulic backfilling, surface structural damage, abandoned mines, room-and-pillar, multiple-seam extraction, pillar extraction, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Dimova, V. I. Influence of Surface Load on the Equation of Mine Subsidence. Direct and Inverse Problems. IN: Proceedings 6th International Congress International Association of Engineering Geology, Amsterdam, August 6-10, 1990, v. 4, Balkema, Rotterdam, p. 2645-2649.

Underground excavations and surface structures disturb the initial state of the host rock mass, and their influences may interact if both are present. The case for an idealized homogeneous medium is examined. The effect of a surface load on the equation of the subsidence trough above a mine, and correct design of an underground structure so as not to interfere with a super-incumbent surface structure are considered. Numerical and analytical solutions to these problems are described.

Keyword(s): surface structural damage, mine design, modeling, engineering

Dinsdale, J. R. Roof Fracturing. Colliery Engineering, v. 10, 1933, p. 161-164, 168.

This article is a mathematical discussion of stresses in and failure of a roof beam; it considers the roof as a beam supported at both ends.

Keyword(s): roof stability

Dinsdale, J. R. Ground Pressure and Pressure Profiles Around Mining Excavations. Colliery Engineering, v. 12, 1935, p. 406-409; v. 13, 1936, p. 19-20, 27.

Keyword(s): roof stability

Dinsdale, J. R. Ground Failure Around Excavations. Institution of Mining and Metallurgy Transactions, 1937, v. 46, 1936-37, p. 673-701.

Keyword(s): ground control

Dismuke, S. R., D. E. Nicholas, P. F. Cicchini. Pillar Recovery at the Buick Mine. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 131-143.

This paper describes a pillar recovery program, conducted in a lead and zinc ore mine, which allowed the company to better regulate the grade of ore produced. One constraint on pillar recovery was that a shale could not be disturbed to the point that aquifers above it might be affected.

Keyword(s): metal mining, partial extraction, finite element, lab testing, rock mechanics, subsurface water

Location(s): Missouri, United States

Dixon, D. Y., H. W. Rauch. Study of Quantitative Impacts to Ground Water Associated with Longwall Coal Mining at Three Mine Sites in the Northern West Virginia Area. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., West Virginia University, Morgantown, p. 321-335.

The objectives of this study were to document the hydrologic impacts of longwall mining on groundwater, identify the factors affecting the extent of dewatering, and develop empirical trends to predict the extent of dewatering and recovery in advance of mining. The study was confined to three mine sites in north-central West Virginia. At each site, available groundwater supplies were identified and monitored for dewatering effects and recovery.

Keyword(s): subsurface water, longwall, hydrology, prediction, overburden, coal mining, active mines

Location(s): West Virginia, Pennsylvania, Appalachian Coal Region, United States

Dixon, D. Y. A Study of Dewatering Effects at Three Longwall Mines in the Northern Appalachian Coal Field. M.S. thesis, Department of Geology and Geography, West Virginia University, Morgantown, 1988, 250 p.

Keyword(s): subsurface water, longwall, coal mining, hydrology, active mines, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

Dixon, D. Y., H. W. Rauch. The Impact of Three Longwall Coal Mines on Streamflow in the Appalachian Coalfield. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 169-182.

The objectives of this study were to document the hydrologic impacts of longwall mining on streams, identify the factors affecting the extent of stream dewatering, and develop empirical trends to predict the extent of dewatering and recovery of streams in advance of mining.

Keyword(s): longwall, hydrology, surface water, coal mining, inflow
Location(s): West Virginia, Appalachian Coal Region, United States

Dixon, J. C., K. B. Clarke. Field Investigation Techniques. IN: Site Investigations in Areas of Mining Subsidence, F.G. Bell, ed., Newnes-Butterworths, London, 1975, p. 40-74.

In dealing with geotechnical problems in areas of mining subsidence, it is axiomatic that the more that is known about the soil and rock profile affected by the mining operations the easier will be the solution of the problem. This chapter sets out the current field procedures in subsurface exploration in the widest sense and includes methods of exploring below the ground surface by direct, semi-direct, and indirect means; the various types of sample that can be obtained; and the range of in situ tests that may be carried out.

Keyword(s): in situ testing, geologic features, geotechnical, rock mechanics, subsurface water, coal mining, monitoring methods
Location(s): United Kingdom

Dixon, J. D., M. A. Mahtab, T. W. Smelser. Procedures for Determining Support of Excavations in Highly Yielding Ground. U.S. Bureau of Mines RI 8990, 1985, 19 p.

This report for stabilization of excavations in highly yielding ground involves nonlinear modeling of the progressive relaxation of the zones of rock mass around the excavations where Coulomb criterion of failure is exceeded. Stresses are calculated by using a computer code. The approach is applied to analysis of stability and support requirements for an entry in a longwall coal mine.

Keyword(s): longwall, ground control, modeling, mathematical model, computer, rock mechanics, roof support, mine design, finite element, coal mining
Location(s): United States

Dixon, J. S. Some Notes on Subsidence and Draw. Transactions, Mining Institute of Scotland, v. 7, 1885, p. 224-233.

The author made observations at Bent Colliery on the amount and mode of occurrence of subsidence and draw from working the coal. The excavation averaged 5.5 feet in height.

Keyword(s): historical, angle of draw, coal mining, survey methods
Location(s): United Kingdom

Djahanguiri, F. Rock Mechanics for a Longwall Mine Design; Carbon County Coal Company. IN: Energy Resources and Excavation Technology, Proceedings 18th U.S. Symposium on Rock Mechanics, Keystone, CO, June 22-24, 1977, F-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, p. 1C5-1 - 1C5-12.

This paper presents the pre-development rock mechanics study for underground mining of a thick coal seam. This study includes the geotechnical investigation and testing of coal and coal measure rocks for the proposed mine site. Extensive uniaxial, triaxial, shear, Brazilian, and point tension tests produced information about the rock substance and rock mass properties of the area. The geotechnical site investigation furnished information about structural geology, joint patterns and orientation of structural features. Geophysical borehole logging and seismic relfection contributed to this study.

Keyword(s): rock mechanics, longwall, coal mining, geotechnical, lab testing, geologic features, mine design, floor stability, pillar strength
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Dobbels, D., G. G. Marino, J. W. Mahar. Mine Subsidence at the Pistor Residence, Belleville, Illinois. Report for the Abandoned Mined Lands Reclamation Council, 1985, 50 p.

Keyword(s): surface structural damage, abandoned mines, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Dobson, W. D., E. L. J. Potts, R. G. S. Roberts, K. Wilson. Surface and Underground Development at Peterlee, Co. Durham. Colliery Guardian, pt. 1, v. 198, no. 5127, June 4, 1959, p. 691-697; pt. 2, v. 198, no. 5128, June 11, 1959, p. 723-730.

The new town of Peterlee is unique, in that it is being developed in a coal mining area in which about 30 million tons of coal are still being mined. The town was first suggested in an attempt to resolve a housing demand. Clearly, both surface and underground interests had to be considered. Certain basic principles were agreed for use in the surface and mining development in the designated area. Those were (1) that the major subsidence effects would take place within 5 years of extraction and (2) that the subsidence effects would extend beyond the working area to a distance equal to one-third of the depth to the seam, except under special circumstances. The National Coal Board also

agreed to sterilize about 1 million tons of coal beneath an area reserved for the town center.
Keyword(s): land-use planning, coal mining, National Coal Board, longwall, angle of draw, vertical displacement, horizontal displacement, survey data processing, surface structural damage, structural mitigation, roads, utilities, pipelines
Location(s): United Kingdom

Dobson, W. D., E. L. Potts, R. G. S. Roberts, K. Wilson. The Coordination of Surface and Underground Development at Peterlee, Co., Durham. Transactions Institute of Mining Engineering, London, v. 119, 1959-60, p. 279-300.
This paper describes the results of subsidence survey research performed in 1958 in Durham, England, with monitoring network design and surface/underground development procedures also included. The work was undertaken to provide information for the building and design of surface structures in an area where coal continues to be worked. The coordination of surface and underground development by "time phasing" and the close cooperation between surface and underground planning is described, together with certain special precautions incorporated into the design of housing and public utilities to serve a town that will house 30,000 people when completed. Reference is also made to the design of factory buildings in the industrial area.
Keyword(s): surface structural damage, mine design, monitoring design, monitoring methods, survey methods, survey design, active mines, coal mining, land-use planning, structural mitigation, utilities, construction, foundations
Location(s): England

Domenico, P. A., M. D. Mifflin. Water From Low-Permeability Sediments and Land Subsidence. Water Resource Research, v. 1, 1965, p. 563-567.
Keyword(s): fluid extraction, hydrology

Domenico, P. A., M. D. Mifflin, A. L. Mindling. Geologic Controls on Land Subsidence in Las Vegas Valley. IN: Proceedings 4th Annual Engineering Geology and Soils Engineering Symposium, Moscow, ID, 1966, Idaho Department of Highways, Boise, p. 113-121.
Keyword(s): fluid extraction, geologic features
Location(s): United States

Domenico, P. A. Land Subsidence in Las Vegas Valley, Nevada. Geological Society of America Special Paper 101 (abstract), 1968, p. 55.
Keyword(s): fluid extraction
Location(s): Nevada, United States

Doney, E. D. Birth of a Longwall--Initial Planning to Post-Subsidence Mitigation. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 220-226.
The first longwall mining system at Kerr-McGee's Galatia Mine was implemented on May 3, 1989. Start-up of the longwall face represented the successful conclusion of an effort begun nearly 4 years earlier. This paper presents a case history of the processes that led to the implementation of the longwall, and the subsequent mining of the first 7,900-foot-long panel.
Keyword(s): coal mining, longwall, mine design, land mitigation, mine operation, multiple-seam extraction, economics, active mines
Location(s): Illinois, Illinois Coal Basin, United States

Doney, E. D. Birth of a Longwall--Initial Planning to Post-Subsidence Mitigation. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 298-302.
This paper presents a case history of the processes that led to the implementation of a longwall at the Kerr-McGee Coal Corporation's Galatia Mine.
Keyword(s): longwall, coal mining, active mines, mine design
Location(s): Illinois, Illinois Coal Basin, United States

Doney, E. D., S. S. Peng, Y. Luo. Subsidence Prediction in Illinois Coal Basin. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, West Virginia University, Morgantown, p. 212-219.
Based on the subsidence data collected through a comprehensive subsidence monitoring program conducted over two longwall panels in an Illinois coal mine, mathematical models have been proposed for predicting final and dynamic subsidence in the Illinois Coal Basin.
Keyword(s): prediction, coal mining, monitoring methods, active mines, mathematical model, longwall
Location(s): Illinois, Illinois Coal Basin, United States

Donner, D. Federal Reclamation Projects Branch Fiscal Year 1985 Objectives. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 15-18.

This paper identifies the steps necessary to establish a more efficient and effective program for the abatement of coal mine related environmental problems.

Keyword(s): reclamation, environment, abandoned mines, coal mining

Location(s): Colorado, Montana, Rocky Mountain Coal Region, United States

Donner, D. L., R. H. Whaite. Investigation of Subsidence in Rock Springs, Sweetwater County, Wyoming. Unpublished Open-File Report, 1969, U.S. Bureau of Mines, Washington, D.C., 14 p.

Keyword(s): coal mining, abandoned mines

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Dortmund Board of Mines. On the Influence of Coal Mines Under Marl Capping Upon the Earth's Surface in the Dortmund District. Zeit fur das Berg Hutten und Salinen Wesen, v. 45, 1897, p. 372.

Keyword(s): coal mining, geologic features, overburden, historical

Location(s): Germany

Dott, G. Pneumatic Stowing in the Wemyss Coal Field. Colliery Engineering, v. 16, 1939, p. 261-265.

The author describes advantages of this method in a mine that had problems of steep gradient and frequent fires.

Keyword(s): coal mining, pneumatic backfilling, mine fires, geologic features

Location(s): England

Dougherty, P. H., M. Perlow. The Macungie Sinkhole, Lehigh Valley, Pennsylvania: Cause and Repair. IN: Karst Hydrogeology: Engineering and Environmental Applications, Proceedings, 2nd Multidisciplinary Conference on Sinkholes and the Environmental Impacts of Karst, Orlando, 1987, B.F. Beck and W.L. Wilson, eds., Balkema, Rotterdam, p. 425-435.

Keyword(s): geologic features

Location(s): Pennsylvania, United States

Dowding, C. H., M. B. Su, K. O'Connor. Choosing Coaxial Cable for TDR Monitoring. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 153-162.

This paper presents recommendations for choosing coaxial cables appropriate for mining applications of Time Domain Reflectometry (TDR) to monitor rock mass movements. Mining applications are illustrated with examples, and the operating principle of TDR is discussed briefly. Items that affect the result of the monitoring system performance include the coaxial cable selected, the grouting material used, and the installation procedure.

Keyword(s): monitoring equipment, monitoring installation, instrumentation

Dowding, C. H., M. B. Su, K. O'Connor. Principles of Time Domain Reflectometry Applied to Measurement of Rock Mass Deformation. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 25, no. 5, 1988, p. 287-297.

Time Domain Reflectometry (TDR) is an electrical pulse testing technique originally developed to locate faults in coaxial power transmission cables. Recently, this technique has been adapted for monitoring deformation of cables grouted into rock masses. Rock mass movements deform the grouted cable, which locally changes cable capacitance and thereby the reflected wave form of the voltage pulse. By monitoring changes in these reflection signatures, it is possible to monitor both local extension and local shearing. This paper concentrates on the electromagnetic wave theory necessary to quantitatively relate changes in cable geometry to changes in reflected voltage signatures. A finite element model is employed to numerically simulate capacitance changes for deformed geometries produced in the laboratory, and the effect of signal attentuation and resolution of two deformities is assessed on the basis of laboratory test results. Finally these models are employed to extract heretofore unrealized information from previously collected field data.

Keyword(s): monitoring equipment, instrumentation, monitoring methods, finite element, modeling, longwall, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Dowding, C. H., M. B. Su, K. O'Connor. Measurement of Rock Mass Deformation with Grouted Coaxial Antenna Cables. Rock Mechanics and Rock Engineering, v. 22, no. 1, January-March, 1989, p. 1-23.

Techniques presented show how reflected voltage pulses from coaxial antenna cable grouted in rock masses can be employed to quantify the type and magnitude of rock mass deformation. This measurement is similar to that obtained from a combined full profile extensometer and inclinometer. Rock mass movements deform the grouted cable, which locally changes cable capacitance, and thereby the reflected wave form of the voltage pulse. Thus, by monitoring changes in these reflection signatures, it is possible to monitor rock mass deformation.

Keyword(s): monitoring equipment, monitoring methods, rock mechanics, instrumentation, lab testing, longwall, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Down, C. G., J. Stocks. Subsidence. IN: Environmental Impact of Mining, Halsted Press, John Wiley & Sons, New York, 1977, p. 311-335.

The discussion in this chapter was oriented towards stratified deposits and particularly the European coalfields, since most of the available data pertained to this type of mining.

Keyword(s): environment, land-use planning, prediction, roof stability, multiple-seam extraction, empirical model, profile function, influence function, surface structural damage, room-and-pillar, coal mining

Location(s): United Kingdom, Europe

Draper, J. C. Surface Movement in the Vicinity of Pillars Left in Gob Areas. SME-AIME Annual Meeting, New York, 1964, SME AIME Preprint 64FM3, 19 p.

This paper describes the results of surface surveys of subsidence above and adjacent to coal pillars left to protect three gas wells.

Keyword(s): mine waste, pillar strength, horizontal displacement, vertical displacement, utilities, survey data processing, survey methods

Location(s): Pennsylvania, Appalachian Coal Region, United States

Drent, S. Some Considerations on the Connection Between Time-Curves and the Thickness of the Noncarboniferous Overburden in the South Limburg Coal Field. IN: Proceedings European Congress on Ground Movement, Leeds, England, 1957, p. 49-57.

Keyword(s): overburden, time factor, coal mining, geologic features

Drent, S. Time-Curves and the Thickness of Overlying Strata. Colliery Engineering, v. 34, no. 401, July, 1975, p. 271-278.

This paper describes the non-carboniferous overlying strata in the South Limburg coalfield.

Keyword(s): horizontal displacement, time factor, coal mining, overburden

Drumm, E. C., R. M. Bennett, W. F. Kane. Mechanisms of Subsidence Induced Damage and Techniques for Analysis. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 168-188.

Structural damage due to mining-induced subsidence is a function of the nature of the structure and its position on the subsidence profile. A point on the profile may be in the tensile zone, the compressive zone, or the no-deformation zone at the bottom of the profile. Damage to structures in the tension zone is primarily due to a reduction of support during vertical displacement of the ground surface, as well as shear stresses between the soil and structure resulting from horizontal displacements. The damage mechanisms due to tension can be investigated effectively using a two-dimensional plane stress analysis. Structures in the compression zone are subjected to positive moments in the footing and large compressive horizontal stresses in the foundation walls. A plan strain analysis of the foundation wall is used to examine compression zone damage mechanisms. The structural aspects affecting each mechanism are identified, and potential mitigation techniques are summarized.

Keyword(s): surface structural damage, vertical displacement, horizontal displacement, abandoned mines, active mines, insurance, modeling, computer, structural mitigation, foundations

Location(s): Illinois, Illinois Coal Basin, Appalachian Coal Region, Pennsylvania, United States

Drzezla, B., S. Czypionka. Prakiyczne Zastosowanie Wzorow Do Obliczania Krzywizn Przekrojow Pionowych Niecki Osiadania (Practical Use of Formulas for Calculating Vertical-Cross-Section

Curvatures of a Subsidence Trough). Przeglad Gorniczy, v. 27, no. 10, 1971, p. 457-462.
Keyword(s): prediction

Drzezla, B. Informacja O Programach Dla Maszyny Cyfrowej Do Obliczania Deformacji Gorotworu Przy Eksploatacji Gorniczej (Computer Systems Programming for Calculating the Deformation of Rock Masses as Effect of Mining Exploitation). Przeglad Gorniczy, v. 30, no. 3, 1974, p. 164-170.
Keyword(s): computer, prediction

Drzezla, B. Zmiennosc Zasiegu Wplywow Eksploatacji W Gorotworze (Variability of the Range of Effects Due to Mine Working in Rock Masses). Przeglad Gorniczy, v. 35, no. 10, 1979, p. 413-418.

Duigon, M. T., M. J. Smigaj. First Report on the Hydrologic Effects of Underground Coal Mining in Southern Garrett County, Maryland. Maryland Geological Survey Report of Investigations No. 41, 1985, 99 p.
This report describes preliminary findings on the hydrogeologic system in southwestern Garrett County, Maryland, where a large underground coal-mining operation had recently begun. A network was established to gather streamflow, water-level, and water-quality data.
Keyword(s): subsurface water, hydrology, coal mining, room-and-pillar, pillar extraction
Location(s): Maryland, United States

Dulaney, R. L. The Structural Strength of Coal Mine Floors. M.S. Thesis, Virginia Polytechnic Institute, Blacksburg, VA, 1960, 73 p.
Keyword(s): floor stability, coal mining

DuMontelle, P. B., E. D. McKay, P. J. Ehret, R. D. Gibson. Mine Subsidence and Unstable Loess in Southwestern Illinois. IN: Geological Society of America Abstracts with Programs, North-Central Section, 13th Annual Meeting, Duluth, MN, May 10-11, 1979, p. 228.
Keyword(s): engineering, soil mechanics, coal mining, soils, surface structural damage, abandoned mines, geologic features
Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B. The Illinois Mined Land Subsidence Program. Illinois in the '80s...Trends in Natural Resource Management. Illinois Institute of Natural Resources, 1980, p. 60-63. (NTIS PB82-177114)
Keyword(s): land-use planning, coal mining, subsidence research
Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B., R. E. Yarbrough, R. S. Pocreva. Review of Underground Mining Practices in Illinois as Related to Aspects of Mine Subsidence with Recommendations for Legislation. Illinois State Geological Survey, Champaign, Institute of Natural Resources Document 80/10, 1980, 142 p.
This report was prepared to provide information to introduce and review background events associated with mine subsidence, to describe underground mining practices in Illinois, to describe mine subsidence and building alternatives to reduce subsidence damage, to review legal aspects of mines subsidence, to explain public access to underground mine maps, and to state the findings and recommendations for future work.
Keyword(s): law, government, coal mining, surface structural damage, structural mitigation, insurance, abandoned mines, active mines
Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B., S. C. Bradford, R. A. Bauer, M. M. Killey. Mine Subsidence in Illinois: Facts for the Homeowner Considering Insurance. Illinois State Geological Survey, Environmental Geology Notes 99, 1981, 24 p.
This booklet covers the geology of Illinois, the areas undermined, the mining methods used, the types of subsidence, and the effects of subsidence.
Keyword(s): surface structural damage, subsurface structural damage, construction, insurance, coal mining, historical
Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B., E. D. McKay, R. D. Gibson. Geology and Subsidence Monitoring of Backfilling Projects in Southwestern Illinois--Television Probes of Injection Borings. IN: Proceedings Conference on Ground Control in Room-and-Pillar Mining, Southern Illinois University, Carbondale, August 6-8, 1980, Y.P. Chugh, ed., SME-AIME, New York, 1982, p. 155-157.
The USBM backfilled abandoned mines at selected sites in southwestern Illinois in an attempt to support failing mine openings. The ISGS assisted the Bureau by developing geologic and engineering

information. As part of this investigation, television probes of 15 injection probes in Belleville augmented conventional methods of study.

Keyword(s): abandoned mines, backfilling, mine waste, grouting, monitoring equipment, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B., R. A. Bauer, R. D. Gibson, J. W. Mahar, R. Yarbrough. Procedures Used in Illinois to Identify Sag Subsidence Resulting from Underground Coal Mining. Paper presented to Association of Engineering Geologists, 1983, San Diego, CA.

Keyword(s): surface subsidence damage, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B., R. A. Bauer. The Mid-Continent Field: General Characteristics of Surface Subsidence. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., 1983, Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146. Elsevier, New York, p. 671-680.

The coal seams of the Illinois Basin comprise a major part of the Mid-Continent Region. Since the latter part of the 1800s, more than 750,000 acres of Illinois land have been undermined for coal. Subsidence of the surface was documented by early workers. And, from time to time, new studies and techniques have provided a better understanding of why mine openings fail and how these failures are expressed at the surface. The detailed case studies in this paper were designed to monitor expected changes characteristic of the Illinois Basin. A brief discussion of the basin setting, mining methods, and typical subsidence events may be helpful.

Keyword(s): coal mining, surface subsidence damage, geologic features, abandoned mines, surface structural damage, hydrology

Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B., R. A. Bauer. A Mine Subsidence Research Program for Illinois: Coal and Crops Working Together. IN: Proceedings Illinois Mining Institute, October, 1985, p. 45-50.

The Illinois Mine Subsidence Research Program was initiated in 1985 to develop guidelines for mining to control and mitigate adverse effects on prime farmland by underground coal mining while maximizing coal recovery of coal resources.

Keyword(s): coal mining, subsidence research, agriculture

Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B., R. A. Bauer. The Second Year Progress Report of the Illinois Mine Subsidence Research Program. IN: Proceedings Illinois Mining Institute, October, 1986, p. 46-52.

Keyword(s): subsidence research, coal mining, agriculture

Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B., R. A. Bauer. The Illinois Mine Subsidence Research Program: An Update. IN: Mine Subsidence, Proceedings, Society of Mining Engineers Fall Meeting, September, 1986, M.M. Singh, ed., St. Louis, MO, p. 87-89.

In 1985, participants of the multi-year Illinois Mine Subsidence Research Program conducted surveys of subsidence effects on crop production from current high-extraction mining methods, selected a site to characterize overburden materials and changes in aquifers produced by subsidence from high-extraction mining, characterized floor materials in three mines, and established bibliographic reference and database files.

Keyword(s): subsidence research, coal mining, active mines, agriculture, monitoring methods, overburden, hydrology, lab testing, in situ testing, computer, literature search, law, government

Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B., L. R. Powell. Illinois Mine Subsidence Research Program. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 89.

The authors introduce a series of papers in the Symposium that describe the current research of the Illinois Mine Subsidence Research Program.

Keyword(s): subsidence research, active mines

Location(s): Illinois, Illinois Coal Basin, United States

Duncan, N., M. A. Devane, J. M. Hickmott. The Analysis of Localised Ground Subsidences. IN: Ground Movements and Structures, Proceedings

3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 565-580.

Localized ground subsidences may occur where cavities exist in the ground as a result of the presence of a number of features including mine workings, tunnels, poorly backfilled shafts and, directly or indirectly, from underlying carbonate rocks susceptible to erosion or solutioning. The methods of analysis described permit conclusions to be drawn on the type and probability of failure in cases where cavities are known to exist. When failures have unexpectedly occurred, analytical methods may give some guidance on the depth and dimensions of the cavities activating the subsidence and thus be of assistance in the design of remedial measures.

Keyword(s): geologic features, surface subsidence damage, soils, surface structural damage

Location(s): United Kingdom

Dunham, R. K., A. G. Thurman, R. D. Ellison. The Use of Geological/Geotechnical Investigation as an Aid to Mine Planning. IN: Energy Resources and Excavation Technology, Proceedings 18th U.S. Symposium on Rock Mechanics, Keystone, CO, June 22-24, 1977, F-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, Golden, p. 1C4-1-1C4-6.

Procedures for geological/geotechnical investigation of a property are outlined and demonstrated by example. Information available with limited field work is listed; studies adaptable to the typical drilling process are summarized; and the requirement for monitoring and further assessment during mine development is noted.

Keyword(s): mine design, geologic features, geotechnical

Location(s): United States

Dunham, R. K., R. L. Stace. Interaction Problems in Multiseam Mining. IN: Proceedings 19th U.S. Symposium on Rock Mechanics, Stateline, NV, May 1-3, 1978, Y.S. Kim, ed., University of Nevada-Reno, p. 174-188.

Interaction effects from earlier workings in seams above or below a seam presently being mined are a constant problem in the U.K. coalfields and are beginning to create difficulties in the United States. On the basis of a series of case studies, this paper attempts to define the major parameters governing the interaction mechanism. A broad relationship between the amount of damage caused by a rib edge or remnant pillar and the major parameters is developed from the case study results.

Keyword(s): multiple-seam extraction, coal mining, ground control, longwall, mine design

Location(s): United Kingdom

Dunker, R. E., R. I. Barnhisel, R. G. Darmody, eds. Proceedings of the 1992 National Symposium on Prime Farmland Reclamation. Department of Agronomy, University of Illinois, Urbana.

This symposium brought together reclamationists from industry, government, and research institutions in a national forum to present and discuss current issues related to prime farmland reclamation.

Keyword(s): reclamation, mitigation, land mitigation, agriculture, soils

Location(s): United States

Dunn, J. R., G. M. Banino, W. D. Ernst. The Physical and Chemical Characteristics of Available Materials for Filling Subsurface Coal Mines. Contract JO155182, Dunn Geoscience Corporation, U.S. Bureau of Mines OFR 151-77, 1977, 282 p. (NTIS PB 274 702)

This report studies the critical physical and chemical characteristics of available high-bulk materials that might be used to fill abandoned rooms in anthracite coal mines of eastern Pennsylvania and bituminous coal mines of western Pennsylvania.

Keyword(s): backfilling, abandoned mines, coal mining, anthracite, bituminous

Location(s): Pennsylvania, Appalachian Coal Region, United States

Dunrud, C. R. Some Engineering-Geologic Controls on Coal Mine Subsidence; Effects of Subsidence on Mining, Conservation of Coal Reserves, and on the Environment. IN: Engineering Geology and the Natural Resources Energy Spectrum, Association of Engineering Geologists Annual Meeting, Program Abstracts, 1974, no. 17, p. 23.

Keyword(s): coal mining, environment, geologic features

Dunrud, C. R. Effects of Coal Mine Subsidence in Selected Mines of Utah, Colorado, & Wyoming from Viewpoint of Engineering Geologist. IN: Proceedings 88th Annual Meeting Geological Society of America, Salt Lake City, UT, October 20-22, 1975, p. 165-174.

Keyword(s): coal mining, engineering
Location(s): Utah, Colorado, Wyoming, Rocky Mountain Coal Region, United States

Dunrud, C. R. Some Environmental and Resource-Recovery Problems Associated with Past Underground Coal Mining Activities in the Western Powder River Basin, Wyoming. IN: Geological Society of America Abstracts with Programs, 89th Annual Meeting, Denver, November 8-11, 1976, Geological Society America, v. 8, no. 6, p. 846-847. (NTIS Accession No. 77-47508)
Keyword(s): coal mining, abandoned mines, environment, room-and-pillar, overburden, mine fires, reclamation
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Dunrud, C. R., F. W. Osterwald. Coal Mine Subsidence Near Sheridan, Wyoming. Bulletin Association of Engineering Geologists, v. 15, no. 2, 1978, p. 175-190.
Keyword(s): coal mining
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Dunrud. C. R., F. W. Osterwald. Effects of Coal Mine Subsidence in the Western Powder River Basin, Wyoming. U.S. Geological Survey OFR 78-473, 1978, 71 p.
Keyword(s): coal mining
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Dunrud, C. R., R. H. Morris, eds. Selected Papers; Seminar on Coal Mining Activities and Concepts of Multiple Land Use. Session Papers, Seminar on Coal Mining Activities and Concepts of Multiple Land Use, Denver, CO, May 6-7, 1976. Association of Engineering Geologists Bulletin v. 15, no. 2, 1978, p. 145-251. (NTIS Accession No. 79-25371)
Keyword(s): land-use planning, coal mining, reclamation
Location(s): United States

Dunrud, C. R. Coal Mine Deformation, Western Powder River Basin. IN: The Energy Lands Programs of the U.S. Geological Survey, Fiscal Year 1976, J.O. Maberry, compiler. U.S. Geological Survey Circular No. 778, 1978, p. 33-35.
Keyword(s): coal mining
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Dunrud, C. R. Some Engineering Geologic Factors Controlling Coal Mine Subsidence in Utah and Colorado. U.S. Geological Survey Professional Paper 969, 1979, 39 p.
Keyword(s): coal mining, engineering, geologic features
Location(s): Utah, Colorado, Rocky Mountain Coal Region, United States

Dunrud, C. R., F. W. Osterwald. Effects of Coal Mine Subsidence in the Sheridan, Wyoming, Area. U.S. Geological Survey Professional Paper 1164, 1980, 49 p.
Keyword(s): coal mining
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Dunrud, C. R. Coal Mine Subsidence--Western United States. IN: Man-Induced Land Subsidence, Geological Society of America Reviews in Engineering Geology VI, 1984, T.L. Holzer, ed., p. 151-194.
This report discusses the nature and extent of subsidence in the western United States, subsidence processes in underground and surface coal mines, and factors controlling subsidence in order to provide a basis for further study and analysis of subsidence. Results of case studies of subsidence and fires caused by underground mining, subsidence hazards, subsidence prediction and control, and land use are also discussed. The report also compares results of subsidence in the western United States with those of other countries.
Keyword(s): coal mining, surface subsidence damage, active mines, abandoned mines, land-use planning
Location(s): Rocky Mountain Coal Region, United States

Dunrud, C. R. Subsidence--An Important Aspect of Land Use Planning Above Abandoned Underground Coal Mines. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October 1987, p. 3-36.
Subsidence effects, as predicted from geologic and mining conditions, should be incorporated into land use plans before development begins. Time and money spent in formulating comprehensive land use plans before development are small compared to the time and money spent later on mitigation.
Keyword(s): land-use planning, coal mining, abandoned mines, overburden, economics
Location(s): United States

Dutton, A. J., J. L. Meek. Discrete Element Modelling of Vertical Stress Changes Induced by Longwall Mining. IN: Proceedings 1st U.S. Conference on Discrete Element Methods, Golden, 1989.
Keyword(s): modeling, longwall

Duvall, W. I. Stress Analysis Applied to Underground Mining Problems, and Stress Analysis Applied to Multiple Openings in Pillars, Parts I and II. U.S. Bureau of Mines RI 4387, November, 1948.
This report is a discussion of average and maximum stress distributions as a function of the shape of openings and as percent of coal recovery.
Keyword(s): pillar strength, coal mining
Location(s): United States

Dyni, R. C. Subsidence Investigations Over Salt-Solution Mines, Hutchinson, KS. U.S. Bureau of Mines IC 9083, 1986, 23 p.
The USBM, in cooperation with the Solution Mining Research Institute, conducted surface and subsurface investigations over five solution-mined salt cavities in the area of Hutchinson, Kansas. The purpose of these investigations was to determine the mechanisms that lead to the formation of sinkholes above collapsed solution cavities.
Keyword(s): non-metal mining, geologic features
Location(s): Kansas, United States

Dyni, R. C. Subsidence Resulting from Multiple-Seam Longwall Mining in the Western United States--A Characterization Study. U.S. Bureau of Mines IC 9297, 1991, 20 p.
This report details the investigation of multiple-seam longwall subsidence from 1978 to 1989. A field investigation monitored ground surface movements over four upper-seam longwall panels and six lower-seam panels. The characteristics of the subsidence occurring as a result of mining these panels are examined; in particular, the angle of draw, subsidence development, total magnitude and areal extent, and critical width are evaluated and discussed. Comparisons are also made between the characteristics of multiple-seam longwall subsidence and single-seam longwall subsidence that occurred at the same site.
Keyword(s): multiple-seam extraction, longwall, angle of draw, coal mining, monitoring methods, survey methods, survey design, survey equipment, survey data processing, National Coal Board
Location(s): Utah, Rocky Mountain Coal Region, United States

Ealy, D. L., R. E. Mazurak, E. L. Langrand. A Geological Approach for Predicting Unstable Roof and Floor Conditions in Advance of Mining. Mining Congress Journal, March, 1979, p. 17-22.
Keyword(s): roof stability, floor stability, geologic features

Earth Satellite Corporation (Washington, D.C.) Use of Photo Interpretation and Geological Data in the Identification of Surface Damage and Subsidence. Appalachian Regional Commission Report ARC-73-111-2554, 1975, 104 p. (NTIS PB 242 468)
Multi-sensor, multi-level remote sensing was examined for utility in detecting and delineating the surface expression of mine subsidence in the Northern Anthracite Coal Field of Pennsylvania. The objectives were to determine not only those sensors and analysis techniques that offer the best results in the identification of mine subsidence, but to identify areas of potential subsidence so they can be considered in future planning and zoning processes.
Keyword(s): photography, surface subsidence damage, geologic features, remote sensing, anthracite, land-use planning
Location(s): Pennsylvania, Appalachian Coal Region, United States

Eaton, L. Surface Effects of the Caving System. Mining and Science Press, v. 97, September, 1908, p. 428-429.
Keyword(s): surface subsidence damage, historical

Eaton, L. Sand Filling Through Pipes and Boreholes. Transactions, AIME, v. 102, February 1932, p. 33.
This article discusses backfilling of active mines by various processes including hand stowage, hydraulic, pneumatic, and a combination of hydraulic and pneumatic.
Keyword(s): hydraulic backfilling, pneumatic backfilling, active mines

Eavenson, H. M. Mining an Upper Bituminous Seam After a Lower Seam Has Been Extracted. Transactions, AIME, v. 69, 1923, p. 398-405.
In many of the bituminous coal districts of the United States, more than one seam of workable coal exists and, in most cases, the lower seam is the more attractive because of either its greater thickness or its superior quality. Apprehension that the mining of a seam will destroy the availability of all overlying seams has hindered the development of many fields and has led to the unprofitable working of certain seams to save them from an expected total loss. A study was made of operating methods applied to superimposed seams, and these cases form the basis of this paper.
Keyword(s): multiple-seam extraction, coal mining, bituminous, active mines
Location(s): West Virginia, Pennsylvania, Maryland, Appalachian Coal Region, United States, South Africa, Scotland

Edgerton, A. T., F. Ruskey, D. N. Williams. Microwave Radiometric Investigations of Mine Subsidence in Rock Springs, Wyoming. U.S. Bureau of Mines Contract H0110156, Aerojet-General Corporation, January, 1971, 97 p. (NTIS PB 203 671)
Keyword(s): instrumentation, monitoring equipment, coal mining, abandoned mines
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Edl, J. N., Jr., W. F. Eichfeld. Subsidence Related Data from Four Representative United States Coal Mines. Special Study Laboratory Report S & SE 78-2, Joint Research Project No. 14-01-0001-1451, Carbondale Mining Technology Center, U.S. Department of Energy, 1978.
Keyword(s): survey data processing, lab testing, coal mining
Location(s): United States

Edl, J. N., Jr. The Effect of Geotechnical Factors on the Subsidence Response. IN: Proceedings 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 268-282.
The purpose of this paper is to discuss the effects of selected geotechnical factors on subsidence. The information presented necessarily relies heavily on subsidence experience from European countries as subsidence research is still in the early stages in the United States.
Keyword(s): geotechnical, coal mining, National Coal Board, overburden
Location(s): United States, Europe

Edmonds, C. N. Towards the Prediction of Subsidence Risk Upon the Chalk Outcrop. Quarterly Journal of Engineering Geology, 16, 1983, p. 261-266.
Keyword(s): prediction

Edmonds, C. N., C. P. Green, I. E. Higginbottom. Subsidence Hazard Prediction for Limestone Terrains, As Applied to the English Cretaceous Chalk. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 283-293.

Soluble carbonate rocks often pose a subsidence hazard to engineering and building works due to the presence of either matastable natural solution features or artificial cavities. It would be advantageous if areas liable to subsidence could be identified in a cost-effective manner in advance of planning and ground investigation.

Keyword(s): prediction, modeling, land-use planning, geologic features

Location(s): United Kingdom

Edwards, J. L. The Effects and Mechanisms of Floor Heave as Observed in the South Newcastle Coalfield. IN: Proceedings, 19th Symposium on Advances in the Study of the Sydney Basin, 1985, Department of Geology, University of Newcastle, New South Wales, p. 68-69.

Floor heave has long been a problem in the mining of various tabular deposits. The manifestation of this phenomenon is an upheaval of the roadway floor by the suggested mechanisms of either plastic flow or rigid buckling, or in some cases a combination of both. The presence of mechanical discontinuities, such as joints and faults, is seen to have an apparent compounding effect in creating the problem, leading to the proposal that drivage direction may have a role to play in minimizing floor heave in critical roadways.

Keyword(s): floor stability, coal mining, geologic features, mine design, room-and-pillar

Location(s): Australia

Ege, J. Mechanisms of Surface Subsidence Resulting from Solution Extraction of Salt. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, T.L. Holzer, ed., The Geological Society of America, 1984, p. 203-221.

Extraction of soluble minerals, whether by natural or man-induced processes, can result in localized land-surface subsidence. The subsidence is caused by partial or total collapse of underground cavities resulting from dissolution of salt or other soluble evaporites. In many cases, subsidence is ultimately related to the strength limit of the overlying rocks that form the unsupported roof above the cavity.

Keyword(s): non-metal mining, fluid extraction

Location(s): United States

Ege, J. R. Surface Subsidence and Collapse in Relation to Extraction of Salt and Other Soluble Evaporites. U.S. Geological Survey OFR 79-1666, 1979, 33 p.

Extraction of soluble minerals, whether by natural or man-induced processes, can result in localized land-surface subsidence and more rarely sinkhole formation. This report summarizes experience in ground subsidence and collapse over cavities formed by either natural or artificial means in saline rocks.

Keyword(s): non-metal mining, surface subsidence damage

Location(s): United States

Eggelsmann, R. F. Subsidence of Peatland Caused by Drainage, Evaporation, and Oxidation. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association Hydrological Sciences Publication 151, 1986, p. 497-505.

Drainage, reclamation, and agricultural use of peatlands change their natural conditions because the layers originally have a high pore volume and high water content. The subsidence of peatland is cased by three main effects: (1) compression of peat layers below the groundwater table, if it is lowered; (2) shrinkage of peat layer upon the groundwater table by desiccation, caused by evaporation; and (3) oxidation/mineralization of the organic matter in the top layer, especially at arable land, depending on pH value.

Keyword(s): fluid extraction, surface subsidence damage, soils

Location(s): Germany

Ehret, P. J. Planning for Subsidence. Coal Mining and Processing, v. 19, no. 4, 1982, p. 130-134.

Keyword(s): coal mining, mine design

Ehret, P. J. The Regulatory Authority. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, 1983, p. 609-612.

Regulatory requirements since the passage of Surface Mining Control and Regulation Act of 1977 have been in a constant state of change. It is likely that this situation will continue for quite some time as the federal Office of Surface Mining and the various state regulatory agencies learn more about the programs they are enforcing. This evolution may result in a streamlining of the regulatory process as the enforcing agencies discover the impractical aspects of the regulations, and as state-of-the-art advancements are made in both mining and the control of subsidence.

Keyword(s): law, government, reclamation
Location(s): United States

Ehret, P. J. The Regulation of Subsidence and Underground Coal Mining in Illinois. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 97-100.

With the passage of the Surface Mining Control and Reclamation Act and the implementation of state programs, underground coal mining operations are for the first time subject to government regulations regarding subsidence. These regulations now and in the future will directly affect the manner in which mining companies mine their coal. Since the promulgation of the original final regulations by Office of Surface Mining, numerous changes in those regulations have been made and many additional changes are pending in the near future. This paper will discuss state and federal approaches to regulating underground coal mines and examine issues surrounding future subsidence regulations.

Keyword(s): coal mining, law, government, geotechnical, mine design, room-and-pillar, longwall, high-extraction retreat, mitigation, reclamation
Location(s): Illinois, Illinois Coal Basin, United States

Ehrhardt, W., A. Sauer. Precalculation of Subsidence, Tilt and Curvature Over Extractions in Flat Formations. Bergbauwissenschaften, 1961, v. 8, p. 415-428 (in German).

Keyword(s): prediction, modeling, empirical model, stochastic model

Eichfeld, W. Photogrammetric Techniques. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, 1983, p. 623-626.

This paper describes the advantages of using photogrammetric surveys for monitoring ground surface movements associated with subsidence.

Keyword(s): monitoring methods, remote sensing
Location(s): United States

Eichfeld, W., E. Ono, Y. P. Chugh, G. Chen. Application of Photogrammetric Techniques in Assessing Underground Mine Opening Deformations and Stability. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 587-594.

This paper describes the use of photogrammetric techniques to improve the measurement of entry deformations and the elements of roof-pillar-floor interactions.

Keyword(s): room-and-pillar, survey methods, survey equipment, photography, coal mining

Elder, B. L. A Study of Mine-Related Surface Subsidence Features Using Landsat Thematic Mapper and Seasat SAR Data; the Western Kentucky Coal Field. M.S. Thesis, Murray State University, Murray, KY, 1985, 56 p.

Keyword(s): coal mining, remote sensing, photography, surface subsidence damage
Location(s): Kentucky, Illinois Coal Basin, United States

Elder, C. H. Evaluation of Procedures Used in Four Mine Subsidence Control Projects. Office of Surface Mining Reclamation and Enforcement, Eastern Field Operations, Ten Parkway Center, Pittsburgh, PA, October 1986.

This project was initiated by the Office of Surface Mining Reclamation and Enforcement to evaluate the effectiveness of selected procedures and materials that have been used to abate abandoned mine subsidence. Specifically, the project was designed to provide the following information: determine the lateral and vertical extent of the fill material injected into the mine voids; and, through the use of "standard" field and laboratory tests, determine the properties of the fill material, such as size distribution, strength, and in situ bearing capacity.

Keyword(s): hydraulic backfilling, pneumatic backfilling, coal mining, anthracite, bituminous, abandoned mines, mine waste, reclamation, in situ testing, lab testing, geologic features, pillar strength

Location(s): Illinois, Pennsylvania, West Virginia, Illinois Coal Basin, Appalachian Coal Region, United States

Elifrits, C. D. A Study of Subsidence Over a Room and Pillar Coal Mine. Ph.D. Dissertation, Department of Geological Engineering, University of Missouri, Rolla, 1980, 118 p.

As underground mining has increased in the Illinois Coal Basin, the problem of disruption of surface land use due to subsidence has increased. Throughout the past 60 years, subsidence investigations have dealt with mining depth, geometry and type of support of overburden left in place, hopefully, to prevent cavity failure. To date few investigations have been made of the geologic characteristics of a mine locale with respect to their influences on the natural events following mining of coal by room-and-pillar, high extraction mining methods. This research was completed to investigate the geologic and mining characteristics at subsidence features. Influence of geology and mining on these features was investigated.

Keyword(s): room-and-pillar, high-extraction retreat, coal mining, geologic features, remote sensing, computer, photography

Location(s): Illinois, Illinois Coal Basin, United States

Elifrits, C. D., D. J. Barr, N. B. Aughenbaugh. Room and Pillar Coal Mine Subsidence. International Journal of Mining Engineering, v. 1, 1983, p. 295-314.

A geographic natural resources computer database was modified to accept data files created from subsurface geological and mining information and remote sensor data. The database files were then used as variables in equations that were produced to represent relationships among the mapped parameters - geological and mining - that identify areas prone to subside, as determined from the field verified subsidence features. Also, the utility of the computer-processed remote sensor data as a tool for indication of subsided areas was evaluated.

Keyword(s): computer, room-and-pillar, prediction, land-use planning, longwall, modeling, coal mining, remote sensing

Location(s): Illinois, Illinois Coal Basin, United States

Elifrits, C. D., N. B. Aughenbaugh. Effects of Moisture Variations and Overburden Geology on Subsidence Proneness. SME-AIME preprint No. 83-389, for presentation at the SME-AIME Fall Meeting and Exhibit, Salt Lake City, UT, October 19-21, 1983, 5 p.

Observations made from laboratory analysis of samples of fine grained argillaceous materials (shales) subjected to various changes in moisture content have been correlated to loss of strength in the rock material. This reaction to a change in conditions (subsequent to mining) at a mine site combined with the observed relationships of surface-disturbing subsidence features at locations where the predominant overburden material is fine grained, provides a predictive tool for the subsidence engineer.

Keyword(s): coal mining, geologic features, overburden, partial extraction, lab testing, in situ testing, floor stability, roof stability

Location(s): United States

Elifrits, C. D., J. D. Rockaway. Landuse Considerations at Locations of Ground Subsidence. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 387-392.

Surface subsidence over areas where high extraction coal mining practices have been used frequently results in a change of land use capability. These changes require that alternative land use patterns be evaluated prior to mining to minimize potential environmental impact. This paper presents the results of a subsidence impact study conducted at Rend Lake, Illinois, where longwall coal mining beneath the reservoir and adjacent shorelines caused noticeable changes in areas subject to inundation. This necessitated additional property acquisition, reconsideration of areas qualifying for wetland designation, and modification of areas suitable for lake access and recreational facilities.

Keyword(s): coal mining, land-use planning, environment, surface water, longwall, active mines, geologic features, subsurface water, prediction, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Eltringham, J. The Reinforcement of Buildings and Their Foundations Against Mining Subsidence. Transactions, Institute of Mining Engineers, v. 66, 1923-24, p. 200-211.

A brick building was successfully constructed over an area liable to subside. The foundations were equipped with concrete rafts and the brickwork reinforced by a band of steel.

Keyword(s): utilities, surface structural damage, foundations, construction

Location(s): United Kingdom

Ely, E. H. The Design of the Skegby Sewage Purification Works to Meet Mining Subsidence. Journal Institute of Public Health Engineering, v. 618, no. 3, 1962, p. 146-165.

Keyword(s): utilities, engineering, surface structural damage

Emery, C. L. In Situ Measurements Applied to Mine Design. IN: Proceedings 6th Symposium on Rock Mechanics, University of Missouri at Rolla, 1964, E.M. Spokes and C.R. Christiansen, eds., p. 218-230.

This paper deals with a rock mechanics study, a simple but characteristic program of measurement, analysis, and application of data to mine design. The mine concerned is an operating mine recovering about 4,000 tons per day from a bedded deposit at a depth of about 2,500 feet in Silurian sediments overlain by Devonian strata. The mine is developed by a room-and-pillar method of mining and, although mining conditions were considered to be good, there was a continuous and significant amount of maintenance caused by rock movements expressed in floor heaving, roof spalling, and pillar deterioration.

Keyword(s): mine design, rock mechanics, in situ testing, lab testing, room-and-pillar

Emrick, H. W. Establishment and Use of Monitoring Networks. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 211-214.

This paper states that modern subsidence monitoring should include the interdisciplinary tools from soils engineering, geophysical engineering, geological engineering, geodetic engineering, mathematical and electrical engineering data processing handling, and modeling methods. The main emphasis is on current methodology in geodesy and geodynamics.

Keyword(s): soils, engineering, geophysical, modeling, remote sensing, survey design, survey equipment, survey methods, survey data processing, monitoring design, monitoring equipment, monitoring installation, monitoring methods, coal mining

Emsley, S. J., J. W. Summers, P. Styles. The Detection of Sub-surface Mining Related Cavities Using the Micro-Gravity Technique. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 27-35.

The presence of mining-related cavities in the rock mass, resulting from past mining activities, often leads to restrictions in subsequent re-use of the land and poses a number of problems for future construction projects. The micro-gravity technique is a geophysical method that has been further developed to improve its use in the detection of mining-related cavities.

Keyword(s): geophysical, abandoned mines, remote sensing, seismic, surface structural damage, coal mining

Location(s): United Kingdom

Enever, J. R., J. Shepherd, J. Huntington. An Initial Mathematical Relationship Between Underground Working Conditions and Overlying Surface Topography with Reference to the Western Coalfields, N.S.W. Commonwealth Scientific and Industrial Research Organization, Mineral Physics, Mount Waverly, Victoria, Australia, Report 5, 1978, 6 p.

Keyword(s): ground control, coal mining

Location(s): Australia

Engineering and Mining Journal. The Flushing Problem in the Anthracite Region. v. 88, September 18, 1909, p. 564-565.

This article describes the danger of subsidence to surface property and also covers attempts at backfilling.

Keyword(s): backfilling, surface subsidence damage, anthracite, coal mining, historical

Location(s): Pennsylvania, Appalachian Coal Region, United States

Engineering News. Concrete Column Foundation for a Building Over Coal Mine Workings. v. 67, no. 14, April, 1912, p. 633.

This paper describes the use of 8- to 12-inch diameter caissons and grade beams for support of a new home located 30 feet above an abandoned mine in Pennsylvania.

Keyword(s): foundations, room-and-pillar, abandoned mines, engineering, surface structural damage, coal mining, historical, grouting
Location(s): Pennsylvania, Appalachian Coal Region, United States

Engineering News. More Mine Cave-Ins Threaten Parts of Scranton. v. 76, 1916, p. 280.
This article discusses the lack of legal responsibility at that time among mine operators for surface subsidence damage.
Keyword(s): mine operation, law, room-and-pillar, historical, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Engineering News-Record. Subsurface Grouting of a Hospital Site. February 9, 1950.
This article describes pressure grouting procedure used by the U.S. Army Corps of Engineers to reconsolidate an area beneath a proposed hospital in Pennsylvania.
Keyword(s): grouting, abandoned mines
Location(s): Pennsylvania, Appalachian Coal Region, United States

Engineering News-Record. Can't Dredge the Harbor?--Then Lower the Land. January 31, 1963.
A brief description is given of a planned, controlled subsidence coal mining operation designed to lower the floor of Duisberg Harbor. Induced subsidence was designed to compensate for a 6.5 foot water level drop that had reduced the efficiency of the harbor operation.
Keyword(s): surface water, coal mining

Engineering News-Record. Piling System Supports Construction Atop Mines. v. 227, no. 6, 1991, p. 19.
The owners of a 2,000-acre commercial and residential development in Birmingham, Alabama, had to develop a way to support the foundation of a seven-story, 185,000-square-foot building, which was part of a $150,000-million project to be built over abandoned coal mines that once fed steel blast furnaces.
Keyword(s): abandoned mines, coal mining, foundations, surface structural damage, architecture, geotechnical, structural mitigation, grouting
Location(s): Alabama, United States

Engineers International, Inc. Criteria for Determining When a Body of Surface Water Constitutes a Hazard to Mining. Final Report on U.S. Bureau of Mines Contract J0285011, August, 1979, 366 p.
Keyword(s): surface water
Location(s): United States

English, J. Some Notes on Subsidence. Iron and Coal Trades Review, v. 141, December 6, 1940, p. 591.
Keyword(s): coal mining

Environmental Systems Application Center, Indiana University. Illinois Basin Coal Planning Assistance Project, Coal Resources Fact Book, Volume One. Prepared for U.S. Geological Survey, Reston, VA, February 1983, in cooperation with Illinois State Geological Survey, Indiana Geological Survey, and Kentucky Geological Survey, 323 p.
Kentucky, Illinois, and Indiana share the vast coal resources of the Eastern Interior Coal province commonly known as the Illinois Coal Basin. As the United States uses more coal, pressures to develop new resources will require states and local communities to plan and manage comprehensive programs. Although some Basin resources have been developed for many years, new legislation, stricter environmental controls, increased costs, and many local agency requirements will make planning and management of coal development more difficult than in the past.
Keyword(s): coal mining, land-use planning, geologic features
Location(s): Kentucky, Illinois, Indiana, Illinois Coal Basin, United States

Enzian, C. Hydraulic Mine Filling. U.S. Bureau of Mines, B 60, 1913.
This bulletin reviews the history of hydraulic mine filling in active mines and its application for fire control, roof support, pillar reclamation, as well as disposing of spoil and alleviating stream pollution.
Keyword(s): roof support, room-and-pillar, hydraulic backfilling, economics, environment, mine fires, mine waste, active mines
Location(s): United States

Enzian, C. Physical and Geological Difficulties of Anthracite Mining with Special Reference to Surface Support in the Northern or Wyoming Basin. Thesis, Lehigh University, 1913.
The thesis discusses the geology of the anthracite regions and the cause of mine caves, analyzes some prominent mine caves, indicates remedial measures being taken, gives the results of

numerous tests on timber, cogs, hydrauliced culm and concrete, and indicates the solution developed for that region.

Keyword(s): anthracite, coal mining, historical, roof support, hydraulic backfilling, geologic features, land mitigation

Location(s): Wyoming, United States, Rocky Mountain Coal Region

Enzian, C. Mine Caving Prevented by Hydraulic Backfilling. Coal Age, April 4, 1914, p. 555.

This article describes the advantages of hydraulic backfilling, including pillar reclamation, mine waste disposal, and fewer environmental problems.

Keyword(s): hydraulic backfilling, mine waste, environment, coal mining

Esaki, T., T. Kimura, K. Shikata. Subsidence and Environmental Impacts in Japanese Coal Mining. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 511-518.

This paper describes the present condition of mining-induced damages in Japan and their characteristics. The change of mining operation and environmental condition has caused various significant impacts on the environment: subsidence, cave-in, springing out of groundwater, etc. The characteristics and the influences of these phenomena are discussed by investigation of the actual conditions and by fundamental studies. Some countermeasures are also introduced.

Keyword(s): coal mining, environment, subsurface water, active mines, abandoned mines, reclamation, mine waste, structural mitigation, land mitigation, geologic features, law, historical, land-use planning, inflow

Location(s): Japan

Esterhuizen, G. S. Modelling of Barrier Pillars in Bord and Pillar Workings. IN: Proceedings, International Congress on Rock Mechanics, Aachen, 1991, W. Wittke, ed., v. 2, p. 1093-1097.

Barrier pillars are designed to isolate production sections from one another so that uncontrolled failure of pillars in one section will not affect the adjacent workings. The strength of a continous barrier pillar and the load it carries are required for the design of barrier pillars. The loading conditions were determined by assuming a simple model of the load distribution in the caved and uncaved ground. The results showed that if pillars fail and the overburden caves gradually, then the load on barrier pillars will not increase significantly. However, if strong strata are present in the roof then a significant increase in load is possible. The strength of barrier pillars was further investigated using three-dimensional numerical models and by studying actual collapsed cases. It was found that if the width to height ratio is 4.0, the strength of long rectangular pillars increases signficantly over square pillars with the same width but if the width to height ratio is 10.0, the strength does not increase.

Keyword(s): pillar strength, modeling, overburden, coal mining, room-and-pillar

Location(s): South Africa

Evans, D. W., G. J. Colaizzi. Control of Mine Subsidence Utilizing Coal Ash as a Backfill Material. IN: Proceedings, 2nd Conference on Ground Control in Mining, West Virginia University, July 19-21, 1982, S.S. Peng and J.H. Kelley, eds., Morgantown, p. 222-228.

A number of methods exist to provide support for the ground overlying mines. All of these methods employ some mechanism for providing additional support to either the roof of the mine or the sides of the pillars. Since failure usually occurs due to overburden stresses transmitted to the roof and pillars, these methods employ techniques to counteract stresses induced due to the coal extraction. The applicability of any particular method will depend on the availability of backfill material, the areal extent of the affected area, and the cost. The primary use of coal ash for subsidence control has been as a backfill material for the stabilization of large areas.

Keyword(s): mine waste, hydraulic backfilling, grouting, coal mining, overburden, pillar strength, roof stability, ground control

Location(s): United States

Evans, D. W., G. J. Colaizzi, R. M. Wood. Program Development for Backfilling Mines to Prevent Mine Subsidence. IN: Proceedings, 19th Annual Engineering Geology and Soils Engineering Symposium, Pocatello, ID, March 31-April 2, 1982, C.W. Blount, ed., p. 355-364.

This paper covers the progression of steps required to initiate a backfilling program. These steps include the establishment of the need for remedial measures; the development of a drilling program to evaluate the extent of voids; the data search to obtain information; the reduction of data obtained from mine maps, publications, and drilling; the development of potential remedial actions; and ultimately the backfilling requirements and techniques utilized to control the subsidence.

Keyword(s): hydraulic backfilling, grouting, abandoned mines, reclamation, surface structural damage, land mitigation, geologic features

Location(s): Pennsylvania, West Virginia, Wyoming, Appalachian Coal Region, Rocky Mountain Coal Region, United States

Evans, G. S., T. Hailu, H. M. Weagraff, J. W. Warner, G. S. Lowry. The Impact of Longwall Mining on the Hydrologic Balance; Premining Data Collection. Contract J0218025, J.F. Sato & Associates, Inc., U.S. Bureau of Mines OFR 187-83, 1983, 141 p. (NTIS PB 84-113174)

Keyword(s): longwall, hydrology, surface water, subsurface water

Location(s): United States

Evans, I., D. C. Pomeroy, R. Berenbaum. The Compressive Strength of Coal. Colliery Engineering, 1961, v. 38, February, p. 75-80, March, p. 123, April, p. 172.

This series of articles discusses laboratory tests on rectangular and irregular lumps of coal to determine their compressive strengths.

Keyword(s): pillar strength, rock mechanics, lab testing, coal mining

Evans, I. D., C. D. Pomeroy. The Strength, Fracture and Workability of Coal. Pergamon Press, New York, 1966, 277 p.

Keyword(s): ground control, coal mining, pillar strength

Location(s): England

Evans, J. A., M. S. Lawrence. A Case Study on Past Shortwall Mining Methods and the Risk of Ground Subsidence in the Lanarkshire Coalfield, Scotland. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 337-349.

A site investigation involving archival research and a borehole drilling program was carried out in order to assess the risk to surface stability from abandoned shallow shortwall mineworkings at a proposed housing development site. The investigations recorded the shortwall panels to be largely consolidated but also noted that several panels had been undeveloped with respect to the lower seam and that some roadways were confined to the upper seam. The borehole investigation together with the use of down-the-hole closed-circuit television also confirmed the presence of broken ground and open voids along former roadway alignments. A risk to surface stability was identified from these open voids and development constraints zones are discussed in relation to the likely mining methods. Seam depths, void heights, condition of roof strata and thickness of superficial cover are considered in the assessment of void migration mechanisms arising from such a past mining situation.

Keyword(s): shortwall, abandoned mines, coal mining, land-use planning, surface structural damage, engineering, geologic features, monitoring methods, rock mechanics, multiple-seam extraction, historical

Location(s): Scotland

Evans, R. T., A. B. Hawkins. Significance and Treatment of Old Coal Workings at Llanelli Hospital, South Wales. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 188-206.

The geology, past mining, and reasons for undergrouting a hospital are discussed. Abandonment plans record extensive workings in the seam beneath much of the site. Several voids were encountered during the investigation, which indicated that the coal seam was overlain by a mudstone and then a thick competent sandstone horizon. In view of the risk of pillar collapse leading to the bridging and overstressing of lateral pillars and following the experience of Bathgate in Scotland, it was considered necessary to undergrout the area on which the structures were to be built. 14,500 tons of grout were injected into 3,550 holes. Water injection tests indicated the grouting had been effective, and it is now considered that no significant future subsidence should take place.

Keyword(s): abandoned mines, coal mining, surface structural damage, grouting, geologic features

Location(s): Wales

Evans, W. H. The Strength of Undermined Strata. Transactions, Institution of Mining and Metallurgy, v. 50, 1941, p. 475-532.

Keyword(s): rock mechanics, overburden

Evans, W. H., T. J. Jones. An Investigation of the Load on Packs at Moderate Depths Part II. Transactions, Institute Mining Engineers, 1946, v. 105, pt. 6.
Keyword(s): backfilling

Ewy, R. T., M. Hood. Old Ben No. 24, Subsidence Analysis and Predictive Program, User's Guide. Department of Material Science and Mining Engineering, University of California, Berkeley, April, 1982, 11 p.
Keyword(s): prediction, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Faddick, R. R., W. R. Eby. Slurry Backfilling of Mine Voids in Hanna, Wyoming. IN: Proceedings of Symposium on Mining, Hydrology, Sedimentology, and Reclamation, December 8-11, 1986, Lexington, KY, p. 209-213.
Keyword(s): hydraulic backfilling, abandoned mines, coal mining
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Faddick, R. R., W. R. Eby. Effects of Slurry Backfilling--Lessons Learned. IN: Conference on Hydraulic Fill Structures, Colorado State University, Fort Collins, August 15-18, 1988, D.J.A. Van Zyl and S.G. Vick, eds., ASCE Geotechnical Special Publication No. 21.
In 1986 the underground coal mine voids in Hanna, Wyoming, were slurry backfilled to alleviate subsidence throughout much of the town. The project was completed successfully, but in a relative sense, because it was not without its share of difficulties. Some of these technical difficulties, pertaining to the fill material used, the operation of the pipeline system, and sequence of backfilling, are discussed with the hope that they may be interpreted as lessons for future slurry backfilling operations.
Keyword(s): hydraulic backfilling, coal mining, abandoned mines, surface structural damage
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Fader, S. W. Land Subsidence Caused by Dissolution of Salt Near Four Oil and Gas Wells in Central Kansas. U.S. Geological Survey Water-Resources Investigations 27-75, 1975, 28 p.
Keyword(s): surface subsidence damage, oil extraction, non-metal mining
Location(s): Kansas, United States

Faig, W. The Use of Photogrammetry for Mining Subsidence Determination. Australian Journal Geodesy, Photogrammetry, and Surveying, v. 41, December, 1984, p. 21-35.
Keyword(s): survey methods, remote sensing
Location(s): Australia

Fairhurst, C. Laboratory Testing of Rock and its Relevance to Mine Design. IN: SME Mining Engineering Handbook, v. 1, A.B. Cummins and I.A. Given, eds., 1973, SME-AIME, New York, p. 13-36 to 13-51.
The design of engineering structures in rock is more art than science, particularly insofar as the behavior of the rock mass is concerned. This is particularly true in mine design. Progress is being made, but currently there are no widely used rational design procedures because of the difficulty of theoretical formulation of the practical problem and because of the lack of information on the mechanical properties of the rock mass affected by extraction.
Keyword(s): rock mechanics, mine design, lab testing, room-and-pillar, pillar strength

Faria Santos, C. Analysis of Floor Stability in Underground Coal Mines. Ph.D. Thesis, The Pennsylvania State University, 1988, 205 p.
Keyword(s): floor stability, coal mining, in situ testing, lab testing, geotechnical, longwall, room-and-pillar, instrumentation, geologic features
Location(s): West Virginia, Appalachian Coal Region, United States

Faria Santos, C., Z. T. Bieniawski. Floor Design in Underground Coal Mines. Rock Mechanics and Rock Engineering, v. 2, no. 4, 1989, p. 249-271.
Floor failure and excessive heave in underground coal mines can jeopardize the stability of the whole structure, including the roof and pillars, due to differential settlements and redistribution of stress concentrations. Besides, floor failure is detrimental to haulageway operation and can lead to unacceptable conditions of high deformation. Thus, the design of any underground opening must consider roof/pillar and floor as one structural system. This paper presents guidelines for designing mine floors, including the necessary field and laboratory investigations and determining bearing capacity of the floor strata. The design methodology is based on a modified Hoek-Brown rock mass strength criterion, with modifications to the introduction of the concept of the point of critical energy relase to account for the long-term strength, the inclusion of tensile strength and the adoption of a lithostatic state of stress in the rock mass. Determining the dimensionless parameters m and s result from correlations with the RMR (rock mass rating) Geomechanics Classification. Nine case histories, both in longwall and room-and-pillar coal mining, were analyzed with the proposed methodology.
Keyword(s): coal mining, mine design, floor stability, rock mechanics, lab testing, longwall, room-and-pillar, pillar strength, geotechnical
Location(s): Ohio, Kentucky, West Virginia, Appalachian Coal Region, United States

Farmer, I. W., P. B. Attwell. A Note on the Similarities Between Ground Movement Around Soft Ground Tunnels and Longwall Mining Excavations. The Mining Engineer, London, v. 134, May, 1975, p. 397-405.
Keyword(s): longwall, tunnelling, geologic features

Farmer, I. W. Case Histories of Settlement Above Tunnels in Clay. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 357-371.
Theoretical and empirical methods for determining ground movement and surface settlement magnitudes above tunnels in soft ground usually relate the geometry of the settlement profile to the geometry of tunnelling. The importance of the tunnel construction method and the ground deformation mechanism is often underemphasized. Three case histories are introduced that show how construction and soil deformation characteristics can significantly affect settlement.
Keyword(s): tunnelling, soils, modeling, empirical model, construction
Location(s): United Kingdom

Farmer, I. W., P. F. R. Altounyan. The Mechanics of Ground Deformation Above a Caving Longwall Face. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 75-91.
An examination of contours of vertical strain computed from three investigations of ground deformation behind caving longwall faces shows that an extensive zone of fractured and dilated rock is created above the caved area. The boundaries of the fractured zone and the magnitude of residual dilation thorughout the zone are strongly influenced by the lithology of the overlying strata.
Keyword(s): longwall, overburden, rock mechanics, coal mining, instrumentation
Location(s): United Kingdom

Farmer, I. W., X. Tan. Outbursts and Rockbursts in Coal Mines. IN: Proceedings 7th International Conference on Ground Control in Mining, Morgantown, WV, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, p. 228-233.
A description of the factors causing outbursts and rockbursts in coal mines is given. The mechanics of both outbursts and rockbursts can be described in terms of conversion of stored strain energy in the coal and surrounding rocks into kinetic energy through failure. The major difference between the two phenomena is that gases adsorbed onto the coal structure and desorbed during deformation contribute to the energy available during outbursts and may also affect the loading and unloading characteristics associated with failure. The amount of energy involved and the type of phenomenon are related principally to gas content, depth, and rock behavior.
Keyword(s): rock mechanics, coal mining, bumps

Farquar, G. B., B. J. Douglas. Risk of Mine Related Subsidence at Ocean View. IN: Proceedings 6th Australia-New Zealand Conference on Geomechanics, Christchurch, February 3-7, 1992, New Zealand Geomechanics Society, p. 236-241.
A subsidence pit appeared in July 1998 in a residential area of Ocean View, New Zealand, above a 100-year-old abandoned coal mine. The extent of the mine and its condition were investigated. Weak overburden strata and a deteriorating and flooded mine were revealed. Mine roof failure and subsequent subsidence of sandy gravel migrating upwards to form a crownhole are considered to have caused the surface movement. Similar conditions were observed nearby. Subsidence risks have been assessed.
Keyword(s): abandoned mines, coal mining, surface subsidence damage
Location(s): New Zealand

Farran, C. E. The Effect of Mining Subsidence on Land Drainage. Journal Institute Water Engineering, v. 6, no. 7, 1952, p. 482-503.
This paper discusses the effects of longwall mining subsidence on flat, low-lying land in England.
Keyword(s): surface water, longwall
Location(s): England

Faulkner, R. Roof Control in the Arley Seam. Transactions, Institute of Mining Engineers, v. 81, 1930-31, p. 507-524; v. 84, 1932-33, p. 57-77, 405.
This article discusses observations of roof failure in longwall mines having shale roofs.
Keyword(s): roof stability, longwall

Fawcett, A. H., Jr., J. Aamot. Economic and Social Indicators With Reference to Land Use in Subsidence-Prone Areas in Northeastern Pennsylvania. v. 2, May, 1975, 42 p. (NTIS PB 273 918)
Keyword(s): land-use planning, economics
Location(s): Pennsylvania, Appalachian Coal Region, United States

Fawcett, A. H. Jr., J. Marcou. Economic and Social Indicators with Reference to Land Use in Subsidence-Prone Areas in Northeastern Pennsylvania. Volume I. General Findings and Recommendations. Appalachian Regional Commission Report ARC-73-163-2556-1, May 1975, 150 p. (NTIS PB-273 917)
This report includes an inventory and analysis of socioeconomic and land-use data for a seven-county region covering most of the Anthracite Region of northeastern Pennsylvania. Conditions of potential land subsidence due to underground coal-mine collapse are related to land-use and other settlement characteristics. The authors conclude that land-use planning alone cannot provide a definitive solution to the problem of potential subsidence damage, but must be combined with appropriate building regulations, stabilization, and insurance programs, as well as effective state policy.
Keyword(s): coal mining, anthracite, land-use planning, insurance, subsidence research, environment, abandoned mines
Location(s): Pennsylvania, Appalachian Coal Region, United States

Fayol, M. Sur les mouvement de terrain provoques par l'exploitation des mines (Effects of Coal Mining on the Surface). Bulletin de la Societe de l'Industrie Minerale, II Serie, Tome 14, 1885. Partial translation by H. F. Bulman, Colliery Engineering, v. 33, 1913, p. 548-552, 617-622.
Keyword(s): roof stability, mine design, surface subsidence damage, ground control, coal mining

Federal Register. Coal Mining Operating Regulations. May 17, 1976, C.F.R. 211: Federal Register, v. 41, no. 96, p. 20261-20273.
Keyword(s): mine operation, coal mining, law
Location(s): United States

Federal Register. Coal Management, Proposed Rulemaking. Part III, March 19, 1980, U.S. Department of Interior, Bureau of Land Management, Washington, D.C., v. 44, no. 54, p. 16800-16845.
Keyword(s): law, coal mining
Location(s): United States

Federal Register. Permanent Regulatory Program: Subsidence Control, Concurrent Operations and Contemporaneous Reclamation. Office of Surface Mining Reclamation and Enforcement, Final Rule, Part VII, v. 48, no. 106, June 1, 1983, p. 24638-246452.
Keyword(s): law

Fedorowicz, L., J. Fedorowicz. Wall Structures Affected by the Static Effects of Mining Operations. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 370-382.
The authors of this paper have been dealing for several years with the problem of adaptation of the numerical method of rigid finite elements for the purpose of calculatingthe following: buildings subjected to bending and twisting, allowing for their two- or three-dimensional statical behavior; and floating foundations, allowing for the interaction of the superstructure and substructure, when exposed to the effects of the horizontal compression and extension of the ground at the site.
Keyword(s): surface structural damage, coal mining, finite element, modeling, foundations, horizontal displacement
Location(s): Poland

Fejes, A. J., R. D. Dyni, J. A. Magers, L. B. Swatek. Subsidence Information for Underground Mines--Literature Assessment and Annotated Bibliography U.S. Bureau of Mines IC 9007, 1985, 86 p.
The purpose of this report is to provide mining industry personnel and regulatory authorities with a subsidence reference list and annotated bibliography that will aid them in locating subsidence information and in developing their own subsidence information sources.
Keyword(s): literature search, subsidence research

Fejes, A. J. Surface Subsidence Resulting from Longwall Mining in Central Utah--A Case Study. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines &

Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 197-204.

This paper summarizes the results of a 5-year subsidence study performed over four adjacent longwall panels in Utah. The objectives of this program were to determine the magnitude, rate, and areal extent of surface subsidence from longwall mining under the geologic and mining conditions commonly found in the western United States. The data were collected from this site to evaluate the applicability of existing prediction methods to conditions in the western United States and, if necessary, to develop new or modified prediction techniques.

Keyword(s): longwall, prediction, monitoring installation, survey design, profile function, empirical model, National Coal Board, vertical displacement, surface subsidence damage

Location(s): Utah, Rocky Mountain Coal Region, United States

Fejes, A. J. Surface Subsidence Over Longwall Panels in the Western United States. U.S. Bureau of Mines IC 9099, 1986, 21 p.

This study was directed toward developing the capability to estimate the surface subsidence resulting from longwall mining in a geologic, topographic, and mining environment common to coalfields in the western United States.

Keyword(s): geologic features, longwall, instrumentation, monitoring design, monitoring methods, monitoring installation, monitoring equipment, survey design, survey equipment

Location(s): Utah, Rocky Mountain Coal Region, United States

Fenk, J. Moeglichkeiten zur Bestimmung der Beanspruchung des Haupthangenden als Abbaufolge (Possibilities of Determining Stresses in Overburden Strata Caused by Mining Sequence). Neue Bergbautechnik, v. 2, August, 1972, p. 601-606.

Keyword(s): instrumentation, overburden

Fenk, J. Modeling of Small, Localized Surface Subsidence. Neue Bergbautechnik, v. 7, no. 6, June, 1977, p. 414-417.

Keyword(s): modeling

Ferguson, P. A. Longwall Mining Systems and Geology. Mining Congress Journal, v. 57, no. 12, 1971, p. 32-35.

Production may approach one million tons per year from one longwall mine, according to the results of this research. Several methods of roof support were developed, including yieldable arches, yieldable legs and beams, and roof trusses.

Keyword(s): coal mining, longwall, yielding supports, roof support

Location(s): Pennsylvania, Appalachian Coal Region, United States

Fernandez-Rubio, R., ed. First World Congress of Water in Mining and Underground Work. SIAMOS, September 18-22, 1978, Granada, Spain, 1550 p.

Water problems in mining and underground work appear almost as a challenge. Therefore, original investigation techniques and methodologies are required. In many cases accumulated experience, in very different environments, has an extraordinary value. These problems are frequent and often complex. Many technicians and scientists have good experience in this field. However, this publication is the first one that tries to unite this experience in a world-wide participation. Contributions of specialists from 24 countries are included, therefore this publication is of strong interest for everybody connected to mining, civil engineering, geology, hydrogeology, and ecology. Volumes I and II contain the full text of the selected papers (70% in English), with an English, French, and Spanish summary, classified in six topic sections.

Keyword(s): subsurface water, coal mining, hydrology, geologic features

Location(s): India, Australia, Illinois, Illinois Coal Basin, United States

Fernando, D. A. Review of Subsidence and Stabilization Techniques. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 189-206.

This paper aims to review the causes of subsidence and the techniques used to minimize its effect on structures. Also, more economic alternative methods of ground stabilization techniques are described and proposed, to be used in this area of ground engineering.

Keyword(s): coal mining, longwall, abandoned mines, land-use planning, grouting, partial extraction, prediction theories, foundations, mine waste

Location(s): United Kingdom

Ferrari, R. Predicting the Unpredictable. IN: Proceedings 2nd International Conference on Construction in Areas of Abandoned Mine Workings, Edinburgh, 1988.
Keyword(s): abandoned mines, prediction, land-use planning

Finlay, J., A. Winstanley. Interaction of Longwall Workings. Transactions, Institute of Mining Engineers, v. 87, 1933-34, p. 172-189; v. 88, 1934-35, p. 24, 298, 415.
Investigations were made in two beds of coal separated by 71 feet of rock and mined 2 years apart by the longwall method.
Keyword(s): longwall, multiple-seam extraction, coal mining

Finol, A., S. M. Farouq Ali. Numerical Simulation of Oil Production With Simultaneous Ground Subsidence. Journal of the Society of Petroleum Engineers, v. 15, October, 1975, p. 411-424.
Keyword(s): modeling, oil extraction

Fischer, W. G., S. R. Felde. Four-North Panel, A Bold Experiment in Roof Deflection. Mining Engineering, April, 1966, p. 63-67.
This mining system leaves small yielding pillars that are meant to deform plastically and produce controlled subsidence. Conventional room-and-pillar mining equipment is used with longwall roof supports.
Keyword(s): longwall, shortwall, room-and-pillar, roof support, roof stability, mine design, yielding supports
Location(s): United States

Fischer, W. G. Time Dependent Subsidence Behavior at a Green River Trona Mine. IN: Mine Subsidence, M.M. Singh, ed., Society of Mining Engineers Fall Meeting, September, 1986, St. Louis, MO, SME, Littleton, CO, p. 111-116.
Equations developed by an early researcher in subsidence, F. Martos of Hungary, have been slightly modified to produce effective equations for predicting the time-dependent nature of Green River trona mine subsidence. Following the initial study, a survey was run to check the results 20 years after mining of the area had been completed. The final results were within a few centimeters of the value that had been projected. Mining conditions in the Green River area are ideal for this sort of study with trough type subsidence being the surface manifestation of high extraction underground room-and-pillar caving operations.
Keyword(s): time factor, prediction, prediction theories, non-metal mining
Location(s): Wyoming, United States

Fisekci, M. Y. Strata Control Instrumentation for Coal Mine Design with Special Reference to Hydraulic Mining. IN: Site Characterization, Proceedings 17th U.S. Symposium on Rock Mechanics, Snowbird, UT, August 25-27, 1976, W.S. Brown, S.J. Green, and W.A. Hustrulid, eds., University of Utah, Salt Lake City (abstract of oral presentation), 1 p.
The paper discusses the recent development in strata control instrumentation to meet the requirements of fast moving faces of hydraulic mining in thick and steep coal seams. The paper further points out that much more effective use can be made of existing knowledge to meet the changing strata control requirements of the coal industry.
Keyword(s): coal mining, ground control, instrumentation

Fisekci, M. Y., A. Chrzanowski, B. M. Das, G. Larocque. Subsidence Studies in Thick and Steep Coal Seam Mining. IN: Proceedings 1st Annual Conference on Ground Control in Mining, West Virginia University, Morgantown, July 27-29, 1981, S.S. Peng, ed., p. 230-238.
This paper concentrates on subsidence measurements applied over the thick and steep seam mining in the Rocky Mountains Region of Western Canada. The studies to date indicate that two new subsidence monitoring techniques appear to be the most suitable methods for these conditions. The computerized telemetry and aerial photogrammetry systems are being tested for the reliability of the systems during the winter months within the network of laser surveying over the workings of the new hydraulic mine.
Keyword(s): coal mining, monitoring methods, monitoring equipment, remote sensing, survey methods
Location(s): Canada

Fisekci, M. Y., C. Chrzanowski. Some Aspects of Subsidence Monitoring in Difficult Terrain and Climate Conditions of Rocky Mountains Western Canada. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 182-196.

Subsidence measurement methods, applied over the thick and steep seam mining in the Rocky Mountains Region of Western Canada are described. The studies to date indicate that two new subsidence monitoring techniques appear to be the most suited methods for these conditions. The computerized telemetry and aerial photogrammetry systems are being tested for reliability during the winter months within the network of laser surveying over the workings of the new hydraulic mine.

Keyword(s): monitoring design, monitoring equipment, monitoring installation, monitoring methods, instrumentation

Location(s): Canada, Rocky Mountain Coal Region

Fisher, A. E. J. Aspects of In-Seam Development for Subsequent Full Extraction. IN: Annual Conference, Australasian Institute of Mining and Metallurgy, May, 1976, p. 337-344.

Keyword(s): mine design, coal mining

Fitzpatrick, D. J., D. J. Reddish, B. N. Whittaker. Studies of Surface and Sub-Surface Ground Movements Due to Longwall Mining Operations. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 68-77.

This paper reviews current mining subsidence research at the Department of Mining Engineering, University of Nottingham. Special attention is being devoted to prediction of ground movements between the mining horizon and the surface using physical and computer-based models. The paper discusses linear and non-linear finite element methods and compares results with those from physical models and field observations. Special attention is focused on the determination of the effect of caved zones on overlying and underlying geological structures. The paper presents data from comparisons with case histories from the United Kingdom.

Keyword(s): modeling, computer, geologic features, finite element, National Coal Board, coal mining, subsidence research, prediction, prediction theories, overburden

Location(s): United Kingdom

Fitzpatrick, D. J. Modelling of Mining Subsidence Mechanisms and Prediction of Ground Movements. Ph.D. Thesis, University of Nottingham, United Kingdom, 1987.

Keyword(s): modeling, prediction, coal mining

Location(s): United Kingdom

Flaschentrager, H. Considerations on Ground Movement Phenomena Based on Observations Made in the Left Bank Lower Rhine Region. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957. London Harrison, 1957, p. 58-73.

This paper presents research conducted to study the influence of incomplete convergence at the edge of workings on surface subsidence. Data were collected in Germany from mines where backfilling was used.

Keyword(s): vertical displacement, time factor, pneumatic backfilling, stowing, modeling, empirical model, influence function

Location(s): Germany

Flaschentrager, H. Consideration on Ground Movement Phenomena. Colliery Engineering, v. 35, 1958, p. 342-350, 391-397.

In this paper, the author sought to clarify the influence of the rib-side (or solid coal side) with incomplete convergence on movements at the surface. Starting with measurements in the face cavity, the conception of the face convergence curve is developed. Its significance is demonstrated from various examples. The limit angle is not changed by the face convergence already occurring in the coal in front of the working face and, consequently, there is no need for a distinction between the theoretical and practical limit angles. Finally, the time factor for underground and surface was discussed from various examples.

Keyword(s): ground control, coal mining, time factor

Fleming, R. M. Subsidence from a Mining Engineer's Point of View. Appendix A to the Report of the Subsidence Committee, Pennsylvania General Assembly, Legislative Journal, 1957, p. 4249-4252.

This appendix reviews the problems of subsidence from anthracite and bituminous mining.

Keyword(s): engineering, government, law, coal mining, anthracite, bituminous

Location(s): Pennsylvania, Appalachian Coal Region, United States

Flowers, A. E. Plans for Long, Productive Life. Coal Age, v. 62, no. 2, 1957, p. 77-83.

Keyword(s): coal mining

Follington, I. L., A. K. Isaac. Failure Zone Development Above Longwall Panels. Mining Science and Technology, v. 10, no. 1, January, 1990, p. 103-116.

The controlled development of failure zones above longwall panels is necessary for maintenance of production and safety of personnel. This is particularly so where aquifers exist above and in relative proximity to coal faces. A brief review of finite element modeling of strata surrounding mining excavations is presented. Particular emphasis is given to determination of input data required for the modeling technique. In this, attention is focussed upon various methods of rating of the rock mass.

Keyword(s): overburden, longwall, subsurface water, coal mining, finite element, modeling, rock mechanics

Location(s): United Kingdom

Follington, I. L., A. K. Isaac. A Coalface Roof Failure Mechanism Beneath Strong Bridging Strata. Mining Science and Technology, v. 10, no. 2, March, 1990, p. 117-126.

An investigation into powered support performance and strata behaviour at Cotgrave Collierty followed difficulties encountered in roof control at a high production coal face.

Keyword(s): roof stability, overburden, geologic features, ground control

Location(s): United Kingdom

Follington, I. L., P. Garritty, A. Dutton. Geotechnical Aspects of Longwall Coal Mining at Cook Colliery, Queensland. IN: Computer Methods and Advances in Geomechanics, Proceedings 7th International Conference, Cairns, QLD Australia, May 6-10, 1991, v. 2, G. Beer, J.R. Booker and J.P. Carter, eds., Balkema, Rotterdam, p. 1319-1326.

This paper describes the findings of an investigation undertaken to determine the geotechnical conditions and strata response to longwall mining. The panel around which the study was based was the first longwall operation undertaken at this colliery and only the second longwall installation in Queensland. There were two main parts to the work: in situ monitoring and material testing. The in situ monitoring was undertaken in the maingate and tailgate roadways during passage of the longwall face. The instrumentation employed included roof extensometers, convergence monitors, and stress cells. The material testing was carried out on a range of samples obtained from a cored hole and from bulk samples collected underground.

Keyword(s): rock mechanics, lab testing, in situ testing, longwall, active mines, instrumentation, coal mining, monitoring equipment, monitoring methods, geotechnical

Location(s): Australia

Fonner, R. F., J. H. Reynolds. OSM Fairmont, WV, Mine Subsidence Study: Core Drilling West Virginia Geological and Economic Survey Open File Report No. 79-3, June 22, 1979, for U.S. Bureau of Mines, 26 p.

Five NX core holes were drilled at Fairmont, WV, to investigate surface subsidence and determine geologic conditions above an old mine. The area of surface subsidence was expected to increase as roof-fall, cave-in, and weathering processes continued. Bedrock over large coal pillars and in-place blocks of coal appeared relatively sound and undisturbed, while bedrock over old mine voids was broken.

Keyword(s): surface structural damage, abandoned mines, geologic features, overburden, geotechnical, coal mining, rock mechanics, soil mechanics

Location(s): West Virginia, Appalachian Coal Region, United States

Fonner, R. F., J. S. McColloch, C. P. Messina. Core-Drill Logs for BOM Mine Subsidence Study, Duncan Hill, Clarksburg, West Virginia. West Virginia Geological and Economic Survey Open File Report No. OF8013, September, 1980, for U.S. Bureau of Mines, 11 p.

The logs of three core-drill holes, with photographs of the rock cores and interpretive remarks, are presented to the USBM for their mine subsidence studies in the vicinity of Duncan Hill, Clarksburg, West Virginia. The holes were drilled through abandoned mines in the Pittsburgh Coal during August 1980.

Keyword(s): coal mining, abandoned mines, geologic features, overburden

Location(s): West Virginia, Appalachian Coal Region, United States

Fookes, P. G. Land Evaluation and Site Assessment (Hazard and Risk). IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 273-282.

This paper discusses the probability of natural hazards of various kinds (including mine subsidence), and efforts to map and predict these hazards.
Keyword(s): land-use planning

Foose, R. M. Mine Dewatering and Recharge in Carbonate Rocks Near Hershey, Pennsylvania. IN: Engineering Geology Case Histories Number 7, Legal Aspects of Geology in Engineering Practice, Division of Engineering Geology, Geological Society of America, Boulder, CO, 1969, p. 45-60.
Keyword(s): subsurface water, hydrology
Location(s): Pennsylvania, Appalachian Coal Region, United States

Forde, M. C., B. H. V. Topping, H. W. Whittington. Mineworkings 84: Proceedings of the International Conference on Construction in Areas of Abandoned Mineworkings. Engineering Technics Press, Edinburgh, 1984, 286 p.
Keyword(s): abandoned mines, construction, engineering, architecture, surface structural damage, land-use planning

Forrester, D. J. An Investigation Into the Effect of Undermining Colliery Spoil Heaps. Ph.D. Thesis, University of Nottingham, England, 1974, 72 p.
Keyword(s): mine waste, coal mining
Location(s): United Kingdom

Forrester, D. J., B. N. Whittaker. Effects of Mining Subsidence on Colliery Spoil Heaps. I. Mining Subsidence and Geotechnical Aspects of Spoil Heaps and Their Foundations. II. Deformational Behavior of Spoil Heaps During Undermining. International Journal of Rock Mechanics and Mining Science & Geomechanics Abstracts, v. 13, no. 4, 1976, p. 113-120, 121-133.
Mining subsidence principles are reviewed with reference to surface displacement and strain. Site conditions and local geology are discussed in relation to foundation engineering problems that are associated with surface structures, especially colliery spoil heaps. The geotechnical aspects of spoil heap foundations are examined. Spoil heap structures and the influence of formation method are discussed, and special mention is made of known subsidence effects that are associated with spoil heaps. A classification of methods of investigating subsidence effects on spoil heaps is presented.
Keyword(s): mine waste, rock mechanics, geotechnical, geologic features, angle of draw, time factor, foundations, vertical displacement, horizontal displacement
Location(s): United Kingdom

Forrester, D. J., T. R. C. Aston. A Review of Mining Subsidence Instrumentation and its Potential Application for Seabed Monitoring. Mining Science and Technology, v. 4, 1987, p. 225-240.
Extraction of the extensive minable coal reserves in the offshore portion of the Sydney Coalfield in Nova Scotia is constrained by the amount of subsidence generated at the seafloor. Field-proven undersea subsidence guidelines are therefore required to allow the optimal recovery of these reserves without producing unacceptable risks regarding major water inflows to the mine workings. To monitor seafloor subsidence, an instrumentation scheme is required that is both rugged and capable of operating in the marine environment. The paper concludes with an examination of potential application of several monitoring techniques (including TDR).
Keyword(s): instrumentation, coal mining, geotechnical, computer, geophysical, monitoring design, monitoring equipment, monitoring installation, monitoring methods, surface water, subsurface water, time factor, geologic features, seismic, longwall, photography, active mines, inflow
Location(s): Canada, Europe, United States, United Kingdom

Forrester, D. J. Underground Coal Mining Research in Canada. IN: MinTech '91, Annual Review of International Mining Technology and Development, T.L. Carr, ed., Sterling Publications International, London, 1991, p. 16-19.
CANMET's research into underground coal mining is primarily conducted at the Cape Breton Coal Research Laboratory in Nova Scotia. The article outlines various parts of the research program concerned with strata mechanics including subsidence, and the mine environment.
Keyword(s): subsidence research, coal mining, active mines, prediction, longwall, monitoring methods
Location(s): Canada

Forster, J. Stability Investigations Applied to the Mining of Evaporites. Ph.D. Thesis, University of Newcastle Upon Tyne, United Kingdom, 1967, 201 p.
Keyword(s): non-metal mining
Location(s): United Kingdom

Forsyth, D. R., B. P. Wrench, I. B. Watt. Reconstruction of a Motorway Bridge Subjected to Severe Mining Subsidence. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May, 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 139-143.

A multi-span reinforced concrete bridge crossed the M2 motorway as part of the Geldenhuis Interchange in Johannesburg. The bridge was subjected to severe differential settlements as a result of deep seated mining subsidence. After intensive monitoring and investigation, the bridge was demolished. This paper summarizes the displacements suffered by the bridge and describes the design philosophy of the replacement structure.

Keyword(s): roads, metal mining, geotechnical, monitoring methods, foundations, engineering, construction

Location(s): South Africa

Fowler, J. C., L. A. Rubin, W. L. Still. Detection, Delineation and Location of Hazard Using Ground-Probing Radar in Coal Mines. IN: Energy Resources and Excavation Technology, Proceedings 18th U. S. Symposium on Rock Mechanics, Keystone, CO, June 22-24, 1977, F-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, Golden, p. 4A5-1--4A5-5.

This paper describes the use of modified ground-probing radar to easily identify many of the major hazards associated with coal mining.

Keyword(s): coal mining, geophysical, roof stability

Location(s): United States

Frankham, B. S., G. R. Mould. Mining Subsidence in New South Wales--Recent Developments. IN: Proceedings New Zealand Conference, Australasian Institute of Mining and Metallurgy, University of Auckland, May 19-23, 1980, Australasian Institute Mining and Metallurgy, Parkville, Victoria, Australia, p. 167-179.

Keyword(s): coal mining

Location(s): Australia

Frankham, B. S., L. Holla. Mining Subsidence and its Effects on Surface Development in the Coalfields of New South Wales. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, July, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 207-222.

An intensive program of subsidence monitoring has been undertaken in New South Wales since the mid-1960s over areas of pillar extraction, shortwall mining, and longwall mining. Much of the data that have been collected since that time have been gathered from survey grids located above working coal mines in the state. The research has now reached the stage where the maximum subsidence accompanying a given extraction pattern can be predicted with a reasonable degree of confidence.

Keyword(s): monitoring methods, coal mining, active mines, pillar extraction, shortwall, longwall

Location(s): Australia

Franks, C. A. M., J. D. Geddes. A Comparative Study by Numerical Modelling of Movements on Sloping Ground Due to Longwall Mining. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 377-396.

This paper describes some of the results from a preliminary study of the influence of ground surface slope on movements, based on finite element numerical modeling. Brief details are given of the procedure adopted and comparisons are made between some of the results and those obtained, using the same model and technique, for horizontal plane surfaces.

Keyword(s): modeling, longwall, coal mining, finite element, horizontal displacement, vertical displacement

Franks, C. A. M. Mining Subsidence and Landslips in the South Wales Coalfield. IN: Proceedings, Symposium on Landslides in the South Wales Coalfield, Cardiff, 1985, p. 225-230.

Keyword(s): coal mining, geologic features

Location(s): Wales

Fredrickson, R. J. Foundation Treatment for Small Earth Dams on Subsiding Soils. International Association Hydrological Sciences Publication 121, 1977, p. 553-566.

Keyword(s): foundations, structural mitigation, geologic features

Freitag, J. A., T. E. Hemminger, G. Garrison. Coal Combustion Ash Disposal Underground Injection of Fly Ash into Mined-Out Portions of Coal Mine. IN: Proceedings, Air & Waste Management Association 84th Annual Meeting & Exhibition, Vancouver, British Columbia, June 16-21, 1991, 8 p.

For Commonwealth Edison Company, the underground mine injection of fly ash has proven to be a cost effective disposal method. Due to the proximity of the mine to the generating station, transportation costs of the fly ash are substantially reduced over landfill disposal. Underground injection takes little surface space, is subject to fewer regulatory constraints than landfilling, and provides additional protection against subsidence in the mined-out areas of the coal mine.

Keyword(s): mine waste, coal mining, subsurface water, hydraulic backfilling

Location(s): Illinois, Illinois Coal Basin, United States

Friedel, M. J., J. A. Jessop, R. E. Thill, D. L. Veith. Electromagnetic Investigation of Abandoned Mines in the Galena, KS, Area. U.S. Bureau of Mines RI 9303, 1990, 20 p.

As part of an investigation aimed at mitigating the hazards caused by abandoned mine openings, the USBM conducted a series of electromagnetic surveys in the area of Galena, Kansas. The application of monostatic ground-penetrating radar (GPR) and inductive electromagnetic methods for detecting and delineating hazardous mine openings and attendant features was demonstrated to be feasible for shallow mine workings occurring below flat-lying areas. Features such as mine voids, fractures, and zones of subsidence were located.

Keyword(s): abandoned mines, land mitigation, structural mitigation, geophysical, metal mining

Location(s): Kansas, United States

Frieser, A. Packing of Coal Seams in Bohemia. Transactions, Institution of Mining Engineers, London, v. 10, 1895, p. 597.

This article discusses the use of hydraulic flushing to stabilize water saturated overburden during the mining of a thick brown coal seam.

Keyword(s): hydraulic backfilling, coal mining, overburden, historical

Location(s): Europe, Czechoslovakia

Fritzsche, C. H., E. L. J. Potts. Horizon Mining. George Allen and Unwin, London, 1954, 614 p.

The authors present a text dealing with coal mining practice in the layout and development of the horizon-mining system. The book includes a detailed description of roadway development and haulage systems, but does not deal with operations at the extraction face. One chapter covers strata control and surface subsidence.

Keyword(s): mine design, ground control

Fruco Engineers, Inc. Geotechnical Investigation for Illinois Department of Law Enforcement, Illinois State Police District 11 Headquarters, Maryville, Illinois. St. Louis, MO, October, 1981, 17 p. plus 4 appendices.

This report presents the results of a geotechnical investigation of subsidence conditions at the Illinois State Police District 11 Headquarters at Maryville. The purpose was to perform an engineering evaluation of the subsurface conditions at the site, including the underlying abandoned coal mine, to determine the suitability of the existing facility for continued use. The scope of the investigation consisted of the following: (1) gathering and studying available site information from soil, geologic, and mining literature references; (2) conducting a field investigation to define the type and condition of the subsurface materials and the state of the underlying abandoned coal mine; (3) developing the necessary laboratory test data; and (4) performing engineering analyses and evaluation.

Keyword(s): abandoned mines, surface structural damage, coal mining, geotechnical, lab testing, rock mechanics, in situ testing, geologic features, engineering

Location(s): Illinois, Illinois Coal Basin, United States

Fry, R. C. Case Study in Monitoring Mining Induced Subsidence Using Photogrammetry and Conventional Surveys. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, June 1-4, 1992, S.S. Peng, ed., West Virginia University, p. 263-271.

Underground coal mining has been active within the East Mountain property since the mid-1950s. As a result, coal from two seams has been extracted within large areas allowing surface subsidence to occur. Annual subsidence monitoring began in 1981 with the use of on-the-ground conventional monumentation, surveying, and photogrammetric monitoring. The data collected have shown the time benefits of photogrammetry, as well as the relationship between observed subsidence and the geometry of the mined out area below.

Keyword(s): survey methods, survey equipment, monitoring methods, photography, remote sensing, coal mining, multiple-seam extraction, longwall, active mines

Location(s): Utah, Rocky Mountain Coal Region, United States

Fuqua, W. D., R. Richter. Photographic Interpretation as an Aid in Delimiting Areas of Shallow Land Subsidence in California. IN: American Society of Photogrammetry Manual of Photographic Interpretation, Appendix A of Ch. 6, 1960, p. 442-456.
Keyword(s): fluid extraction, photography, remote sensing, prediction
Location(s): California, United States

Fuqua, W. D. Shallow and Deep Subsidence Areas in West Central San Joaquin Valley. IN: Annual Field Trip Guidebook, California Geological Society, Central Portion of Great Valley of California, San Juan Bautista to Yosemite Valley, Sacramento, 1963, p. 59-64.
Keyword(s): fluid extraction
Location(s): California, United States

Gabrysch, R. K. Land Surface Subsidence in the Houston-Galveston Region, Texas. International Association Hydrological Sciences Publication 88, 1970, p. 43-54.

Keyword(s): fluid extraction, surface subsidence damage

Location(s): Texas, United States

Gabrysch, R. K. Methods of Predicting Land-Surface Subsidence in the Houston-Galveston Region, Texas. Geological Society of America, Abstracts with Programs, v. 6, 1974, p. 748.

Keyword(s): prediction, fluid extraction

Location(s): Texas, United States

Gaddy, F. L. A Study of the Ultimate Strength of Coal as Related to the Absolute Size of the Cubical Specimens Tested. Virginia Polytechnical Institute Bulletin, August, 1956, p. 1-27.

Keyword(s): pillar strength, lab testing, coal mining

Location(s): United States

Gaffney, D. V., M. M. Stewart, N. K. Chakravorti, R. M. Hays. Feasibility of Using Cemented Backfill in Active Underground Coal Mines to Prevent Subsidence. U.S. Bureau of Mines contract JO295001, Michael Baker, Jr., Inc., U.S. Bureau of Mines OFR 92-82, 1981, 218 p. (NTIS PB 82-244252)

This report details the use of cemented backfill in active underground coal mines to minimize or prevent subsidence.

Keyword(s): stowing, active mines, coal mining

GAI Consultants, Inc. Survey of Ground Surface Conditions Affecting Structural Reponse to Subsidence. Phase I Report to Twin Cities Mining Research Center, U.S. Bureau of Mines, Contract No. JO295017, April, 1980, GAI Consultants, Inc., Pittsburgh, PA, 15146, 35 p.

This document summarizes visits to and information exchanged with subsidence experts in Great Britain.

Keyword(s): coal mining, soils, surface structural damage, geologic features, abandoned mines, active mines, National Coal Board, horizontal displacement, vertical displacement, backfilling, grouting, modeling, tunnelling, multiple-seam extraction, land-use planning

Location(s): United Kingdom

GAI Consultants, Inc. Abandoned Mined Lands Reclamation Control Technology Handbook, Chapter 2. Mine Subsidence Control. Prepared for U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement, Contract J5101109, January 28, 1981, 37 p.

This chapter describes the various Abandoned Mined Lands funding priorities and subsidence abatement methods that may be used. A discussion of the advantages and disadvantages of the various abatement methods and the cost of implementation are included, as are a series of decision matrices and cost estimation guidelines, which are useful for evaluating and selecting the most appropriate abatement methods for a particular project.

Keyword(s): literature search, abandoned mines, coal mining, land-use planning, surface structural damage, reclamation, mitigation, structural mitigation, land mitigation, hydraulic backfilling, pneumatic backfilling, grouting

Location(s): United States

Gall, V., D.-W. Park. Effective Iterative Technique in Numerical Modeling to Simulate Progressive Failure in Underground Coal Mines. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 313-320.

Park and Gall developed a large scale three-dimensional, finite-element model for a longwall coal mine using a supercomputer. The Hoek-Brown failure criterion, which describes the behavior of rock masses, was adopted for the determination of element failure. Simulated stresses and stress redistributions are therefore realistic, but a large amount of computer time had to be consumed due to the numerous iterations that were necessary to reach an equilibrium state. In this paper, an improved method of iteration is introduced. Using this method, the number of iterations was reduced, thus the computer time was considerably reduced.

Keyword(s): coal mining, modeling, finite element, computer, longwall

Location(s): Alabama, United States

Gallagher, R. T. A Method of Determining Subsidence in Mining With Particular Reference to Block Caving. Ph.D. Thesis, Colorado School of Mines, Golden, 1941, 128 p.

This thesis studies the use of subsidence forces to cave rock in mining, using geophysical methods to locate the line of break. Seismic measurement of caving proved the most useful tool.

Keyword(s): geophysical, seismic, prediction

Location(s): United States

Gallant, W. D., T. R. C. Aston. Instrumentation and Geotechnical Monitoring Techniques Used in the Sydney Coalfield, Nova Scotia. Canadian Geotechnical Journal, v. 28, June, 1991, p. 327-337.

Since 1982, a group has been involved in assessing the behavior of mine openings in the underground workings of the Sydney Coalfield in Nova Scotia. This paper examines a variety of geotechnical instrumentation and monitoring techniques used to assess strata behavior during the different phases of longwall mining operations: gateroad deformation, floor heave, intersections, gateside pack behaviour, and subsidence monitoring.

Keyword(s): instrumentation, monitoring methods, geotechnical, longwall, coal mining, floor stability

Location(s): Canada

Gallant, W. D., D. J. Forrester, D. A. Payne. Determination of the Stopline Subsidence Profile of Phalen 2 West Panel from within a Near Horizontal Borehole over the Panel Stopline. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 220-224.

The subsidence profile over the stopline of a longwall panel was observed. A novel technique was designed and implemented to determine vertical displacements of the overlying strata from within a near horizontal borehole drilled over the 2 West panel. Restrictions on data collection techniques due to the submarine nature of the coalfield are discussed.

Keyword(s): longwall, monitoring methods, monitoring equipment, instrumentation, multiple-seam extraction, coal mining, vertical displacement, horizontal displacement

Location(s): Canada

Gallavresi, F., G. Rodio. Soil Upheaving by Grouting to Safeguard Zones Affected by Significant Subsidence Problems: Its Application to Venice as Peculiar Example. IN: Land Subsidence, Proceedings 3rd International Symposium on Land Subsidence, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds.,International Association Hydrological Sciences Publication No. 151, 1986, p. 707-715.

The subsidence of Venice, at present essentially due to natural causes only, is characterized by very small rate. Nevertheless, the general situation of the lagoon town is still dramatic because of the high subsidence values that have occurred in the past.

Keyword(s): soils, surface subsidence damage, land mitigation

Location(s): Italy

Galvin, J. M. The Significance, Behavior and Influence of Ashfill on South African Thick Seam Mining Operations. Chamber of Mines of South Africa, Research Report No. 9/82, January, 1982.

Keyword(s): backfilling

Location(s): South Africa

Galvin, J. M., K. G. Anderson. Design of Multi-Seam Workings at Shallow Depth Under Tidal Waters. IN: Proceedings, Symposium on Ground Movement and Control Related to Coal Mining, Illawarra, Australia, August, 1986, N.I. Aziz, ed., Australasian Institute of Mining and Metallurgy, p. 352-361.

Multiseam mining has been carried out beneath Lake Macquarie in New South Wales since 1982. Three seams, which cover 40 to130 meters, are mined simultaneously. Subsidence control was the major factor influencing choice of mining method and layout of workings, which were designed according to 1974 guidelines. These guidelines are re-evaluated in the light of state-of-the-art rock mechanics knowledge and local subsidence data collected since 1974. The design according to the guidelines is seen to be conservative, and improved extraction is possible.

Keyword(s): multiple-seam extraction, surface water, rock mechanics, mine design, coal mining

Location(s): Australia

Gamble, J. C., R. E. Gray. Subsidence Control and Alternatives for Areas Above Abandoned Coal Mines. IN: Proceedings 41st Annual Meeting of American Society of Photogrammetry, Boulder, CO, March 6-8, 1975, p. 62.

Keyword(s): ground control, abandoned mines, coal mining

Location(s): United States

Gamble, J. C., R. E. Gray. Subsidence Control and Alternatives for Areas Above Abandoned Coal Mines. IN: Proceedings Northeastern Section Meeting of the Geological Society of America, Syracuse, New York, March 7, 1975, 12 p.

Mine subsidence can cause severe damage to structures located above abandoned mines. Alternatives in dealing with potential damage problems include subsidence control, construction of structures resistant to subsidence damage, land-use planning to minimize problems, subsidence insurance, and acceptance of risk of possible damage.

Keyword(s): abandoned mines, coal mining, surface structural damage, overburden, utilities, ground control, insurance, construction, land-use planning, foundations, hydraulic backfilling, pneumatic backfilling, grouting, roof stability

Location(s): Pennsylvania, Appalachian Coal Region, United States

Gamble, J. C., R. E. Gray. Mine Subsidence and Mine Subsidence Control. The Encyclopedia of Applied Geology, Encyclopedia of Earth Science Series, R.W. Fairbridge and C.W. Finkl, Jr., eds. Dowden, Hutchinson & Ross, Stroudsburg, PA, 1976.

Keyword(s): ground control, coal mining

Gambolati, G. Estimate of Subsidence in Venice Using a One-Dimensional Model of the Subsoil. IBM Journal of Research Development, v. 16, March, 1972, p. 130-137.

Keyword(s): modeling

Location(s): Italy

Gambolati, G., R. A. Freeze. Mathematical Simulation of the Subsidence of Venice, I: Theory. Water Resources Research, v. 9, no. 3, June, 1973, p. 721-733.

Keyword(s): modeling, mathematical model

Location(s): Italy

Gambolati, G., P. Gatto, R. A. Freeze. Mathematical Simulation of the Subsidence of Venice, II: Results. Water Resources Research, v. 10, no. 3, June, 1974, p. 563-577.

Keyword(s): modeling, mathematical model

Location(s): Italy

Gamzon, L. Hydraulic Stowing at French Collieries. Colliery Engineering, v. 34, 1914, p. 289.

This article describes the use of hydraulic stowing in 1909 to prevent surface subsidence.

Keyword(s): hydraulic backfilling, stowing, coal mining

Location(s): France

Gang, Y., Z. Guoquan, C. Jixian. Research on Sliding Layers for Buildings Subjected to Mining Subsidence. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 430-442.

The provision of a sliding layer is a structural measure for preventing damage to buildings due to mining. The authors made model tests on the sliding layer, analyzed and compared the materials for sliding layers, and carried out an analysis, by means of the finite element method, of the stress in a building wall subjected to mining.

Keyword(s): surface structural damage, foundations, lab testing, finite element, modeling, coal mining, horizontal displacement, structural mitigation

Location(s): China

Ganow, H. C. A Geotechnical Study of the Squeeze Problems Associated with the Underground Mining of Coal. Ph.D. Thesis, University of Illinois, Urbana, 1975.

Keyword(s): floor stability, geotechnical, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Ganow, H. C. Results of Long Term Ground Surface Measurements at the Hoe Creek III Site. 10th Underground Coal Gasification Symposium, Williamsburg, VA, August 12-15, 1984, 17 p.

Ground surface subsidence was first observed over the Hoe Creek burn cavity 21 days after gasification ceased. It manifested itself as a small circular depression or sink and was followed 5 days later by the formation of a second collapse structure. Concurrently, a single large elliptically shaped depression, whose major axis parallels the experimental axis, slowly formed over the burn cavity. These features appear to represent two distinctly different deformation modes. The first mode includes discrete voids that propagate rapidly upward. The second mode is represented by the elliptically shaped classical subsidence depression that forms slowly by a strata bending. Seventeen isolation type survey monuments have been used to track both the horizontal (one dimensional) and vertical motion components intermittently over a 54-month span. The resulting data set is combined with ground surface sketches and post-burn core drilling results and provides an important case study against which numerical and centrifugation model results can be compared.

Keyword(s): coal gasification, modeling, monitoring methods, monitoring equipment, survey methods, horizontal displacement, vertical displacement, environment

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Gardner, B. H., F. Carr, E. Martin. Longwall Design Improvement in Coal Mines Using Finite Element Analysis. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 693-694.

This mine design method draws together three distinct elements of technique: infinite element simulation, stress control via yielding pillars, and specialized techniques for geomechanical behavioral monitoring of underground openings.

Keyword(s): mine design, finite element, modeling, longwall, roof support, yielding supports, monitoring methods

Location(s): Alabama, United States

Gardner, F. P., G. Hibberd. Subsidence--The Transference of Ground Movement to Surface Structures. The Mining Engineer, London, v. 121, 1961-62, p. 19-36.

Keyword(s): surface structural damage, coal mining

Location(s): United Kingdom

Garner, J. H. Report on the Effect of Mining (Coal) Subsidence on Sewers and Sewage Disposal Works in the West Riding of Yorkshire. The West Riding of Yorkshire Rivers Board, December, 1945.

Keyword(s): utilities, coal mining

Location(s): United Kingdom

Garrard, G. F. G., R. K. Taylor. Collapse Mechanisms of Shallow Coal-Mine Workings from Field Measurements. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 181-192.

Simple stereo-photographic techniques were employed to look in detail at more than 150 shallow (< 75 m) collapsed old workings exposed in the high walls of 18 opencast coal sites across the country. Sixty variables, including collapse dimensions and various ratios, were defined to characterize the workings and the resulting data analyzed statistically. The data were compared with existing theories and design recommendations and used to develop new empirical relationships. The study shows that at shallow depths the crushing of coal pillars is rare and that bulking and arching, considered to be complementary mechanisms, are the normal limiting factors on the height of collapse. The collapse height of the working was found to be proportional to the span width. Where span widths are known or can be estimated, the following relationship for collapse height is suggested: collapse height = 2.68 x span width. This relationship encompasses all but one observed collapse structure. The existing established relationship, based on bulking theory, of collapse height = 10 x seam thickness is shown to be valid and encompasses all observed collapse structures.

Keyword(s): coal mining, abandoned mines, pillar strength, room-and-pillar, prediction, remote sensing

Location(s): United Kingdom

Garritty, P. Water Percolation into Fully Caved Longwall Faces. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 25-29.

Production at a number of mines operating off the North-East coast has been seriously affected by the percolation of major water feeders onto working coal faces. A detailed study of the factors affecting the incidence and distribution of water feeders was undertaken, using operational geological and hydrological data.

Keyword(s): subsurface water, coal mining, longwall, hydrology, geologic features, overburden, inflow

Location(s): United Kingdom

Garza, S. Artificial Recharge for Subsidence Abatement at the NASA-Johnson Space Center, Phase I. U.S. Department of the Interior, Geological Survey, Open-File Report 77-219, 1977, 82 p.

Keyword(s): fluid extraction

Location(s): Texas, United States

Gaskell, P., D. J. Reddish, B. N. Whittaker. Subsurface Ground Movements Associated with Longwall Mining. IN: Proceedings 7th International Conference on Ground Control in Mining, Morgantown, WV, 1988, S.S. Peng, ed., West Virginia University, p. 195-204.

This paper examines the development of rock movement between a longwall extraction horizon and the surface for a fully caved mining situation. Physical modeling has been used to examine the mechanics of ground movement and the propagation of fractures around the longwall working. The paper discusses dimensional anlaysis, model construction, and measurement technique, and data processing of the results into effective graphical forms for further study.

Keyword(s): longwall, coal mining, ground control, overburden, modeling, vertical displacement, horizontal displacement, National Coal Board

Gauna, M., K. R. Price, E. Martin. Yield Pillar Usage in Longwall Mining at Depth--No. 4 Mine, Brookwood, Alabama. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 695-702.

Jim Walter Resources No. 4 Mine extracts coal at 610 to 670 m of depth. Yield pillar designs, using pillars 6.1 and 7.6 meters wide alongside the longwall headgate entry, were established in two adjacent longwall gate sections. The experimental yield pillar-abutment pillar areas were formed for comparison to chain pillar gate road designs of equal size. Data were collected through monitoring roadway deformational behavior during longwall mining. Yield pillars in conjunction with abutment pillars offered improved roadway stability and improved resource recovery.

Keyword(s): room-and-pillar, instrumentation, mine design, longwall, yielding supports, pillar strength

Location(s): Alabama, United States

Geddes, J. D., D. W. Cooper. Structures in Areas of Mining Subsidence. The Structural Engineer, London, v. 40, no. 3, March, 1962, p. 79-93, and 377-381.

This paper examines structural design methods used in areas with potential subsidence problems. These methods range from foundations offering maximum resistance to earth movements to articulated frames offering little or no resistance.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, structural mitigation, ground control, architecture, foundations, engineering

Location(s): England

Geddes, J. D. The Effect of Horizontal Ground Movements on Structures. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 623-646.

This paper concetrates on the interaction between soils and essentially horizontal foundation surfaces on which the loading resulting from the movements is delivered in the form of shearing (frictional) stresses. A simplified look is taken at the problem and some factors of importance are described and illustrated by laboratory and field experiments. It is shown how the behaviour of foundations can be explained in a rational and quantitative way. Attention is focused on cases produced by underground mining activities.

Keyword(s): surface structural damage, soils, foundations, horizontal displacement, coal mining

Location(s): United Kingdom

Geddes, J. D. Construction in Areas of Large Ground Movement. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 949-974.

Large ground movements (those greater than 50 mm) may be produced by a variety of factors. Some are natural and some man-made; some are controllable and others not. They have at least one feature in common and that is the potential or actual difficulty they present to civil/structural engineers in carrying out their work. Conventional practice would regard vertical settlements of 50 mm as a desirable limit to be set as a design objective for rafts on natural soils. Individual footings would be designed for a settlement typically half this value.

Keyword(s): surface structural damage, construction, engineering, geologic features, soils, fluid extraction, tunnelling, coal mining

Geddes, J. D. The Behaviour of a CLASP-System School Subjected to Mining Movements IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff,1977, John Wiley & Sons, New York, 1978, J.D. Geddes, ed., p. 579-596. (NTIS Accession No. 79-22637)

A detailed study of the behavior of a CLASP-system school was carried out as part of a wider investigation into aspects of design to counter mining subsidence.

Keyword(s): coal mining, foundations, surface structural damage, engineering, construction, multiple-seam extraction, monitoring methods, National Coal Board

Location(s): United Kingdom

Geddes, J. D., D. Kennedy. Structural Implications of Horizontal Ground Strains. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 610-629.

It is well established that, in the vicinity of underground mining, tunnelling and deep excavations, ground movements with horizontal as well as vertical components are developed at ground surface level. These generally vary in magnitude with time as the workings progress. Structural foundations placed at the surface of, or within, the moving ground are subjected to horizontal forces generated at the soil/foundation interface.

Keyword(s): horizontal displacement, coal mining, tunnelling, foundations, subsurface subsidence damage, surface subsidence damage, soils, modeling, surface structural damage

Geddes, J. D., D. Kennedy. Mining Ground Movements and Tied Portal Frames. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 396-410.

In earlier papers, a method of calculation was developed that determined the horizontal forces created at the interface between a continuous structure and the moving ground that supported it. This was made on the basis of the idealization that the structure was sufficiently flexible so as to deform under the influence of the vertical ground movements without any redistribution of the vertical support reactions along its length and that the interface relationship was essentially frictional in nature. A similar method is applied here to multi-bay tied portal frames, but it makes allowance for the variation in vertical support reactions as the structure is exposed to vertical and horizontal ground movements of the kind produced by mining activity.

Keyword(s): horizontal displacement, coal mining, surface structural damage, vertical displacement, longwall, foundations

Location(s): United Kingdom

Geddes, J. D., ed. Large Ground Movements and Structures. Proceedings of International Conference, University of Wales Institute of Science and Technology, Cardiff, July 4-7, 1977, John Wiley & Sons, New York, 1978, 1074 p.

This book contains papers dealing with such topics as the estimation and measurement of surface and near-surface ground movements due to the extraction of coal, tunnelling, the presence of old underground workings, large excavations, hillside instability and creep, reclaimed and back-filled areas. The effects of such movements on structures are discussed.

Keyword(s): surface structural damage, coal mining, ground control, tunnelling, active mines, abandoned mines, instrumentation, monitoring methods

Geddes, J. D., ed. Ground Movements and Structures. Proceedings of 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, Pentech, London, 1981, 964 p.

Keyword(s): surface structural damage, ground control, coal mining

Geddes, J. D., ed. Ground Movements and Structures. Proceedings of 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, Pentech, London, 1985, 876 p.

Keyword(s): surface structural damage, ground control, coal mining

Geddes, J. D., ed. Ground Movements and Structures. Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, Pentech, London, 1992, 826 p.

The papers presented in this volume cover such topics as the estimation and measurement of surface and near-surface ground movements of reclaimed and backfilled land due to excavations, trenches, tunnelling, coal mining, and seasonal changes. The book is intended for civil and structural engineers, geologists, mining engineers, surveyors, and others concerned with structures on moving ground.

Keyword(s): surface structural damage, coal mining, active mines, abandoned mines, tunnelling, grouting, backfilling, structural mitigation, foundations, engineering

Geertsma, J. Land Subsidence Above Compacting Oil and Gas Reservoirs. Journal of Petroleum Technology, 1973, p. 734-744.

Keyword(s): fluid extraction, oil extraction

Geertsma, J., G. Van Opstal. A Numerical Technique for Predicting Subsidence Above

Compacting Reservoirs, Based on the Nucleus of Strain Concept. Verhandelingen, Koninklijke Nederlands Geologisch Mijnbouwkundig Genootschap, v. 28, 1973, p. 63-78.
Keyword(s): prediction, modeling, subsurface water

General Assembly of Pennsylvania. Bituminous Mine Subsidence and Land Conservation Act. Commonwealth of Pennsylvania, 1966, 12 p.
This document contains laws enacted in 1966 to protect the public health, welfare, and safety by regulating the mining of bituminous coal.
Keyword(s): law, mine design, government, mine safety, mine operation, surface structural damage, coal mining, bituminous
Location(s): Pennsylvania, Appalachian Coal Region, United States

Geng, D. Y., S. S. Peng. Surface Subsidence, Overburden Behavior, and Structural Damages Due to Longwall Mining--Two Case Studies. Department of Mining Engineering, West Virginia University, Morgantown, November 1983, 19 p.
This report investigates the subsidence caused by two longwall panels, with data analyzed in terms of zone of advance influence and delay angle of maximum subsidence velocity.
Keyword(s): surface structural damage, mine design, longwall

Gentry, D. W. Rock Mechanics Instrumentation Program for Kaiser Steel Corporation's Demonstration of Shield-Type Longwall Supports at York Canyon Mine, Raton, New Mexico. Kaiser Steel Corporation contract RD-R-0174, Colorado School of Mines, Golden July, 1976, 456 p.
This report presents the results of a rock mechanics instrumentation program designed to determine the rock mass response due to longwall mining of a thick coal seam, with details on the geology and instrumentation.
Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, rock mechanics, longwall, roof support, coal mining
Location(s): New Mexico, Rocky Mountain Coal Region, United States

Gentry, D. W., J. F. Abel, Jr. Rock Mass Response to Longwall Mining. Mines Magazine, v. 66, no. 3, 1976, p. 11-12, 28-29.
Keyword(s): longwall, coal mining, overburden

Gentry, D. W., J. F. Abel, Jr. Rock Mass Response to Mining Longwall Panel 4N, York Canyon Mine. Mining Engineering, v. 30, no. 3, 1976, p. 273-280.
Keyword(s): longwall, coal mining, overburden
Location(s): New Mexico, Rocky Mountain Coal Region, United States

Gentry, D. W., C. L. Stewart. Surface and Underground Rock Response, Longwall Panel 4N, York Canyon Mine. IN: Proceedings 2nd Symposium on Underground Mining, National Coal Association/ Bituminous Coal Research Coal Conference and Expo III, Louisville, KY, October 19-21, 1976, p. 184-205.
Keyword(s): longwall, overburden, coal mining
Location(s): New Mexico, Rocky Mountain Coal Region, United States

Gentry, D. W., C. L. Stewart. Surface Response to Longwall Mining. Mines Magazine, v. 67, no. 3, 1977, p. 11-12, 22-23; v. 67, no. 4, 1977, p. 16-18.
Keyword(s): longwall, coal mining

Gentry, D. W., J. F. Abel, Jr. Surface Response to Longwall Coal Mining in Mountainous Terrain. Bulletin Association of Engineering Geologists, v. 15, no. 2, December, 1978, p. 191-220.
The response of the ground surface above longwall panels in a virgin geologic environment can only be approximated by prediction models developed from subsidence measurements made in other coal mining districts. Above the 10-foot-thick seam longwall at the York Canyon Mine, west of Raton, New Mexico, the measured angle of draw was 5 to 15 degrees which is 0.09 to 0.27 times the depth, outside the panel. This compares to the British National Coal Board predicted angle of draw of 35 degrees, 0.7 times the depth. The measured subsidence effects outside of the panel did not extend even one-half as far as the NCB predictions. However, measured subsidence at York Canyon closely compared with NCB predictions.
Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, survey data processing, longwall, coal mining, prediction, National Coal Board
Location(s): New Mexico, Rocky Mountain Coal Region, United States

Gentry, D. W., C. L. Stewart, R. P. King. Rock Mechanics Instrumentation Program for Kaiser Steel Corporation's Demonstration of Shield-Type Longwall Supports at York Canyon Mine, Raton, New Mexico. Final Report, Department of Energy, 1981, DE-AC01-74ET12530.
Keyword(s): rock mechanics, longwall, instrumentation, coal mining
Location(s): New Mexico, Rocky Mountain Coal Region, United States

Gentry, D. W., C. L. Stewart. Characterization of Subsidence Over Multiple Lift Longwall Panels. U.S. Department of Energy Contract AC22-80PC-30118, Mine Subsidence Engineering Final Technical Report, 1982, 135 p. (NTIS DOE/PC/30118-T4)
This report describes the procedures and equipment used in installing and removing a subsidence monitoring network in rugged terrain.
Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, longwall, coal mining

Germanis, E., G. W. Smith. Criteria for Design and Tolerance of Structures and Services to Subsidence Movements. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Illawarra Branch, Australian Institute of Mining and Metallurgy, A. Hargraves, ed., February 20-22, 1973, p. 12-1--12-10.
Three basic types of subsidence occur in the Newcastle and Wyong districts. Their effects can cause serious damage to structures that have not been suitably designed. There are generally accepted design principles to accommodate subsidence movements. The main difficulty for the designer is to assess the most suitable application of the design principles. To assist in this regard there are various design suggestions for structures such as small cottages, tall buildings, swimming pools, reservoirs and bridges.
Keyword(s): utilities, surface structural damage, engineering, coal mining, active mines, abandoned mines, structural mitigation, foundations
Location(s): Australia

Germanis, E., S. Valliappan. Mining Subsidence at the Graving Dock Site, New Castle. IN: Symposium on Recent Developments in the Analysis of Soil Behavior and Their Application to Geotechnical Structures, University of New South Wales, Australia, 1975, 14 p.
Keyword(s): surface structural damage
Location(s): Australia

Ghose, A. K. Extraction Below Surface Structures--An Appraisal of the Jharia Coalfield Situation. Journal of Mines, Metals & Fuels, v. 29, no. 12, 1981, p. 347-354, 366.
Keyword(s): surface structural damage, coal mining
Location(s): India

Ghouzi, D. Mining Subsidence and its Impact on the Environment: The Example of the Nord/Pas-de-Calais Coalfield. IN: Proceedings European Conference on Coal and the Environment, Session 3, Minerals and the Environment, v. 4, nos. 2 & 3, September, 1982, p. 93-98. ISSN 0142-7245.
Public opinion is less and less willing to tolerate the various harmful effects of mining subsidence. Compensation for damage can become a major cause for concern for mining companies. The object of this report is to try to identify the main potential effects of mine workings, both on finances, and on the environment itself, to further the debate.
Keyword(s): coal mining, economics, environment, vertical displacement, horizontal displacement, surface structural damage, hydrology, utilities, hydraulic backfilling, pneumatic backfilling, stowing, railroads, roads
Location(s): France, Poland, Soviet Union, Europe

Gibbs, H. J. A Laboratory Testing Study of Land Subsidence. IN: Proceedings 1st Pan-American Conference on Soil Mechanics and Foundation Engineering, Mexico City, 1959, v. 1, p. 13-36.
Keyword(s): lab testing

Gibson, R. D., G. G. Marino. Mine Subsidence - Laur Case, Du Quoin Illinois. Illinois Abandoned Mined Lands Reclamation Council, September, 1981, 8 p.
This report details investigation of pit-type subsidence over an abandoned mine.
Keyword(s): surface structural damage, coal mining, abandoned mines, foundations
Location(s): Illinois, Illinois Coal Basin, United States

Gibson, R. D. Subsidence Rapid Response Team Quarterly Progress Report, April 1 through June 30, 1981. Illinois Abandoned Mined Lands Reclamation Council, July, 1981, 17 p.
Keyword(s): structural mitigation, coal mining, abandoned mines, monitoring methods
Location(s): Illinois, Illinois Coal Basin, United States

Gibson, R. D. Subsidence Rapid Response Team Quarterly Progress Report, January 1 through March 31, 1981. Illinois Abandoned Mined Lands Reclamation Council, April, 1981, 18 p.
This report details subsidence investigations in four Illinois counties.
Keyword(s): abandoned mines, coal mining, structural mitigation
Location(s): Illinois, Illinois Coal Basin, United States

Gibson, R. D. Mine Subsidence, O'Kraski Residence, Streator, Illinois. Illinois Abandoned Mined Lands Reclamation Council, July 1981, 9 p.
Keyword(s): coal mining, abandoned mines, surface structural damage, structural mitigation
Location(s): Illinois, Illinois Coal Basin, United States

Gibson, R. D. Mine Subsidence, Bruce Park Case, Energy, Illinois. Illinois Abandoned Mined Lands Reclamation Council, September, 1981, 8 p.
This report details investigation of pit-type subsidence over an abandoned mine in a city park in Energy, Illinois. The pit measured 21 feet in diameter and was approximately 21 to 25 feet deep.
Keyword(s): abandoned mines, coal mining, land mitigation, reclamation
Location(s): Illinois, Illinois Coal Basin, United States

Gibson, R. D., J. W. Mahar. Monitoring Techniques of Small Structures Subjected to Subsidence Induced Ground Movements. IN: Abandoned Mine Reclamation Symposium, November 3-5, 1982, Ohio University-Belmont County, St. Clairsville, OH, p. 4-2--4-9.
The response of structures to subsidence induced ground movements is dependent upon the sensitivity of the structure as well as its orientation and position within the area of subsidence. On site evaluation of vertical displacement, horizontal strain, tilt, and damage surveys, aids decisions for optimum placement of monitoring points and interpreting structural damage data.
Keyword(s): surface structural damage, coal mining, abandoned mines, vertical displacement, horizontal displacement, monitoring methods
Location(s): Illinois, Illinois Coal Basin, United States

Gibson, R. D., J. W. Mahar. The Mid-Continent Field: Structural Monitoring. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., 1983, Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, p. 709-716.
This paper provides a conceptual framework from which an efficient monitoring program can be designed. The authors state that in a structural monitoring program, the response of the structures to ground movements should be determined, and the future performance of the structure on a site-specific basis should be estimated. Field techniques and monitoring point installation are discussed from a mechanical and application point of view. Finally, the proposed monitoring method is meant to provide the reader with an integrated approach for checking preliminary assumptions (building location and orientation relative to ground movements), modifying predictions (changes in structural response due to an outward extension of the subsidence profile), and accurately predicting future structural response.
Keyword(s): abandoned mines, coal mining, room-and-pillar, monitoring methods, monitoring installation, surface structural damage, monitoring equipment, vertical displacement, horizontal displacement, prediction
Location(s): Illinois, Illinois Coal Basin, United States

Gibson, R. D. Mine Subsidence Camp Butler Site Riverton, Illinois, Progress Report, May 1982 to June 1983. Illinois Abandoned Mined Lands Reclamation Council, Springfield, March, 1984, 30 p.
This report details investigation of sag-type subsidence that formed over an abandoned room-and-pillar mine. Damage to the structures located within the sag developed primarily within the first few weeks of the subsidence event. Continued ground movements reuslted in only minor additional damages.
Keyword(s): surface structural damage, abandoned mines, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Gibson, R. D., B. C. Schottel. Computerized Modeling of Coal Mine Subsidence Profiles. IN: Proceedings National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, December 7-11, 1987, Springfield, IL, University of Kentucky, Lexington, p. 249-252.

The intent of this paper is to illustrate two techniques that can be used to model ground movements with curves that are mathematically derived from single Sourier series or polynomial expansion (and least squares method) equations. The advantages in expressing ground movements in terms of mathematical equations is that the speed and accuracy of the computer can be utilized to perform the computations and graphically portray the results. The examples of ground movement modeled in this paper are associated with sag-type subsidence. By definition, sag subsidence is a descriptive term for those failures within underground room-and-pillar mines that propagate to the ground surface and form elliptically shaped depressions.

Keyword(s): coal mining, prediction, computer, modeling, room-and-pillar, mathematical model

Location(s): Illinois, Illinois Coal Basin, United States

Gibson, R. D., B. C. Schottel. A Case History Illustrating the Application of Computerized Modeling of Coal Mine Subsidence Profiles and the Development of a Settlement Prediction Technique. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 369-376.

A single-story brick school building is being structurally damaged by sag-type subsidence developing over an abandoned coal mine. The T-shaped building is positioned in the sag so that the intersection of all three wings coincides with the center of maximum subsidence. Two of the wings originate outside the event and extend through the tension and compression zones; the third wing extends from the inflection point into the compression zone. The ground movements were monitored via standard level surveying techniques and analyzed employing a computer modeling technique.

Keyword(s): coal mining, computer, modeling, prediction, surface structural damage, foundations, architecture, abandoned mines, survey methods, construction, room-and-pillar, survey data processing, vertical displacement, horizontal displacement

Location(s): Illinois, Illinois Coal Basin, United States

Giedl, J. G. Subsidence Hazard Assessment Relating to Abandoned Coal Mines: Wonthaggi Coalfields Region of South-West Gippsland, Victoria. IN: Proceedings 19th Symposium on Advances in the Study of the Sydney Basin, 1985, Department of Geology, University of Newcastle, New South Wales, p. 71-81.

Wonthaggi, in south-western Gippsland, is an area where extensive black coal mining has occurred from the early 1840s until the late 1960s. The area is largely undermined by a number of mines of varying depths and extraction thickness. Undermined areas are prone to subsidence and the Borough of Wonthaggi often requests the Department of Minerals and Energy of Victoria (DME) to evaluate the extent of undermining and associated subsidence potential of proposed building allotments. The flow of requests and the need to constantly refer back to old plans of various scales meant that more suitable means for managing such requests was needed. A set of new plans to a common metric scale, detailing all old mine locations, current surface road locations, and subsidence risk zones, was devised to enable rapid processing of any requests and eliminate the need to refer back to ageing workings plans. The Subsidence Risk Zone classification scheme for the Wonthaggi region had to be created because existing risk classifications were not applicable in this coalfield. The integration of plans of numerous scales and a variety of data was done via computer.

Keyword(s): coal mining, abandoned mines, computer, land-use planning

Location(s): Australia

Gilboy, A. E. Ground Penetrating Radar: Its Application in the Identification of Subsidence Solution Features--A Case Study in West-Central Florida. IN: Karst Hydrogeology: Engineering and Environmental Applications, Proceedings of the 2nd Multidisciplinary Conference on Sinkholes and the Environmental Impacts of Karst, Orlando, 1987, B.F. Beck and W.L. Wilson, eds., Balkema, Rotterdam, p. 197-203.

Keyword(s): monitoring equipment

Location(s): Florida

Giles, J. R. A. Identification of Former Shallow Coal Mining from Aerial Photographs: An Example from West Yorkshire. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 133-136.

The presence of shallow mine workings is a major constraint on planning in areas of exposed coalfield. The examination of large scale aerial photographs offers a rapid reconnaissance method of identifying such workings.
Keyword(s): coal mining, remote sensing, abandoned mines, engineering, historical
Location(s): United Kingdom

Gilluly, J., U. S. Grant. Subsidence in the Long Beach Harbor Area, California. Bulletin of the Geological Society of America, v. 60, March, 1949, p. 461-530.
Surveys and other observations in the area of Long Beach Harbor, California, indicate a general subsidence of a large area. It is also highly significant that the subsidence, as indicated by tide-gauge records, first became notable in 1937, shortly after the beginning of the development of the Wilmington oil field. The effects of a variety of mechanisms which could lead to surface subsidence are discussed, but the discussion emphasis is on the effect of petroleum extraction on the overlying surface.
Keyword(s): fluid extraction, oil extraction
Location(s): California, United States

Girrens, S. P., C. A. Anderson, J. G. Bennett, M. Kramer. Numerical Prediction of Subsidence With Coupled Geomechanical-Hydrological Modeling. IN: Proceedings of Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 63-70.
This paper investigates the development of a coupled finite element geomechanical-hydrology code applied to the problem of predicting groundwater disturbances associated with mine subsidence. It includes analyses of hydrologic modeling.
Keyword(s): vertical displacement, horizontal displacement, subsurface water, hydrology, prediction, finite element, modeling
Location(s): West Virginia, Appalachian Coal Region, United States

Gloe, C. S., J. P. James, R. J. McKenzie. Earth Movements Resulting from Brown Coal Open Cut Mining--Latrobe Valley, Victoria. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, A.J. Hargraves, ed., Australasian Institute Mining & Metallurgy, Wollongong, New South Wales, Australia, 1973, p. 8-1 - 8-11.
Large vertical and horizontal earth movements have resulted from the development of deep and extensive open cuts in brown coal deposits. The movements are not only of significance to safe mining operations, but also affect adjacent areas in which major power-generation projects are located.
Keyword(s): engineering, coal mining, prediction, vertical displacement, horizontal displacement, surface structural damage
Location(s): Australia

Gloe, C. S. Land Subsidence Related to Brown Coal Open Cut Operations, Latrobe Valley, Victoria, Australia. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 399-407.
Keyword(s): surface subsidence damage, coal mining
Location(s): Australia

Glover, C. M. H., N. E. Webster. The Law Relating to Damage by Mining Subsidence and Its Effect on Mining Practice. Transactions Institute of Mining Engineers, London, v. 118, 1958-59, p. 75-99, 456-459.
Legislation in Great Britain imposed on the National Coal Board the general liability to pay compensation for damage resulting from mine subsidence. The development and consequences of this legislation are discussed together with known factors relating to subsidence damage including the precalculation of the amplitude and timing of subsidence. Preventative measures such as solid stowing are considered. The importance of subsidence damage to the mining industry is discussed.
Keyword(s): vertical displacement, horizontal displacement, law, prediction, National Coal Board, backfilling, stowing, mine operation, coal mining
Location(s): United Kingdom

Glover, T. O. Surface Subsidence Due to Underground Coal Mining in Illinois. Presented at SME/AIME Fall Meeting, St. Louis, MO, October 19-21, 1977, SME/AIME preprint 77-F-324, 8 p.
Keyword(s): surface subsidence damage, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Goldreich, A. H. Theory of Land Subsidences in Coal Regions. With Special Regard to the Railway Subsidences of the Ostrau-Karwin Coal District.

Julius Springer, Berlin, 1913, translated by O.L. Schwarg, in Unpublished Manuscripts, Illinois State Geological Survey Library, Champaign, 178 p.

In this manuscript, the author describes the geological conditions of the Ostrau-Karwin coal district. A theory of land subsidence in consequence of coal mining is also given.

Keyword(s): coal mining, railroads, geologic features, historical

Location(s): Germany

Golze, A. R. Land Subsidence--Why the State is Concerned. IN: Proceedings 2nd Geologic Conference on Landslides and Subsidence, Los Angeles, 1966, California Resources Agency, Sacramento, p. 97-104.

Keyword(s): fluid extraction

Location(s): California, United States

Goodman, R., S. Korbay, A. Buchignani. Evaluation of Collapse Potential Over Abandoned Room-and-Pillar Mines. Bulletin Association of Engineering Geologists, v. 17, no. 1, 1980, p. 27-37.

This paper summarizes the procedure used to evaluate surface subsidence hazards posed by abandoned room-and-pillar workings beneath a school site. If the workings are deeper than about 150 feet, the expense of providing deep foundations may be prohibitive and filling the mines may be required. However, if it can be demonstrated that the pillars can support the overburden safely, the site may be used without such expenses. This was done at the particular site by examining the implications of failure of isolated pillars on the stability of contiguous pillars and the roof. The method used is applicable only if reliable mine maps can be obtained.

Keyword(s): abandoned mines, room-and-pillar, surface structural damage, grouting, pillar strength, rock mechanics

Gormley, J. T., J. J. Gusek, V. Scovazzo. Case Study: The Glenrock, Wyoming Subsidence Control Project. SME Fall Meeting, St. Louis, MO, September 1986, SME-AIME, p. 83.

Glenrock, Wyoming, is underlain by two abandoned coal mines. Subsidence events have been recorded over the years, with increasing frequency in recent years. As part of Wyoming's Abandoned Mine Lands Program, investigations including mining history/methods/mappings, subsurface drilling, and material site searches were performed. Portions of the mines less than 80 feet from the surface were identified as probable for subsidence. Subsidence control by hydraulic backfill was selected. Design included search and injection boreholes; water supply from the mines; and slurry mixing, transport, and injection systems. Injection system performance and backfill success is being monitored during construction.

Keyword(s): hydraulic backfilling, abandoned mines, coal mining

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Gorrell, G. R., K. M. McGuire. Major Issues in Subsidence Regulation. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University.

The legal issues surrounding the regulation of subsidence are among the major concerns facing the underground mining industry today. Whether subsidence occurs almost immediately as a result of longwall mining or without warning as a result of room-and-pillar mining conducted years ago, the resulting disputes are highly controversial and typical of the disputes involving the competing interests of surface and mineral estate owners. Until recently, the law governing these disputes was firmly established under the common law. The passage of the SMCRA, the utilization of new mining technologies, and the general heightened environmental awareness of our times, however, have interjected new issues into this area of the law. State and federal court decisions and administrative agency interpretations have helped clarify some of the issues. As evidenced by the many recent lawsuits between operators, surface owners, and regulatory agencies, many uncertainties still exist.

Keyword(s): law, government, land values, coal mining, active mines, abandoned mines, longwall

Location(s): Pennsylvania, Appalachian Coal Region, United States

Granda, A., J. Casas, J. L. Sastre. Geophysical Prospecting for Mined Areas Identification, "San Jose" Mine Case History (Caceres - Spain). IN: Mine Water, Proceedings 2nd International Congress, Granada, Spain, September 1985, R. Fernandez-Rubio, ed., v. 2, p. 943-951.

Geophysical methods, especially those of resistivity, offer interesting possibilities for use in the study of some problems that are related with subsurface water and mine diggings. Particularly attractive due to its versatility, ease of use, and good results, the "mise-a-la-masse" method is perhaps the one that has the greatest potential use in this field. The present work is concerned with a trial carried out in the "San Jose" Mine (Caceras, Spain). This mine has been abandoned for years, and the authors sought to check the effectiveness of the method to define the position of the old drifts and the approximate magnitude of the exploitation. The results obtained have been completely satisfactory and, on the basis of these results, a more complete study has been planned.

Keyword(s): geophysical, abandoned mines, subsurface water, hydrology

Location(s): Spain

Grant, U. S. Subsidence of the Wilmington Oil Field, California. IN: Geology of Southern California Bulletin 170, Sec. 3, Ch. 10, Engineering Aspects of Geology, Division of Mines, State of California Department of Resources, 1954, p. 19-24.

This article describes and discusses surface subsidence as a result of oil extraction from the Wilmington oil field of California. The author discusses horizontal displacements as a result of subsidence and suggests artificial repressuring of oil zones to delay or retard future subsidence but not as a mechanism to restore the surface to its original elevation.

Keyword(s): oil extraction, horizontal displacement

Location(s): California, United States

Grard, C. Mining Subsidence and the Means Permitting the Limiting of Their Effects on the Surface. Revue de L'Industrie Minerale, v. 51, January, 1969, p. 35-70 (in French).

Keyword(s): surface structural damage, ground control

Location(s): France

Gray, R. E. Mine Subsidence and Support Methods in the Pittsburgh Area. American Society of Civil Engineers Annual Meeting, Preprint No. 758, 1968, 37 p.

Keyword(s): ground control, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Gray, R. E., U. G. Henderson. Subsurface Stabilization, Hatfield's Ferry Power Station. Structures and Hydraulics Committee Minutes, Pennsylvania Electric Association, Engineering Section, January, 1969.

The use of grout columns to stabilize an undermined site for the construction of an electric power station is discussed.

Keyword(s): subsurface structural damage, utilities, grouting

Location(s): Pennsylvania, Appalachian Coal Region, United States

Gray, R. E., J. F. Meyers. Mine Subsidence and Support Methods in the Pittsburgh Area. IN: Proceedings Journal of the Soil Mechanics and Foundations Division, American Society of Civil Engineers, v. 96, no. SM4, Paper 7407, July 1970, p. 1267-1287.

The Pittsburgh area exhibits two distinct subsidence problems: (1) active mining at depths of 300 feet or more beneath the surface; and (2) subsidence associated with structures located over old mine workings at relatively shallow depths. In areas of active mining, subsidence damage is prevented by leaving coal pillars in place to support the ground surface. For structures located over old mines with shallow cover, the method of support selected is dictated by the cost and the degree of risk the owner is willing to accept.

Keyword(s): surface structural damage, mine design, grouting, room-and-pillar, ground control, backfilling, engineering, construction, geologic features, coal mining, active mines, abandoned mines

Location(s): Pennsylvania, Appalachian Coal Region, United States

Gray, R. E. Mine Subsidence. IN: Geology of the Pittsburgh Area, W. R. Wagner, et al., Pennsylvania Geological Survey, General Geology Report G59, 1970, p. 111-116.

This section describes subsidence problems from both active and abandoned bituminous coal mines in the Pittsburgh area. Protective measures are discussed, including pillar support, grout columns, and backfilling.

Keyword(s): backfilling, grouting, abandoned mines, active mines, room-and-pillar

Location(s): Pennsylvania, Appalachian Coal Region, United States

Gray, R. E. Mine Subsidence, Support, and Stabilization in Western Pennsylvania. IN: Geological Society of America Annual Meeting, Field Trip Guidebook, 1971, no. 6, p. 25-35.

Keyword(s): surface subsidence damage, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Gray, R. E., H. A. Salver. Discussion of State of Predictive Art in Subsidence Engineering by B. Voight and W. Pariseau. IN: Proceedings American Society Civil Engineers, Journal of Soil Mechanics & Foundations Division, v. 97, no. SM1, January, 1971, p. 258-260.
Keyword(s): prediction
Location(s): United States

Gray, R. E., H. A. Salver. Foundation Support in an Undermined Substation. American Society of Civil Engineers, National Structural Meeting, Cleveland, OH, April 25, 1972.
This paper describes the use of fly ash injection, grout columns, predrilled piles, and caissons for support of roads and structures in an undermined power substation.
Keyword(s): surface structural damage, foundations, utilities, grouting, pneumatic backfilling, mine waste
Location(s): United States

Gray, R. E., J. C. Gamble, R. J. McLaren, D. J. Rodgers. State of the Art of Subsidence Control. Appalachian Regional Commission Report ARC-73-111-2550, 1974, 182 p.
This report discusses methods of controlling or preventing surface subsidence damage above active and abandoned mines; it contains annotated bibliographies.
Keyword(s): vertical displacement, horizontal displacement, mine design, backfilling, monitoring design, monitoring installation, monitoring equipment, ground control, mine operation, literature search, active mines, abandoned mines, coal mining
Location(s): Appalachian Coal Region, United States

Gray, R. E., H. A. Salver, J. C. Gamble. Subsidence Control for Structures Above Abandoned Coal Mines. IN: Subsidence Over Mines and Caverns, Moisture and Frost Actions, and Classification, Transportation Research Record 612, 1976, Part 1, Transportation Research Board, Washington D.C., 1976, p. 17-24. (NTIS PB 272 844)
Subsidence of the ground surface above abandoned coal mines can cause serious damage to surface facilities. Two categories of techniques used in controlling subsidence are selective support for structures and filling of voids caused by past mining operations. The particular methods used must be adapted to the local geologic setting and the mining methods used to extract the coal, as well as the support requirements of the structure because these factors vary within any given site and from one locality to another. This paper presents a case history of subsidence control for an electric substation.
Keyword(s): surface structural damage, abandoned mines, ground control, coal mining, pneumatic backfilling, grouting, mine waste, anthracite, bituminous, historical, foundations
Location(s): Appalachian Coal Region, United States

Gray, R. E., R. W. Bruhn, R. J. Turka. Study and Analysis of Surface Subsidence Over the Mined Pittsburgh Coalbed. Contract J0366047, GAI Consultants, Inc., U.S. Bureau of Mines OFR 25-78, 1977, 374 p. (NTIS PB 281 511)
The purpose of the study was to investigate cases of subsidence over abandoned mined-out areas of the Pittsburgh Coal identified from published and unpublished sources. It was also to determine through a consideration of the geology, topography, climate, mining activity, and evidence at ground surface, what mechanisms control subsidence and under what circumstances it takes place. The report identifies 354 incidents of subsidence in the 8,000-square-mile Pittsburgh Coal Region.
Keyword(s): abandoned mines, bituminous, rock mechanics, surface structural damage, room-and-pillar, economics, partial extraction, insurance, historical, coal mining
Location(s): Pennsylvania, Maryland, West Virginia, Appalachian Coal Region, United States

Gray, R. E., R. W. Bruhn. Subsidence Above Abandoned Coal Mines. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, September, 1982, Y.P. Chugh and M. Karmis, eds., SME-AIME, p. 253-271.
This paper reviews the development of coal mining in the United States; it includes a discussion on subsidence characteristics including modes, time effects, overburden thickness, and lithology.
Keyword(s): vertical displacement, horizontal displacement, backfilling, abandoned mines, longwall, room-and-pillar, historical, time factor, economics, coal mining
Location(s): United States

Gray, R. E., R. J. McLaren. Research Needs in Subsidence Abatement Over Abandoned Mines. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 259-273.

A review of subsidence abatement methods resulted in identification of items where research may impact the current state of technology in mine subsidence control. These research needs are presented to stimulate discussion of their importance in subsidence abatement and to encourage funding agencies, researchers, and practitioners to work on them.

Keyword(s): abandoned mines, hydraulic backfilling, pneumatic backfilling, grouting, subsidence research, surface structural damage, structural mitigation

Location(s): United States

Gray, R. E., R. W. Bruhn. Coal Mine Subsidence--Eastern United States. IN: Man-Induced Land Subsidence, Geological Society of America Reviews in Engineering Geology VI, 1984, T.L. Holzer, ed., p. 123-149.

Underground coal mining has occurred beneath eight million acres of land in the United States, two million of which have been affected by subsidence. Most of this mining has taken place in the eastern half of the country (east of the 100th meridian), where thousands of acres in urban areas are threatened by subsidence.

Keyword(s): coal mining, active mines, abandoned mines, surface structural damage, vertical displacement, horizontal displacement

Location(s): Illinois Coal Basin, Appalachian Coal Region, United States

Gray, R. E. Coal Mine Subsidence and Structures. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 69-85.

This paper briefly reviews the magnitude of the subsidence problem in the United States resulting from underground coal mining, presents the similarities and differences between subsidence over abandoned and active mines, contrasts the experience in the United States with Europe; and considers the role of ground-structure interaction and structural details in subsidence damage.

Keyword(s): coal mining, surface structural damage, abandoned mines, engineering, active mines, prediction, horizontal displacement, foundations

Location(s): Illinois, Illinois Coal Basin, Pennsylvania, Appalachian Coal Region, United States, England, Europe

Gray, R. E. Subsidence Over Abandoned Coal Mines. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 322-344.

Underground coal mining has occurred in the United States for more than 200 years, resulting in almost 70,000 abandoned or inactive underground mines. The risk of subsidence over these abandoned mines is dependent upon the amount and extent of mining and the characteristics of the mine floor, the coal pillars, and the overburden.

Keyword(s): abandoned mines, coal mining, surface structural damage, historical, overburden, pillar strength, floor stability, land-use planning, backfilling, insurance, structural mitigation, soils

Location(s): Wyoming, Pennsylvania, Virginia, Illinois Coal Basin, Illinois, Appalachian Coal Region, United States

Gray, R. E., R. W. Bruhn, R. J. Turka, K. K. Kohli. Guidance Manual on Subsidence Control. GAI Consultants, Inc., Monroeville, PA., Office of Surface Mining Reclamation and Enforcement Technical Report 596, 1991, 127 p. (NTIS PB91-228403)

This manual was developed as an aid for the preparation of subsidence control plans for underground coal mining operations. It describes the subsidence process and reviews available subsidence prediction methods. Each mining area is unique and different states have different regulatory program requirements, consequently, clear communication between the state regulatory authority and the mine operator is needed so that specific needs and requirements of the subsidence control regulations are understood and met.

Keyword(s): room-and-pillar, longwall, shortwall, coal mining, law, partial extraction

Location(s): United States

Gray, R. E., R. W. Bruhn. Structural Damage - Mine Subsidence or ??? IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 113-120.

This paper presents information on distress to structures and briefly reviews a number of causes of ground movements other than subsidence. These include mass movements, dissolution, erosion, frost action, shrinking and swelling, yield into excavations, and compressibility.
Keyword(s): surface structural damage, soils, engineering, coal mining, vertical displacement, horizontal displacement
Location(s): United States

Grayson, R. L., G. Mishra. Understanding and Controlling Subsidence Over A Longwall Panel. Session paper, American Mining Congress 1982 Coal Convention, St. Louis, MO, May 9-12, 1982, 23 p.
A private residence located at mid-panel, length-wise and width-wise, was undermined by a longwall unit operating in the Pittsburgh coal seam. The surface, approximately 400 feet above the seam, was closely monitored for subsidence effects. This paper presents action taken in an attempt to minimize subsidence damage to the dwelling. It also presents the results from biweekly survey-grid monitoring. Subsidence development curves, contour maps, differential settlement data, and pictures reflecting the extent of damage to the surface structure are presented in an analysis of the situation.
Keyword(s): longwall, surface structural damage, monitoring methods, survey methods, active mines, coal mining, structural mitigation, foundations
Location(s): Pennsylvania, Appalachian Coal Region, United States

Green, J. H. Compaction of the Aquifer System and Land Subsidence in the Santa Clara Valley, California. U.S. Department of the Interior, Geological Survey Professional Paper 450-D, Geological Survey Research 1962, p. D175-D178.
Keyword(s): fluid extraction, hydrology
Location(s): California, United States

Green, J. H. The Effect of Artesian-Pressure Decline on Confined Aquifer Systems in Areas of Land Subsidence. Journal of Geophysical Research, v. 67, 1962, p. 3532.
Keyword(s): fluid extraction, hydrology

Greenfield, R. J., P. M. Lavin, R. R. Parizek. Geophysical Methods for Location of Voids and Caves. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 465-484.
Keyword(s): geophysical

Greenwald, H. P., E. R. Maize, L. Hartman, G. S. Rice. Studies of Roof Movement in Coal Mines, I. Montour 10 Mine of the Pittsburgh Coal Co. U.S. Bureau of Mines B 25, 1912.
Keyword(s): roof stability, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Greenwald, H. P., S. Avins, G. S. Rice. Compressibility and Bearing Strength of Coal in Place. U.S. Bureau of Mines Technical Paper No. 527, 1933, 12 p.
In an experimental mine, tests were made by applying a pressure from a hydraulic jack against a coal face.
Keyword(s): pillar strength, in situ testing, coal mining
Location(s): United States

Greenwald, H. P., E. R. Maize, I. Hartmann, G. S. Rice. Studies of Roof Movement in Coal Mines. U.S. Bureau of Mines RI 3355, 1937, 41 p.
Laboratory and in situ strength measurements were performed on specimens of Pittsburgh sandstone, Pittsburgh coal, and mine props through a cooperative agreement with the Pittsburgh Coal Company.
Keyword(s): roof stability, roof support, mine waste, rock mechanics, lab testing, in situ testing, coal mining, literature search
Location(s): Pennsylvania, Appalachian Coal Region, United States

Greenwald, H. P. Physics of Subsidence and Ground Movement in Coal Mines. Applied Physics, v. 8, no. 7, 1937, p. 462-469.
The author describes or reviews tests run by various investigators on the properties of coal and coal-measure strata.
Keyword(s): floor stability, mathematical model, pillar strength, time factor, lab testing, overburden, coal mining, rock mechanics, geotechnical

Greenwald, H. P., H. C. Howarth, I. Hartmann. Experiments on Strength of Small Pillars of Coal in the Pittsburgh Bed. U.S. Bureau of Mines Technical Paper No. 605, 1939, 22 p.
Tests for compressive strength and other properties were performed in situ on seven small coal pillars.

Keyword(s): pillar strength, in situ testing, floor stability, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Greenwald, H. P., E. R. Maize. Studies of Roof Movements in Coal Mines. U.S. Bureau of Mines RI 3452, 1939.
This report discusses floor heave, timber failures, the effect of overlying sandstone, and the magnitude of surface subsidence with regard to roof studies in the Crucible Mine.
Keyword(s): roof stability, overburden, floor stability, coal mining
Location(s): Appalachian Coal Region, United States

Greenwald, H. P., H. C. Howard, I. Hartmann. Progress Report--Experiments on Strength of Small Pillars of Coal in the Pittsburgh Bed. U.S. Bureau of Mines RI 3575, June, 1941.
This report presents results of five compression tests on in situ pillars.
Keyword(s): pillar strength, rock mechanics, in situ testing, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Greenwald, H. P. Surface Factors Affecting Pillar Recovery. Mining Congress Journal, v. 35, no. 3, 1949, p. 54-57.
Keyword(s): pillar extraction, coal mining

Gren, K. Modelling the Propagation of the Effects of Mining Exploitation by Means of a Photoelectric Analog. IN: Proceedings, International Science Symposium on Mine Surveying, Mining Geology and the Geometry of Mine Deposits, Prague, Czechoslovakia, August 26-30, 1969, Conference Paper I/1, v. 1, Sec. 1, 1969, 17 p.
Keyword(s): modeling

Gresley, W. S. Culm Filling: How It May Be Used Advantageously in Mining Anthracite by the Longwall System. Colliery Engineering, v. 14, September, 1893, p. 32.
This article suggested applications to modify the longwall system to recover more coal. The method required suitable terrain and plenty of available fill.
Keyword(s): stowing, longwall, anthracite, coal mining, geologic features, historical
Location(s): United States

Griffith, W. Flushing of Culm in Anthracite Mines. Journal of the Franklin Institute, v. 149, 1900, p. 271.
This article covers the first use of hydraulic backfilling for subsidence prevention and roof control in anthracite coal mines.
Keyword(s): hydraulic backfilling, roof stability, anthracite, coal mining

Griffith, W. Method of Supporting Mine Roofs by Blasting Down Roof and Blasting Floor Up. United States Patent no. 1,004,419, Mines and Minerals, v. 32, 1911, p. 279 and 402.
Griffith's patent was a proposal for blasting the roof and/or floor and allowing the fractured rock, which bulks and occupies a larger volume, to remain in place as permanent support pillars. The rock could also act as a dam for hydraulic backfilling materials.
Keyword(s): hydraulic backfilling, roof support
Location(s): United States

Griffith, W., E. T. Conner. Mining Conditions Under the City of Scranton, PA, Report and Maps. U.S. Bureau of Mines B 25, 1912, 89 p.
Mine plans and cross sections of the Scranton area are included. Strength and compressibility of anthracite pillars and backfill materials are discussed.
Keyword(s): backfilling, mine waste, historical, roof support, pillar strength, coal mining, anthracite
Location(s): Pennsylvania, Appalachian Coal Region, United States

Grigorovich, V. T., Y. A. Makhan'ko, A. V. Isaev. Surface Subsidence During the Working of a Sequence of Seams at the "Kaierkan" Pit of the Noril'sk Coalfield. Soviet Mining Science, no. 2, 1965, p. 86-93.
Surface effects and subsidence parameters of mining the upper four seams at the Noril'sk Coalfield, where permafrost extends to 200 meters, are discussed.
Keyword(s): multiple-seam extraction, surface subsidence damage, geologic features, coal mining
Location(s): Soviet Union

Grim, R. E., V. E. Allen. Petrology of the Pennsylvanian Underclays of Illinois. Bulletin, Geological Society of America, v. 49, 1938, p. 1485-1514.
Keyword(s): floor stability, lab testing
Location(s): Illinois, Illinois Coal Basin, United States

Grond, G. J. A. Disturbances of Coal Measures Strata Due to Mining Activity. Iron and Coal Trades Review, v. 160, 1949, p. 1323-1326, 1377-1382, 1445-1449; v. 161, 1950, p. 37-40, 85-88, 135-137, 197-200, 244-251, 295-297, 394-397.

This series of articles gives a short history of subsidence investigations and early theories, principally those from Germany.

Keyword(s): historical, prediction, overburden, subsidence research, coal mining

Location(s): Germany

Grond, G. J. A. The Precise Topographical Measurements in Coal-Mine Underground Works. IN: Proceedings International Conference About Rock Pressure and Support in the Workings, Liege, Belgium, April 24-28, 1951, Institut National de l'Industrie Charbonniere, 15 p.

When we want to get an exact idea of movements and pressures occurring in works and galleries, it is very useful and even necessary, first to consider movements occurring at a certain distance from the face. This paper deals with research made in this field by the surveyors of the Dutch State Mines. The observations made in Holland do not apply integrally to other coal districts, for in one single district we observe fairly considerable differences and contradictions. It will be useful, however, to compare them with observations made abroad, for the methods of observation are often nearly identical, and the results may give us more accurate ideas.

Keyword(s): coal mining, survey methods, overburden, monitoring methods, geologic features

Location(s): Holland

Grond, G. J. A. A Critical Analysis of Early and Modern Theories of Mining Subsidence and Ground Control. Powney-Parker Publicity Services, Ltd., 1st ed., 1953, 57 p.

The author provides a critical analysis of European subsidence prediction methods, including both early and modern theories.

Keyword(s): vertical displacement, horizontal displacement, prediction, prediction theories, ground control, historical

Location(s): Europe

Grond, G. J. A. Ground Movements Due to Mining. Colliery Engineering, v. 34, April, 1957, p. 157-158; v. 34, May, 1957, p. 197-205.

The author discusses theories of ground movements occasioned by the winning of minerals, particularly with coal mining. Survey observations are considered, in particular exact survey measurements to establish an outline of the phenomena of movement in their various aspects.

Keyword(s): surface subsidence damage, overburden, coal mining, survey methods, prediction, prediction theories

Location(s): United Kingdom

Grond, G. J. A. Ground Movements Due to Mining With Different Types of Strata and at Different Depths. IN: Proceedings of European Congress on Ground Movements, Leeds, England, April 9-12, 1957, London Harrison, p. 115-127.

The author discusses the theory of arch support with respect to mine subsidence by summarizing papers presented by other investigators in this field.

Keyword(s): overburden, geologic features

Growitz, D. J. Hydrogeologic Factors that May Affect Mine Drainage in the Anthracite Region of Pennsylvania, Eastern United States. Symposium on Water in Mining and Underground Works, SIAMOS--78, Granada, Spain, 1978, p. 153-172.

Hydrologic and water-quality data collected during a 2-week period of average flow were used in a regional analysis of mine drainage in the anthracite coal region of Pennsylvania. The analysis shows that the flow and quality of mine drainage are influenced by (1) proportion of land surface in the coal fields disturbed by mining, (2) residence time of mine water, (3) changes in the hydrologic system due to cessation of pumping and the recovery of water levels, and (4) method of mining.

Keyword(s): hydrology, coal mining, anthracite, subsurface water, environment, surface water, mine waste

Location(s): Pennsylvania, Appalachian Coal Region, United States

Groy, D. L., R. C. Moore. Application of Electrotelluric Geophysical Techniques to Subsurface Void Exploration in Subsidence Investigation and Control. Final Report to Office of Surface Mining, Reclamation and Enforcement by Goodson & Associates Inc., Denver, CO, January, 1989, 176 p. (NTIS PB90-267246)

Results from a series of evaluations on the Petro-Sonde instrument emphasize the difficulty in delineating subsurface cavities. The degree of success achieved in detecting coal at Marissa, Illinois, indicates that the instrument may not be suited for detailed site characterization, but it may be useful as a preliminary investigative tool.

Keyword(s): abandoned mines, coal mining, geophysical

Location(s): Colorado, Rocky Mountain Coal Region, West Virginia, Pennsylvania, Appalachian Coal Region, Illinois, Illinois Coal Basin, United States

Guangxiao, D., Z. Yiaoqi. Land Subsidence in China. IN: Land Subsidence, Proceedings 3rd International Symposium on Land Subsidence, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds. International Association of Hydrological Sciences Publication No. 151, 1986, p. 405-414.

The most serious land subsidence occurs in areas with thick and fine-grained loose sediments or with shallow-buried karst, which is mainly attributed to groundwater pumping for water supply or dewatering of the mine. It is also closely related to the local geological environments. The paper describes the engineering geological and hydrogeological conditions and their influence on land subsidence in some of the studied areas. It also gives a brief account of measures to bring land subsidence under control.

Keyword(s): surface subsidence damage, geologic features, fluid extraction

Location(s): China

Guither, H. D., S. A. Neff. Appraisal of Farmland Overlying Underground Coal Mines. Journal of the American Society of Farm Managers and Rural Appraisers, October, 1983, v. 47, no. 2, p. 49-50.

Extensive literature of underground coal mining exists but the documentation concerning its economic effects on agriculture is limited. Underground mining does use smaller amounts of surface lands than surface mining for comparable coal production. The coal is extracted without disturbing the upper soils, unless subsidence, planned or unplanned, occurs. In view of the growing concern for damage from mine subsidence, a research project was begun in Illinois to assess the economic effects and policy implications of underground coal mining upon agricultural land. Part of this project involved an effort to determine the effects of subsidence upon land values.

Keyword(s): land values, land-use planning, agriculture, economics, coal mining, mine waste, abandoned mines, active mines, surface water

Location(s): Illinois, Illinois Coal Basin, United States

Guither, H. D. The Economic Effects of Subsidence from Underground Coal Mining on Agricultural Land in Illinois. Research Report to U.S. Bureau of Mines Twin Cities Mining Research Center, Minneapolis, MN, Contract No. HO222010, 1984, 60 p.

In a survey of Illinois agricultural extension advisers, subsidence was reported in 31 counties. The most frequently reported problems were standing water, depressions, disruption of surface drainage, broken tile lines, and reduced crop yields.

Keyword(s): agriculture, surface subsidence damage, economics, surface water, subsurface water, utilities, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Guither, H. D. Coal Mine Subsidence on Illinois Farmland. Illinois Agricultural Economics Staff Paper, no. 84E-297, July 1984, 6 p.

This paper suggests the need for further research into the areas of identification of where subsidence has occurred, complete yield sampling and tests, and best mitigation methods.

Keyword(s): agriculture, land mitigation, active mines, coal mining, economics, longwall, high-extraction retreat, room-and-pillar, land values

Location(s): Illinois, Illinois Coal Basin, United States

Guither, H. D., J. Hines, R. A. Bauer. The Economic Effects of Underground Mining Upon Land Used For Illinois Agriculture. Department of Energy and Natural Resources, Document 85/01, Springfield, IL, 1985.

The objectives of this project were to inventory acreage overlying underground mines in Illinois, assess the extent of subsidence overlying coal mines, assess economic effects of subsidence for landowners, gather information about tax assessment policies in subsidence areas, and develop and assess policy alternatives to deal with subsidence problems on Illinois agricultural land.

Keyword(s): economics, agriculture, coal mining, law, land mitigation, insurance, soils, surface structural damage, active mines, abandoned mines

Keyword(s): Illinois, Illinois Coal Basin, United States

Guither, H. D. The Mine Subsidence Threat to Soils. Journal of Soil and Water Conservation, January-February, 1986, p. 21-23.

This article covers subsidence, the extent of the problem in relation to the 1977 Federal Surface Mining Control and Reclamation Act, the extent of damage, and agricultural costs of subsidence from a 1983 survey of Illinois extension advisers.

Keyword(s): soils, agriculture, environment, law, surface subsidence damage, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Gullachsen, B. C. Hydraulic Stowing in the Gold Mines of the Witwaterstrand. Transactions Institution of Mining Engineers, London, v. 48, 1914-15, p. 122-139.

This paper describes mechanics of sand filling in gold mines of South Africa.

Keyword(s): hydraulic backfilling, stowing, metal mining

Location(s): South Africa

Gupta, R. N., I. W. Farmer. Relations Between Strata Deformation and Support Performance on Longwall Faces. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 7-12.

Keyword(s): longwall, overburden, rock mechanics

Gupta, R. N., I. W. Farmer. Strata Deformation and Support Performance at a Longwall Face. IN: Proceedings 5th International Congress, International Society for Rock Mechanics, Melbourne, April, 1983.

During a series of detailed observations on three retreating longwall faces at Westoe Colliery, Tyne and Wear, United Kingdom, the effect of setting pressure on support performance and strata deformation was investigated. Increased setting pressures, resulting in an increase in setting load density, were shown to reduce convergence and face spalling as well as roof flaking. This was shown to result mainly from the change in roof strata deformation from a wedge shaped compression zone with tension at the face edge to an even beam shaped compression zone over the face area.

Keyword(s): longwall, rock mechanics, overburden, coal mining, roof support

Location(s): United Kingdom

Gupta, R. N., K. P. Mukherjee. Pillar Extraction in a Multi-Section Working of a 13m Thick Seam Based on Strata Deformation Investigations. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 98-106.

A retreating system of pillar extraction in a two-section working was developed based on considerable strata deformation investigations. The system was successfully used to extract pillars in a 13.4 m thick seam at a colliery in Jharia Coalfield (India). Earlier attempts to extract two sections simultaneously proved abortive and resulting in puncturing of parting and overriding of pillars, which led to complete loss of a few panels. The success of the new method is a result of extracting the bottom section pillars in the destressed zone. It provides good face ventilation; better strata conditions; and concentration of work in a few places, enabling effective supervision, enhanced production, increased productivity, and maximum percentage of extraction. It also minimizes loss of coal in the form of ribs.

Keyword(s): coal mining, pillar extraction, ground control

Location(s): India

Gurtunca, R. G., E. H. R. Schumann. Computer Simulation of Surface Subsidence Using a Displacement Discontinuity Method. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 81-87.

Results of computer modeling of surface subsidence above longwalls at three different collieries are described. A computer program based on the displacement discontinuity method was used to simulate subsidence profiles and maximum subsidence. Modeling of static and dynamic profiles were carried out separately; results show a linear relationship between elastic parameters of the surrounding rock, the thickness of dolerite, and the face advance.

Keyword(s): computer, modeling, longwall, prediction, finite element, geologic features, coal mining

Location(s): South Africa

Gusek, J. J., J. T. Gormley. Tube-A-Manchette Grouting As An Abandoned Mine Stabilization Method. IN: Proceedings, Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 336-355.

A method of stratified grouting and a high-strength, high-fluid grout mixture was used to stabilize the near-surface rock beneath a school in Superior, Wyoming. The school is undermined and damage was related to the probability of trough subsidence, which caused differential settlement in the foundation units.

Keyword(s): abandoned mines, surface structural damage, grouting, foundations, structural mitigation, geologic features, historical, coal mining, economics

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Gustkiewicz, J. Fleksyjne Deformacje Terenu W Zasiegu Wplywow Eksploatacji Gorniczej (Flexural Deformations of the Surface Within the Area of Mining Effects). Archiwum Gornictwa, v. 17, no. 2, 1972, p. 83-116.

Keyword(s): surface subsidence damage

Gustkiewicz, J., A. Kanciruk, L. Stanislawski. Some Advancements in Soil Strain Measurement Methods with Special Reference to Mining Subsidence. Mining Science and Technology, v. 2, no. 4, 1985, p. 237-252.

Investigations of phenomena associated with rock mechanics make it necessary to carry out long-term measurements of two- and three-dimensional states of strains. Studies have been conducted for a number of years to design measuring devices that can be installed in the soil to allow long-term observation of the strain states. The basis of these instruments is a vibrating-wire strain transducer. The effects of environmental factors on the measuring instrumentation installed in the soil over a number of years was also investigated.

Keyword(s): soils, monitoring methods, monitoring equipment, rock mechanics, soil mechanics

Location(s): Poland

Haas, C., S. Tangchawal. Relation Between Engineering Properties and Clay Mineralogy for Illinois Coal Mine Roof Shales and Underclays. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 48-72.

This research was undertaken to determine if the engineering properties and moisture-sensitive index properties of Illinois coal mine roof shales and underclays are related to clay and non-clay mineral content. A full suite of laboratory property tests were performed on core from five mines in the Illinois Basin. The results, in the form of regression equations, indicate that (1) engineering properties have a high degree of correlation with the total clay mineral content, mixed-layer mineral content, and quartz content; and (2) the moisture absorption phenomena are nearly direct functions of total clay minerals, mixed-layer minerals, illite, and quartz. The higher the clay mineral and clay-size contents in the materials, the lower will be the rock durability and stability.

Keyword(s): roof stability, floor stability, coal mining, engineering, lab testing, geologic features, rock mechanics

Location(s): Illinois, Illinois Coal Basin, United States

Habenicht, H., E. Urschitz. Rib Pillar Extraction--An Alternative to Long Walling and Short Walling. SME-AIME Preprint No. 86-65, for presentation at the SME Annual Meeting, New Orleans, LA, March 2-6, 1986, 13 p.

Requirements for full extraction in underground coal mining call for inexpensive, safe techniques to be competitive with conventional methods. Longwall and shortwall systems are to some extent employed for this purpose. Another method would be rib pillar extraction and pillar extraction. These methods are compared with respect to procedure, equipment, safety, roof control, investment, output, performance, and costs.

Keyword(s): longwall, shortwall, economics, pillar extraction, roof stability, coal mining, mine design

Hackett, P. An Elastic Analysis of Rock Movement Caused by Mining. Transactions AIME, v. 118, no. 7, April, 1959, p. 421-433.

This paper describes work done at the University of Nottingham by Professor R. Hill. Hill's conception of a longwall working was a horizontal crack in an infinite medium. Hill also suggested the methods by which the existence of a free surface and the result of excavation closure are investigated, and he formed the basic problem for the allowance of crushing of the coal.

Keyword(s): continuum mechanics, phenomenological model, ground control, elastic model, longwall, modeling

Location(s): England

Hackett, P. Prediction of Rock Movement by Elastic Theory Compared With Insitu Measurements. Rock Mechanics & Engineering Geology, Supplement 1, 1964, p. 88-102.

Keyword(s): prediction, elastic model, modeling, phenomenological model, rock mechanics, in situ testing

Haimson, B., C. Fairhurst. In-situ Stress Determination at Great Depth by Means of Hydraulic Fracturing. IN: Rock Mechanics-Theory and Practice, Proceedings 11th Symposium on Rock Mechanics, University of California, Berkeley, June 16-19, 1969, W.H. Somerton, ed., SME-AIME, New York, 1970, p. 559-584.

This paper extends the criterion for hydraulic fracturing and reports on some laboratory tests on simulated boreholes. Some interesting field results are also mentioned.

Keyword(s): rock mechanics, lab testing

Location(s): United States

Hake, S. S. A Review of Engineering Geological and Geotechnical Aspects of Town and Country Planning with Particular Reference to Minerals and the Extractive Processes. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 69-74.

The objective of this paper is to demonstrate the importance of, and connection between, town and country planning matters and the need for engineering geological and geotechnical assessments. One section considers Britsh Coal's rights of working and their obligation to consult and to make reparations for subsidence damage caused by underground coal mining activities.

Keyword(s): land-use planning, law, government, coal mining, structural mitigation

Location(s): United Kingdom

Hakelberg, F. Flexible Bituminous Bases for Areas of Mining Subsidence. Strassen-Asphalt und Tiefbau-Technik, v. 9, 1956, p. 657 (in German); also Road Abstract No. 247, March, 1957 (in English).

Keyword(s): surface subsidence damage, construction, roads

Halat, W. An Analysis of the Behaviour of the Roof Over the Longwall Working. Gornictwo, Quarterly of Stanislaw Staszic Academy of Mining and Metallurgy, Cracow, Poland, v. 15, no. 4, 1991, p. 247-257 (in Polish; English summary).

Computer calculations were realized for the discrete numeric rock mass model corresponding to the geological-mining conditions of one of the Hard Coal Mines. Critical state of the rock mass was described by the Coulomb-Mohr flow function. The results were analyzed graphically. In areas where the rock mass was destroyed, forming relaxed zones, values of secant module of the stress-deformation rock mass characteristic, in the form of a laminar plan, were determined. The varying values of the secant module, not being a characteristic features of strength properties, may determine the changes in the rock mass structure destruction.

Keyword(s): modeling, finite element, coal mining, longwall, active mines, roof stability, computer

Location(s): Poland

Halbaum, H. W. G. The Action, Influence and Control of the Roof in Longwall Workings. Transactions Institute of Mining Engineers, London, v. 2, 1903, 22 p.

Keyword(s): longwall, roof stability, roof support

Halbaum, H. W. G. The Great Planes of Strain in the Absolute Roof of Mines. Transactions Institute of Mining Engineers, London, v. 6, 1905, 18 p.

Keyword(s): roof stability

Hall, B., S. Glynn. Road Crossing of Mined Out Reef Outcrops: Two Case Histories. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 185-191.

The crossing of mined-out gold reef outcrops by new roads posed particular challenges as economical alternative solutions were sought. The geotechnical investigations and the alternatives to the more frequently used but expensive grouting methods are described.

Keyword(s): grouting, roads, metal mining, geotechnical, monitoring methods

Location(s): South Africa

Hall, B. M. Subsidence Prediction Methods and Instrumentation for Caved Longwall Coal Mines. Mineral Resources Engineering and Management Program, Northwestern University, Evanston, IL, MREM R107, August, 1980, 128 p.

Thirty-three subsidence models for caved longwall coal mines are investigated. The emphasis of this study includes evaluation of the ability of the models to predict subsidence, examination of the assumptions in the models, and indication of the areas for improvement. The data from four instrumented longwall panels are presented to determine which geologic traits influence the amount and pattern of subsidence, and if in situ data can be obtained to improve the prediction methodology.

Keyword(s): vertical displacement, horizontal displacement, survey methods, survey equipment, prediction, longwall, prediction theories, coal mining, empirical model, stochastic model, phenomenological model, elastic model, mathematical model, viscoelastic model

Location(s): Illinois, New Mexico, West Virginia, Illinois Coal Basin, Rocky Mountain Coal Region, Appalachian Coal Region

Hall, B. M., C. H. Dowding. Prediction of Subsidence from Full Extraction Coal Mining. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 19, no. 3, June, 1982, p. 305-312.

The authors examine empirical and phenomenological methods for predicting subsidence over longwall panels.

Keyword(s): vertical displacement, horizontal displacement, longwall, prediction, prediction theories, coal mining, empirical model, phenomenological model

Location(s): Illinois, New Mexico, West Virginia, Illinois Coal Basin, Rocky Mountain Coal Region, Appalachian Coal Region, United States

Hall, H. C. Masonry Buildings: Construction on Subsidence Sites. IN: Proceedings, North American Masonry Conference, August 14-16, 1978, University of Colorado, Boulder, Masonry Society, Denver, Paper 84, 1978, 12 p.

Keyword(s): engineering, construction, architecture
Location(s): United States

Hall, M., R. J. Orchard. Subsidence Profile Characteristics. Chartered Surveyor, v. 95, no. 8, February, 1963, p. 422-428.
Keyword(s): survey data processing

Hall, R. D. Squeezes in Mines and Their Causes. Mines and Minerals, v. 30, no. 5, 1909, p. 286-287.
Keyword(s): floor stability

Hall, R. D. The Strength of Mine Roofs. Mines and Minerals, v. 30, 1910.
Keyword(s): roof stability

Hall, R. D. Permanent Roof Sustension. Coal Age, v. 1, January 20, 1912, p. 481.
The article describes and supports Griffith's process of blasting up the floor and blasting down the roof to produce roof supports and dams for hydraulic flushing.
Keyword(s): hydraulic backfilling, roof support, coal mining

Ham, B. W. The Impact of Underground Coal Mining on Farming. IN: Mining and Environment, A Professional Approach, National Conference, Brisbane, July 1987, p. 33-40.
The proportion of coal production from underground operations in Queensland is likely to increase in the future. A portion of this increase will come from mines working under farming areas. The degree of compatibility between underground coal mining operations and farming is examined. Two case histories are considered in detail.
Keyword(s): coal mining, agriculture, surface water, soils, longwall, room-and-pillar, subsurface water, multiple-seam extraction
Location(s): Australia

Hambleton, R. B. Inspectorial Aspects of Subsidence with Special Reference to the Newcastle Coal Fields. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute Mining & Metallurgy, Illawarra Branch, Paper 14, p. 14-1--14-3.
Technical aspects of the administration of the Mine Subsidence Compensation Act (1961) are investigated by the New South Wales (Australia) Mines Inspectorate. Some areas are extensively undermined by ancient coal workings, some of which are very close to the surface. In other areas, coal deposits are being mined at greater depths or will be mined in the not too distant future.
Keyword(s): surface subsidence damage, coal mining, active mines, abandoned mines, surface structural damage, law, government, structural mitigation, mitigation, land mitigation
Location(s): Australia

Hammond, A. J., G. W. Plant. The Stabilization of Outcrop Workings for a Multi-Storey Building in Johannesburg. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 53-58.
The desire for land close to the central building district and the consequent escalation in cost led to a reappraisal of undermined ground in this area. This paper describes the investigation and treatment of a site required for development of a multi-story building. The treatment method chosen enabled physical inspection of the actual workings, and the stabilization consisted of the construction of concrete buttresses followed by specialized grouting.
Keyword(s): abandoned mines, metal mining, historical, engineering, construction, surface structural damage, geotechnical, foundations
Location(s): South Africa

Hanes, J., J. Shepherd. Mining Induced Cleavage, Cleats and Instantaneous Outbursts in the Gemini Seam at Leichhardt Colliery, Blackwater, Queensland. IN: Proceedings, Australasian Institute of Mining and Metallurgy, no. 277, March, 1981, p. 17-26.
Megascopic and microscopic studies of cleats and mining induced cleavage in the first workings at Leichhardt Colliery revealed the presence of four distinct fracture sets. Microscopic studies confirmed underground observations of the fracture sets.
Keyword(s): coal mining, geologic features, active mines
Location(s): Australia

Hanna, K., K. Haramy, D. Conover. Field Investigations of Roof and Pillar Stability in Coal Mine Intersections. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 76-83.

This report describes a rock mechanics instrumentation program conducted in an underground coal mine in central Illinois. This research project was designed to provide a basic understanding of pre- and post-mining roof stresses, pillar loading, strata movement, floor heave, and bolt loading at coal mine intersections. The instrumentation plan, a description of the instruments installed in and around a four-way intersection, and the data obtained during the development of the intersection are presented. Data collected include physical properties of coal and rock, strata lithology, strata movements, in situ stresses, mining-induced stresses, and roof bolt loading. An analysis of observations made and instrumentation results obtained during development and initial monitoring of the intersection is also presented.

Keyword(s): coal mining, rock mechanics, instrumentation, roof stability, roof support, roof bolting, pillar strength, geologic features, geotechnical, in situ testing, mine safety, monitoring methods

Location(s): Illinois, Illinois Coal Basin, United States

Hanna, K., D. Conover, P. H. Lu. Integrity Factor Approach to Assess the Stability of Room-and-Pillar Mines. IN: Proceedings 7th International Conference on Ground Control in Mining, Morgantown, WV, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, p. 20-29.

The integrity factor approach was developed by the USBM to assess the stability of mine pillars and has been applied primarily to longwall chain pillars. Recently, this approach was applied to a room-and-pillar mine in the Illinois Coal Basin. A special configuration of hydraulic borehole pressure cells was installed in a pillar to determine the in situ strength-and-stress relationship of the coal pillar and to verify the applicability of the integrity factor approach. Results indicate that the integrity factor approach is applicable to the assessment of pillar stability. The integrity factor approach may be a realistic and effective approach for room-and-pillar mine design.

Keyword(s): room-and-pillar, mine design, monitoring equipment, instrumentation, coal mining, pillar strength

Location(s): Illinois, Illinois Coal Basin, United States

Hanna, K., D. P. Conover. Design of Coal Mine Entry Intersections. SME Preprint 88-39, for presentation at SME Annual Meeting, Phoenix, AZ, January 25-28, 1988, 11 p.

This paper describes a method to improve coal mine entry intersection design and considers the effect of in situ stresses, local geologic conditions, rock physical properties, and mining sequence. Development of the method is discussed, including the results of field instrumentation studies and numerical modeling investigations. Ground control studies conducted by the USBM in two underground mines in the Illinois Coal Basin have shown that in situ horizontal stresses and roof geology have a critical effect on intersection stability. Methods to reduce the adverse effects of these parameters are emphasized. Typical failure behavior is presented to illustrate proposed control methods to alleviate adverse ground conditions.

Keyword(s): coal mining, mine design, geologic features, rock mechanics, instrumentation, modeling, roof stability, roof bolting, ground control, horizontal displacement, vertical displacement

Location(s): Illinois, Illinois Coal Basin, United States

Hanna, S., P. Corlew, D. Cote. Surface Subsidence Monitoring: Surveying Techniques. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, 1983, p. 613-622.

The objective of the paper is to describe survey procedures that can be used in least-cost subsidence monitoring systems for mines of various sizes, types, and regions.

Keyword(s): monitoring methods, vertical displacement, horizontal displacement, monitoring equipment, survey equipment, survey methods, survey design, monitoring installation

Location(s): United States

Hannon, J. B., B. E. McGee. Ground Subsidence Associated with Dewatering of a Depressed Highway Section. IN: Subsidence over Mines and Caverns, Moisture and Frost Actions, and Classification, Transportation Research Record 612, F.R. Zwanzig, ed., 1976, National Academy of Sciences, Washington, D.C., 83 p. (NTIS PB 272 844)

Subsidence of land areas adjacent to construction of an interstate highway is reported. Foundation settlements of structures adjacent to a depressed section occurred as a result of pumping groundwater during construction dewatering operations. Preliminary recommendations and actual construction dewatering operations are discussed. The stability of the Sacramento River levee and the possibility of piping during high water were significant factors in planning the dewatering operation.

Keyword(s): roads, hydrology, subsurface water, foundations, fluid extraction

Location(s): California, United States

Hao, Q.-W., Y. P. Chugh. Surface Subsidence Characteristics Resulting from Secondary Mining in an Illinois Mine. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 285-300.

Surface subsidence characteristics resulting from secondary mining (pillar notching) were studied for three pillar sizes (solid): 70 x 70 feet, 70 x 55 feet, and 55 x 55 fet. Two patterns of subsidence trough were observed: shallow and deep. The former occurred over 70 x 70 feet pillars, and subsidence characteristics were similar to those observed over unnotched areas. Maximum subsidence of about 0.10 feet was observed in this area. The deep trough was observed over the 70 x 55 and 55 x 55 feet pillars. In this case, more than 2 feet of maximum subsidence was observed; about half of which occurred immediately after the development of pillar notches. This quick subsidence was casued by the sinking of the pillars into weak floor strata. Deformations in the deep trough were much larger than those in the shallow trough but still smaller than those due to longwall mining.Surface subsidence was correlated with the pillar settlement.

Keyword(s): pillar extraction, coal mining, active mines, pillar strength, floor stability, partial extraction, room-and-pillar, survey methods, survey design, geologic features, survey equipment

Location(s): Illinois, Illinois Coal Basin, United States

Hao, Q.-W., Y. P. Chugh. Potential of a Void Diffusion Model to Predict Longwall Subsidence in the Illinois Coal Basin. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 199-206.

The authors attempt to apply a simplified nonhomogenous void diffusion model (NHVDM) to predict surface subsidence for longwall mining in Illinois. A generalized error function subsidence profile is derived from this model. The model validation indicates that the NHVDM approach appears to fit the observed subsidence data as well or better than the error and the trigonometric functions, particularly around the trough edge areas.

Keyword(s): longwall, coal mining, modeling, overburden

Location(s): Illinois, Illinois Coal Basin, United States

Hao, Q. W., W. M. Ma. Void Diffusion Models for Analysis and Prediction of Mine Subsidence. IN: Rock Mechanics Contributions and Challenges: Proceedings 31st U.S. Symposium, Golden, CO, June 18-20, 1990, Balkema, Rotterdam, p. 203-210.

A variety of methods of exist for prediction of surface subsidence over longwall mines. The Void Diffusion Model, based on physical concepts, is developed for conditions in Chinese coal mines. The concept of void diffusion with bulking is introduced. The three physical principles, conservation of void volume, linear void diffusion, and linear void convection are presented and used to derive governing equations. Model validation against field data is shown.

Keyword(s): modeling, prediction, longwall, coal mining

Location(s): China

Hao, Q.-W., Y. P. Chugh, W.-M. Ma. Prediction of Longwall Mine Subsidence Based on a Nonlinear Void Diffusion Model. IN: Proceedings VIII Congress International Society for Mine Surveying, September 22-27, 1991, University of Kentucky, Lexington, UKY BU154, p. 279-282.

In this paper, a nonlinear finite element approach of the void diffusion model is established to predict mine subsidence. The nonlinear characteristic curve of void diffusion coefficient can be estimated from a subsidence profile observed at a half-infinite mining condition. Relationships between the void diffusion coefficient and the subsidence value, which are the bases for nonlinear prediction, were formulated for a Chinese coal field and a United States coal mine.

Keyword(s): modeling, finite element, coal mining, active mines, longwall, prediction
Location(s): China, United States

Hao, Q. W., Y. P. Chugh. An Engineering Approach to Predict Subsidence Likelihood Over Abandoned Coal Mines in Illinois. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 189-196.

In this paper, the authors attempt to develop engineering-based approaches for estimating safety factors against pillar and floor failures and predicting the likelihood of subsidence events over abandoned coal mines in Illinois. There are two critical problems involved in the analysis: determination of geotechnical properties and consideration of time effect. The authors attempt to solve the problems by generating hypotheses, which are then used to modify existing engineering models for estimating pillar and floor safety factors.

Keyword(s): abandoned mines, coal mining, prediction, floor stability, pillar strength, engineering, modeling, geotechnical
Location(s): Illinois, Illinois Coal Basin, United States

Hao, Q.-W., Y. P. Chugh. Subsidence Modeling in Abandoned Coal Mines in Illinois: Implications for GIS-Based Risk Assessment. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 353-372.

This paper examines some of the background materials related to mine subsidence problems and subsidence modeling in Illinois. The results of statistical and engineering analyses based on a well developed Abandoned Mine Subsidence Events Database are presented. Finally, the concepts and models of predicting subsidence risk and the implications for GIS-based subsidence risk assessment are suggested.

Keyword(s): abandoned mines, coal mining, modeling, insurance
Location(s): Illinois, Illinois Coal Basin, United States

Harada, K., T. Yamanouchi. Land Subsidence in the Saga Plain, Japan, and Its Analysis by the Quasi-Three-Dimensional Aquifer Model. Geotechnical Engineering, v. 14, no. 1, 1983, p. 23-54.

Keyword(s): surface subsidence damage, modeling, subsurface water, fluid extraction
Location(s): Japan

Haramy, K. Y., J. A. Magers, J. P. McDonnell. Mining Under Strong Roof. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 179-194.

Strong roof helps minimize roof fall problems in coal mine entries. The inability of strong roof to cave readily may contribute, however. to major ground control problems in longwall and retreat mining operations. The concern expressed by mine operators prompted this USBM study to analyze the effects of strong roof members on ground stability around longwall openings. The problem was approached from three directions: development of a theory to analyze the strain energy conditions in the coal and surrounding strata, modeling of the effects of different thicknesses and strengths of coal and roof strata, and field instrumentation of powered supports in two longwall mines.

Keyword(s): roof stability, geologic features, coal mining, longwall, high-extraction retreat, modeling, instrumentation, roof support, bumps, rock mechanics, active mines, overburden
Location(s): Colorado, Utah, Rocky Mountain Coal Region, United States

Haramy, K. Y., J. P. McDonnell, L. A. Beckett. Control of Coal Mine Bursts. Mining Engineering, April 1988, p. 263-267.

Dangerously high stress areas can be controlled by proper mine planning and/or destressing. This paper reviews practical methods to detect and destress high-stress zones along coal faces. The USBM investigated stress-related burst problems and destressing efforts at a cooperating mine. Laboratory tests of the drilling yield method for high stress detection were conducted to determine the correlation between the volume of cuttings obtained and the magnitude of the applied stress. A three-dimensional computer modeling program was used to evaluate the effectiveness of stress relief methods.

Keyword(s): bumps, coal mining, mine design, geologic features, computer, modeling, finite element, boundary element, lab testing
Location(s): Rocky Mountain Coal Region, United States

Haramy, K. Y., R. O. Kneisley, B. T. Brady. Analysis of Major Failure Through Integration of Static and Dynamic Rock Mechanics Investigation. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 218-227.

This study reports the unique combination of both static and dynamic instrumentation for monitoring a longwall panel in a deep western coal mine and shows that the two methods used in tandem provide information to understand the causes of a major bump.

Keyword(s): coal mining, instrumentation, monitoring methods, monitoring equipment, monitoring design, longwall, bumps, rock mechanics, geologic features

Location(s): Colorado, Rocky Mountain Coal Region, United States

Haramy, K. Y., R. O. Kneisley. Comparative Study of Western US Longwall Panel Entry Systems. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 125-132.

This paper summarizes ground control studies of longwall panel entry systems in two coal mines in the western United States. Comparisons are presented of in situ pressure change measurements and assessments of chain pillar and entry behavior under a wide range of cover. Results indicate that no one entry system design is universally applicable and that site-specific factors need to be considered for panel entry design. Relationships between overburden depth, face advance, and magnitude and location of the forward abutment are discussed for western operations. In addition, analysis indicates that use of yield pillars may reduce or eliminate some stress-related problems that plague longwall panel entry design.

Keyword(s): longwall, mine design, coal mining, overburden, yielding supports, instrumentation, geologic features, bumps

Location(s): United States, Rocky Mountain Coal Region

Haramy, K. Y., R. O. Kneisley. Yield Pillars for Stress Control in Longwall Mines--A Case Study. International Journal of Mining and Geological Engineering, v. 8, no. 4, December 1990, p. 287-304.

Yield pillars fail on isolation from the coal seam and allow general lowering of the roof and transfer of overburden load to adjacent panels. Chain pillar behavior in a mine in Utah with a history of bumps in both longwall and room-and-pillar sections is described. Chain pillars generally yield as designed but are influenced by very localized conditions. Chain pillars effectively destress the longwall entries, improve stress control and recover, and reduce bump potential. Pre-longwall experience indicates the presence of a pressure arch having a width that increases with depth.

Keyword(s): yielding supports, pillar strength, longwall, active mines, bumps, ground control, mine design, room-and-pillar, geologic features

Location(s): Utah, Rocky Mountain Coal Region, United States

Haramy, K. Y., W. C. Smith, R. O. Kneisley. Automated Ground Control Monitoring. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 227-235.

Ground failures induced by an accumulation of stress near the longwall face have necessitated development of a reliable monitoring system capable of rapidly and effectively receiving, processing, and transmitting rock behavior information. This allows for quick adjustments in mine planning to prevent ground failures. The inclusion of a remotely located, high-speed computer in the monitoring system increases the rate at which data can be collected, processed, and analyzed. The objective of the initial phase of the program was to design an effective automated data monitoring system (ADMS). It consists of a primary, commercially available computer linked to an underground array of pressure sensors installed in and around a working longwall panel. An experimental system is presently operating in a coal mine in the western United States.

Keyword(s): ground control, monitoring methods, monitoring equipment, monitoring design, longwall, mine design, computer, instrumentation, coal mining, mine safety, active mines

Location(s): Rocky Mountain Coal Region, United States

Harding, S. D. Barite Authigenesis in Illinois Soils. M.S. Thesis, Department of Agronomy, University of Illinois at Urbana-Champaign, 1991, 118 p.

Two similar and adjacent soils in southern Illinois, one with abundant barite and one without, were chosen for this study. The locations were chosen in conjunction with a mine subsidence study over active longwall panels.

Keyword(s): soils, longwall, active mines, hydrology, agriculture, land mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Hardy, H. R., R. M. Belesky. Potential Application of Seismic and Acoustic Emission/Microseismic Techniques to the Monitoring of Highway Subsidence. Department of Mineral Engineering, Pennsylvania State University, University Park, June, 1986. (NTIS PB86-232592/WNR)

This report discusses the problem of highway subsidence and considers the possible application of seismic and acoustic emission/microseismic techniques for monitoring such subsidence. A recent monitoring study is referenced. Results are considered to be directly relevant to problems of karst- or mining-induced subsidence.

Keyword(s): roads, geologic features, coal mining, monitoring methods, monitoring equipment, monitoring design, seismic, utilities, instrumentation

Location(s): Pennsylvania, Appalachian Coal Region, United States

Hardy, H. R., Jr., L. A. Beck. Microseismic Monitoring of a Longwall Coal Mine. Volume II--Determination of Seismic Velocity. U.S. Bureau of Mines OFR 30(2)-80, by Pennsylvania State University, October 31, 1977, 232 p. (NTIS PB 80-163405)

This is volume 2 of a three-volume report dealing with the microseismic monitoring of a longwall coal mine. The report describes the evaluation of a number of different field techniques and the seismic velocity data obtained at a Pennsylvania mine site. Three different methods were employed to evaluate seismic velocities: surface refraction, downhole, and transmission. In all cases, the seismic sources were either located on surface (mechanical impact) or near-surface (explosive charges). It was found that a mechanical source could be conveniently utilized to determine shallow velocities and make bedrock-regolith interface depth determinations. For deeper velocity determinations, suitable explosive charge sources were required. In general, refraction data did not always plot in a linear manner, and some subjective interpretation was necessary. The downhole method was useful for incremental vertical velocity evaluation; however, the transmission method provided the most consistent average vertical velocity data.

Keyword(s): seismic, monitoring methods, longwall, coal mining, active mines, geophysical, overburden

Location(s): Pennsylvania, Appalachian Coal Region, United States

Hardy, H. R., Jr., B. A. Anani, A. W. Khair. Microseismic Monitoring of a Longwall Coal Mine. Volume III--Field Study of Mine Subsidence, Grant G0144013, Pennsylvania State University, U.S. Bureau of Mines OFR 30(3)-80, October 31, 1977, 141 p. (NTIS PB 80-163413. Also available in set of 3 reports: PC E15, NTIS PB 80-163389.)

This is volume 3 of a three-volume report dealing in general with the microseismic monitoring of a longwall coal mine. The research presented was undertaken as part of the overall microseismic project in an effort to relate, if possible, observed microseismic activity with surface subsidence. Field measurements of subsidence carried out at a central Pennsylvania coal mine are described. Comparative analysis of actual field results with data obtained using empirical and finite element techniques was undertaken. Comparison of field results with published NCB data revealed marked differences. The influence of stronger rock beds overlying the coal seam in the current study was assumed to be the main cause. Use of the general Gaussian profile resulted in a satisfactory fit to the field data, provided the value of the maximum field subsidence was used in the analysis. In general, when low tensile strengths were assumed for the associated rocks, finite element techniques gave results that compared well with the field data. The study also indicates that, at shallow depths, there is a marked difference in subsidence over dip and rise sides of the coal face, maximum subsidence shifts more towards the dip side. Finally, time-dependent formations were insignificant shortly after mining operations ceased.

Keyword(s): seismic, longwall, monitoring methods, coal mining, survey methods, finite element, empirical model, National Coal Board, overburden, active mines

Location(s): Pennsylvania, Appalachian Coal Region, United States

Hardy, H. R., Jr., G. L. Mowrey, E. J. Kimble, Jr. Microseismic Monitoring of a Longwall Coal Mine. Volume 1--Microseismic Field Studies, Pennsylvania State University, U.S. Bureau of Mines OFR 30(1)-80, August 31, 1978, 320 p. (NTIS PB 80-163397)

This is volume 1 of a three-volume report on the microseismic monitoring of longwall coal mines. Volume 1 deals mostly with the detailed aspects of the microseismic field study; however, brief references are made to other secondary studies described in volumes 2 and 3. During the field study, a mobile microseismic monitoring facility and associated transducers were employed to detect and record microseismic activity above a longwall panel in Pennsylvania. The fundamental objectives of the study were (1) to evaluate the feasibility of detecting microseismic activity originating from longwall mining operations using an approximately planar, near-surface, geophone array installed above the longwall and (2) to attempt to locate the sources of various microseismic events. The investigation proved that, using the techniques developed, it is possible to detect microseismic events at depths of more than 400 feet and at horizontal distances in excess of 800 feet from the source. The majority of the events had frequencies on the order of 10 to 100 Hz, and particle velocities of 50 to 300 microips. When a suitable velocity model was used, most of the events located were computed to be within 100 feet vertically of the coal seam and 50 feet horizontally of the longwall face.

Keyword(s): seismic, longwall, coal mining, monitoring methods, geophysical, overburden, active mines

Location(s): Pennsylvania, Appalachian Coal Region, United States

Hardy, W. Removing Pillars in Coal Mines. Mining World, v. 26, March 9, 1907, p. 334-335.

This paper discusses backfilling, removing pillars under surface water, and management of water in mines.

Keyword(s): surface water, pillar extraction, backfilling, mine operation, coal mining

Location(s): United States

Hares, S., J. Silar. Application of Isotope Techniques and Well Logging in Investigating Ground Water Influenced by Mining. IN: Proceedings 1st World Congress of Water in Mining and Underground Work--SIAMOS, September 18-22, 1978, Granada, Spain, R. Fernandez-Rubio, ed., p. 199-206.

Keyword(s): hydrology, subsurface water

Location(s): Czechoslovakia

Hargraves, A. J., ed. Subsidence in Mines. Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, Illawarra Branch, Australasian Institute of Mining & Metallurgy, 110 p.

Topics cover prediction methods, monitoring techniques, mine design, hydrological effects, and structural problems as related to mine subsidence.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, surface water, subsurface water, mine design, monitoring design, monitoring installation, survey methods, survey equipment, survey data processing, prediction theories, monitoring methods

Location(s): Australia, England, United States

Harlow, E. H., P. Weaver. Land Subsidence Problems--Discussion. IN: Proceedings, ASCE Journal Surveying and Mapping Division, v. 89, no. SU3, 1963, p. 217-223.

Keyword(s): fluid extraction

Location(s): United States

Harper, D. Mine Subsidence in Indiana. Department of Natural Resources, Geological Survey Special Report 27, Bloomington, IN, 1982, 17 p.

This publication reviews past and present mining practice and subsidence problems in southwestern Indiana.

Keyword(s): coal mining, abandoned mines, active mines, room-and-pillar, historical

Location(s): Indiana, Illinois Coal Basin, United States

Harris, A. G. Stabilization and Filling of Abandoned Deep Coal Mines in the Mahoning Valley of Ohio. IN: Proceedings 88th Annual Meeting Ohio Academy of Science, Tiffion, April 20-22, 1979 (abstract only), Ohio Journal Science, v. 79, p. 26. (NTIS Accession No. 79-26227)

Keyword(s): abandoned mines, coal mining, backfilling, engineering, reclamation, environment

Location(s): Ohio, United States

Harris, F. K. C. Town and Country Plannings. Colliery Guardian, v. 178, January 27, 1949, p. 139-143; v. 178, February 10, 1949, p. 178-180.

Keyword(s): land-use planning, coal mining

Location(s): England

Harrison, V., G. D. Fyles. Observations on a Three Dimensional Approach to Mining Subsidence. IN: Proceedings 23rd Annual Conference Engineering Group of the Geological Society, Engineering

Geology of Underground Movements, University of Nottingham, September 13-17, 1987, p. 273-285.

The National Coal Board Subsidence Engineers Handbook, first published in 1965, enables rapid subsidence prediction at a given site. Its widespread acceptance has led to ground movement being described by vertical lowering and lateral strain. Subsidence is not, however, merely a two-dimensional phenomenon. The implications of ground movement in three dimensions are examined using the subsidence model of Burton (1984).

Keyword(s): prediction, prediction theories, National Coal Board, vertical displacement, horizontal displacement, modeling, coal mining

Hart, P. A. Investigations into the Role of Groundwater in Promoting Floor Heave in Coal Mine Gateroads. IN: Groundwater in Engineering Geology, Proceedings 21st Annual Conference of the Engineering Group of the Geological Society, September 15-19, 1985, J.C. Cripps, et al., eds., University of Sheffield, The Geological Society Engineering Geology Special Publication No. 3, 1986, London, p. 115-126.

The geological environment of two South Wales collieries at which site investigations were carried out is summarized. This is followed by a review of identified geological parameters and their effects on floor heave under the headings of discontinuities, mineralogy, and groundwater. Methods of underground site investigation, laboratory testing, and data treatment are summarized. The effect of an increase of groundwater content on mechanical parameter values was quantified for laboratory tested rock cores and in situ interbedded strata sections. The extent to which groundwater affects floor heave was found to be controlled by the mineralogical and structural nature of the floor strata.

Keyword(s): coal mining, floor stability, lab testing, geologic features, subsurface water, hydrology, in situ testing, rock mechanics, overburden

Location(s): Wales, United Kingdom

Hart, P. A. Application of Lithic and Structural Geological Data to the Assessment of Ground Stability Above Shallow Abandoned Coal Mines. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 137-149.

Borehole log data gathered during a subsidence investigation in 1978-1979 were used to derive a classification scheme for coal measure rocks. The results of height of void migration above workings were compared to those arising from use of Piggot & Enyon's (1977) geometrical collapse zone method and Bieniawski's (1980) Rock Mass Rating scheme. It was concluded that the analysis helps to assess areas of greatest instability, which thus aids land-use planning and also the planning of ground investigations, ground stabilization, and re-development.

Keyword(s): coal mining, geologic features, abandoned mines, land-use planning, surface structural damage, room-and-pillar

Location(s): Wales, United Kingdom

Hart, S. S. History and Evolution of Mining and Mining Methods. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed, Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 25-37.

The underground coal mines that are currently of concern to subsidence professionals in Colorado were generally mined between 1860 and 1960. Careful study of dates of mining, production records, mine maps, and interviews with former miners can aid in predicting current mine conditions.

Keyword(s): historical, abandoned mines, room-and-pillar, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, United States

Hartman, H. L., ed. Proceedings of the Fourth Symposium on Rock Mechanics, March 30, 31, and April 1, 1961. Bulletin 76 of the Mineral Industries Experiment Station, November, 1961, Pennsylvania State University, University Park.

Keyword(s): rock mechanics, modeling, pillar strength, ground control

Hartmann, I., H. P. Greenwald. Effect of Changes in Moisture and Temperature on Mine Roof, First Report on Strata Overlying the Pittsburgh Coal Bed. U.S. Bureau of Mines RI 3588, October, 1941, 40 p.

The objectives of the work described in this report were to determine the relative importance of humidity and temperature changes on the expansion and contraction of mine-roof rock samples; to determine the stresses that might result from such expansions and contractions and to correlate this information with the physical properties of the rocks; to determine the expansion and disintegration of rocks immersed in water; and to study the effectiveness of paints and cement coatings in reducing absorption of moisture.

Keyword(s): coal mining, roof stability, mine safety, lab testing, mine operation

Location(s): Appalachian Coal Region, United States

Harza Engineering Co. Comprehensive Ground Control Study of a Mechanized Longwall Operation. Final Report-Volume 1, Contract H0230012, U.S. Bureau of Mines OFR 5(1)-77, 1976, 151 p. (NTIS PB 262 475)

Keyword(s): longwall, ground control, coal mining

Location(s): United States

Harza Engineering Co. Comprehensive Ground Control Study of a Mechanized Longwall Operation. Final Report-Volume II, Contract H0230012, U.S. Bureau of Mines OFR 5(2)-77, 1976, 270 p. (NTIS PB 262 476)

Keyword(s): longwall, coal mining, ground control

Location(s): United States

Hasenfus, G. J., K. L. Johnson, D.W.H. Su. A Hydrogeomechanical Study of Overburden Aquifer Response to Longwall Mining. IN: Proceedings 7th International Conference on Ground Control in Mining, Morgantown, WV, August 3-5, 1988, S.S. Peng, ed., West Virginia University, p. 149-162.

This paper presents the results of an extensive hydrological and geomechanical monitoring program that was conducted at a longwall coal mine in West Virginia. The field program included monitoring of groundwater levels, overburden hydraulic conductivity, overburden movement, and surface subsidence relative to the passage of the longwall. Overburden geology and rock strength characteristics were evaluated prior to mining. A postmining corehole was drilled to evaluate main roof fracturing. An overburden response model is proposed based on the correlations between hydrological and geomechanical data.

Keyword(s): overburden, hydrology, subsurface water, geologic features, rock mechanics, roof stability, modeling, longwall, coal mining, surface subsidence damage, instrumentation, survey methods, vertical displacement, survey equipment, monitoring methods, monitoring equipment, monitoring installation, monitoring design, seismic, geophysical, finite element

Location(s): West Virginia, Appalachian Coal Region, United States

Hatheway, A. W. Engineering Geology of Subsidence at San Manuel Mine. Mining Engineering, 1964, v. 16, p. 92.

Keyword(s): metal mining, engineering

Location(s): Arizona, United States

Hatheway, A. W. Engineering Geology of Subsidence at San Manuel Mine, Pinal County, Arizona. M.S. Thesis, 1966, University of Arizona, Tucson, 110 p.

Keyword(s): metal mining, engineering, geologic features

Location(s): Arizona, United States

Hatheway, A. W. Subsidence at San Manuel Copper Mine, Arizona. IN: Southern Arizona Guidebook 3, Geological Society of America, Cordilleran Section, 64th Annual Meeting, 1968, Arizona Geological Society,Tucson, p. 113-124.

Keyword(s): metal mining

Location(s): Arizona, United States

Hatheway, A. W. Subsidence at San Manuel Copper Mine, Pinal County, Arizona. IN: Engineering Geology Case Histories, G.A. Kiersch, ed., Geological Society of America, 1968, no. 6, p. 65-81.

Keyword(s): metal mining

Location(s): Arizona, United States

Hatheway, A. W. Subsidence at San Manuel Copper Mine, Arizona. Geological Society of America Special Paper 121, 1969, p. 511.

Keyword(s): metal mining

Location(s): Arizona, United States

Hatton, T., J. E. Turney. Annotated Bibliography of Subsidence Studies Over Abandoned Coal Mines in Colorado. Colorado Geological Survey Information Series 22, Department of Natural Resources, Denver, CO, June, 1989, 123 p.

This bibliography is a compilation of data on coal mine subsidence studies along the Front Range of Colorado. The information contained within can be used to facilitate further study of undermined areas subject to increased development pressure from Colorado's growing population. Specific mine investigation studies were obtained from private consultants and public sources. Many of these reports are available for review in the offices of the Colorado Geological Survey and the Division of Mined Land Reclamation.

Keyword(s): coal mining, abandoned mines, literature search, historical, land-use planning, land mitigation, reclamation, surface structural damage

Location(s): Colorado, Rocky Mountain Coal Region, United States

Hawkins, A. B., D. Tomlinson. Planning and Construction of an Industrial Site on the Bristol Coalfield. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference of the Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 439-446.

This paper examines the progress of a large industrial/retail development on the Bristol Coalfield, from the planning stage through the site investigation to the construction phase. The planning history of the site, the local geology, and the history of mining in the area are reviewed. In localized areas, the ground had subsided by as much as 1.5 m.

Keyword(s): land-use planning, construction, abandoned mines, coal mining

Location(s): United Kingdom

Hawkins, A. B., S. Morley, T. S. Swainson, D. M. Tyson. Don Valley Stadium, Sheffield, UK. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 283-301.

This paper discusses the design and construction of a new sports stadium in an area where abandoned mines were present. The investigations for and treatment of the old mine workings form the main emphasis of the paper. The ground problems were exacerbated by the presence of the Kirkbridge Dike across part of the site and the lack of adequate records of past mining, particularly in a near-surface high quality seam. Excavation of soft ground identified during one of the rigorous formation inspections located a series of tunnels leading from an adit that had not been apparent at the time of grouting.

Keyword(s): abandoned mines, coal mining, land-use planning, structural mitigation, backfilling, grouting, engineering, construction, architecture, foundations, land values

Location(s): United Kingdom

Hay, W. Damage to Surface Buildings Caused by Underground Workings. Transactions, Institute of Mining Engineers, London, v. 36, 1908, p. 427-436; v. 37, 1909, p. 354-355, 647-648.

Keyword(s): surface structural damage

Haycocks, C., J. M. Townsend, G. M. Neall, L. P. Johnson. Design Optimization in Underground Coal Systems: Section 1. Structural Parameters of Coal Measure Rocks. Section 2. Longwall Mining System Strata Simulator. Section 3. Design Criteria for Underground Roof-Truss Support Systems. Interim Report, April-June 1977. Virginia Polytechnic Institute and State University, Blacksburg, DOE Contract/Grant EX-76-C-01-1231 report, December, 1977, 52 p. (NTIS FE-1231-9)

Research in areas related to coal mining is described. Computer programs related to longwall mining were developed and tested. Sampling and testing of coal specimens was performed, especially with respect to the effects of size and shape (cylinder versus cube) of the specimens on the measured properties. Loading rate was found to be of significance. The literature of supports in underground mining was reviewed, especially with respect to roof bolts and roof trusses.

Keyword(s): coal mining, active mines, rock mechanics, longwall, computer, modeling, roof bolting, roof support, room-and-pillar, in situ testing

Location(s): Alabama, United States

Haycocks, C., C. D. Breeds. Design Optimization in Underground Coal Systems. Interim Report, January--March, 1978. Report on U.S. DOE Contract/Grant EX-76-C-01-1231, Virginia Polytechnic Institute and State University, Blacksburg, June, 1978, 58 p. (NTIS FE-1231-12)

Research in the planning and simulation of longwall mining is reported. The mechanical properties of coal were studied with respect to the size and shape of the specimen and the loading rate. Finally, the potential of roof trusses as roof supports was studied with respect to design and properties by the use of photoelastic models, computer calculation, and field experience with trusses instrumented with strain gages.

Keyword(s): coal mining, active mines, longwall, modeling, rock mechanics, roof support, computer, instrumentation, monitoring equipment, in situ testing

Location(s): United States

Haycocks, C., C. D. Breeds. Design Optimization in Underground Coal Systems. Interim Report, October--December 1977. Virginia Polytechnic Institute and State University, Blacksburg, DOE Contract/Grant EX-76-C-01-1231 report, March, 1978, 54 p. (NTIS FE-1231-11)

Results of measurements of the mechanical properties of coal samples are summarized. Some dependence of measured strength on the loading rate was found. Information and computer programs were developed for longwall mining simulation and economic analysis. Roof truss type supports were studied further by theory, photoelastic models, and experimental and field data.

Keyword(s): coal mining, active mines, longwall, computer, roof support, modeling, rock mechanics, economics

Location(s): United States

Haycocks, C. Design Optimization in Underground Coal Systems. Sections 1--4. Interim Report, January--March 1979. Virginia Polytechnic Institute and State University, Blacksburg, DOE Contract/Grant EX-76-C-01-1231 report, June 1979, 66 p. (NTIS FE-1231-16)

This report describes work on a longwall simulator with a detailed examination of the potential for utilizing a roof characterization factor in the estimation of roof stability. The benefits of this approach are a much more realistic evaluation of roof conditions and, therefore, a more accurate prediction of strata responses during underground mining. The report includes the theory, modeling method, experimental and field data, and data analysis and correlation; it also includes development and maintenance of computer programs used in the work.

Keyword(s): longwall, active mines, coal mining, mathematical model, modeling, computer, roof stability, rock mechanics

Location(s): United States

Haycocks, C., M. Karmis, E. Topuz. Optimizing Productive Potential in Multi-Seam Underground Coal Mining. IN: Coal Conference & Expo VI, McGraw-Hill, 1981.

Keyword(s): multiple-seam extraction, coal mining

Haycocks, C., M. Karmis, B. Ehgartner. Multiple Seam Mine Design. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, Y.P. Chugh and M. Karmis, eds., 1982,, SME-AIME, p. 59-65.

Considerable valuable experience in multi-seam mining comes from British mining operations where interaction problems are common and the longwall is the primary method used. Limitations persist in the application of much of this information to conditions in the United States because of variation in layouts between advancing and retreating longwall systems and the inherent differences in the geologic environment. Field data are available for room-and-pillar operations in the United States and, where successful pillaring operations have been carried out, close parallels may be drawn with ground control mechanisms in longwall operations.

Keyword(s): multiple-seam extraction, longwall, ground control, mine design

Location(s): United States, United Kingdom

Haycocks, C., M. Karmis, E. Barko, J. Chaman, S. Hudock, B. Ehgartner, S. Webster. Ground Control Mechanics in Multiple-Seam Mining. U.S. Bureau of Mines OFR 7-84, 1984.

Keyword(s): ground control, multiple-seam extraction

Location(s): United States

Haycocks, C., W. Wu, Y. Zhou. Integrated Design for Stability in Multiple-Seam Mining. IN: Eastern Coal Mine Geomechanics, Proceedings, Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, November 19, 1986, U.S. Bureau of Mines IC 9137, p. 44-56.

Research into ground control problems resulting from mining in a multiple-seam environment has been carried out using statistical analysis, numerical modeling, and body-loaded multilayer photoelastic analysis in conjunction with numerous case studies. Findings demonstrate situations under which the worst ground control conditions can be expected to occur for a specified geologic environment, depth, innerburden spacing, and mining geometry. Special emphasis has been placed on the effect of upper pillar load transfer on the lower seam in terms of pillar and floor stability and roof control.

Keyword(s): geologic features, ground control, multiple-seam extraction, modeling, mine design, computer, finite element, prediction

Location(s): Appalachian Coal Region, United States

Haycocks, C., Y. Zhou. Multiple-Seam Mining--A State-of-the-Art Review. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 1-11.

The relevant literature concerning ground control, mine planning, and reserve conservation in multi-seam mining is reviewed. Factors affecting interaction, interaction mechanisms, and design guidelines are presented in detail. The impact of multi-seam mining on future mining, measures for ameliorating negative interaction effects, and future research needs are also discussed.

Keyword(s): multiple-seam extraction, ground control, longwall, room-and-pillar, coal mining, time factor, pillar strength, overburden, geologic features

Haycocks, C., M. Karmis. Subsidence Effects in Multiple Seam Mining. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 94-99.

Subsidence induced innerburden shearing and stress fields, whether active or passive, frequently contribute to significant ground control failures in overlying seams. In this paper, proven multi-seam technology is used on upper seams to forecast and quantify the magnitude and severity of damage and the increased mining risk due to interaction. Increased upper seam ground control problems are demonstrated using hazard mapping, which provides a viable technique for utilizing damage predictions in design.

Keyword(s): multiple-seam extraction, overburden, prediction, ground control, active mines, abandoned mines, mine design, geologic features

Location(s): United States

Hayes, G. R., Jr. Stresses Imposed on a Pipeline by Longwall Mining. IN: American Gas Association, Operating Section Proceedings, No. 80-T-65, 1980, p. T-309--T323.

This paper discusses the results of a testing program being conducted by Columbia Gas Transmission Corporation to determine the effects and behavior of its LINE 20 pipeline while under the influence of ground subsidence caused by longwall mining. LINE 20 is a continuously welded 12-3/4" O.D. x 0.250" wall steel pipeline, with a Specified Minimum Yield Strength of 42,000 PSI. Maximum Allowable Operating Pressure is 617 PSIG. The total longwall mining operation consists of seven panels, four of which are directly beneath the pipeline. Each panel to be longwall mined is approximately 650 feet wide and approximately 5,000 feet long. The coal seam varies in thickness from 64 to 68 inches, with a horizontal slope of essentially 0 degrees. The depth of the coal varies from 800 to 1,000 feet from the surface.

Keyword(s): coal mining, pipelines, longwall, utilities, monitoring methods, monitoring equipment, vertical displacement, horizontal displacement, survey data processing

Location(s): United States

Hazen, G. A. Practical Pillar Design Problem Encountered Under Deep Cover and with Different Block Geometric Pillar. U.S. Bureau of Mines OFR 75-77, Grant No. GO144139, 1975. (NTIS PB-266705)

Keyword(s): pillar strength

Location(s): United States

Hazen, G. A., S. M. Sargand. The Effect of Longwall Mining on Surface Subsidence of Highways and Bridges. Final report to Ohio Department of Transportation by Ohio University, Athens, College of Engineering and Technology, Civil Engineering, November, 1985, 142 p.

For this study subsidence profiles over three longwall panels mined beneath state highways in southeastern Ohio were measured. The average maximum subsidence was 3.5 feet. The average maximum compressive strain recorded was 0.008 in./in. Three predictive methods for the determination of displacements and strains were compared: the National Coal Board graphical method, the profile method with empirical constants determined for southeastern Ohio, and a finite element program. Excellent subsidence agreement was found with the profile method, and reasonable strain agreement was determined with the finite element model.

Keyword(s): rock mechanics, longwall, coal mining, roads, surface structural damage, prediction, prediction theories, National Coal Board, profile function, finite element

Location(s): Ohio, United States

Hazen, G. A., S. M. Sargand. The Effect of Longwall Mining on Surface Subsidence of Highways and Bridges. SME-AIME Preprint 87-10, for presentation at the SME Annual Meeting, Denver, CO, February 24-27, 1987, 6 p.

Predictions of structural damage from high-extraction mining are dependent on the magnitude of the expected horizontal strains. Three methods for predicting subsidence characteristics are considered in this paper: the graphical method, the profile method, and the finite element method.

Keyword(s): roads, prediction theories, empirical model, finite element, profile function, geologic features, rock mechanics, computer, coal mining

Location(s): Ohio, United States

Hazen, G. A., S. M. Sargand. Methods for Assessing Effects of Longwall Mining on Surface Subsidence. Mining Engineering, June, 1988, p. 451-454.

This study monitored longwall mining subsidence profiles over three panels mined beneath state highways in southeastern Ohio. The average maximum subsidence was 1.07 m (3.5 feet). The average maximum compressive strain recorded was 0.008 mm/mm. Three predictive methods for the determination of displacements and strains were compared: the National Coal Board (NCB) graphical method, the profile method with empirical constants determined for southeastern Ohio, and a finite element excavation program. Excellent subsidence agreement was found with the profile method, and reasonable strain agreement was determined with the finite element program.

Keyword(s): longwall, finite element, National Coal Board, modeling, coal mining, prediction, surface structural damage, geologic features, overburden, lab testing, in situ testing, rock mechanics, geotechnical, elastic model, phenomenological model, profile function, empirical model, roads

Location(s): Ohio, United States

Hazine, H. I. A Study of the Surface Strains Produced by Mining Subsidence. Master's Thesis, University of Nottingham, U.K., 1977.

Keyword(s): surface subsidence damage, survey data processing, horizontal displacement

Location(s): United Kingdom

He, G., T. H. Wilson. Changes in the Seismic Properties of the Cover Produced by Longwall Mining. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 327-334.

Common offset seismic data collected over two active longwall panels at different stages of mining reveal that significant arrival time delays are produced in reflections from different levels within the mine cover. Mining-induced arrival time delays are also observed beyond the edges of the mine over unmined areas. Reflection arrival time delays increase with reflector depth and are laterally variable. The arrival time delays are produced by reductions of seismic velocity within the overburden. Reflection arrival time delays from a major strong unit located neutrally within the cover are proportional to subsidence; however, delays in other events are not.

Keyword(s): longwall, active mines, overburden, coal mining, seismic, modeling, geophysical

Location(s): United States, Appalachian Coal Region

He, G., T. H. Wilson. Longwall Mine Subsidence and its Effect on Seismic Properties of the Overburden. IN: Society Exploration Geophysics 59th International Meeting and Exposition, October 29-November 2, 1989, Dallas, Extended Abstracts, p. 368-371.

Common offset seismic data collected over an active longwall panel at different stages of mining reveal that significant arrival time delays occur for reflections from different intervals within the overburden. Subsidence correlates best with arrival time delays observed for a reflection from a thick sandstone located neutrally within the overburden. Mining-induced arrival time delays are also observed beyond the edges of the panel over unmined areas. These delays are produced by mining induced reductions of seismic velocity within the overburden.

Keyword(s): longwall, seismic, overburden, coal mining, geophysical, monitoring methods

Location(s): Appalachian Coal Region, United States

He-yuan, S. Mechanism of Land Subsidence and Deformation of Soil Layers in Shanghai. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association Hydrological Sciences Publication No. 151, 1986, p. 425-433.

This paper, based on an analytical study of data collected from in situ observations and laboratory experiments, endeavours to expound the mechanism of land subsidence and the rule of deformation of the soil layers in Shanghai. Particular mention is made of a close analysis of the unit deformation, which reveals that the values of deformation of the soil layers can be readily evaluated by normalizing the observed deformation of different soil strata according to the range of variation of the groundwater table and that the characteristics of the residual deformation of various soil strata can be observed in terms of the ratio between rebound and compression.

Keyword(s): soils, fluid extraction

Location(s): China

Healy, P. R., J. M. Head. Construction Over Abandoned Mine Workings. Construction Industry Research and Information Association Special Publication 32/Property Services Agency Civil Engineering Technical Guide 34, London, 1984, 94 p.

This is a guide for engineers planning the development of undermined sites. It describes British mining methods of the past and present, as well as giving techniques for consolidation of old mine workings and foundation design options.

Keyword(s): construction, foundations, abandoned mines, engineering, surface structural damage, geotechnical, longwall, room-and-pillar, National Coal Board, backfilling, grouting, historical

Location(s): England, Scotland, Wales

Heasley, K. A., L. W. Saperstein. Practical Subsidence Prediction for the Operating Coal Mine. IN: Proceedings 2nd Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 54-67.

The purpose of this paper is to present and demonstrate a subsidence-predictive method (SPASID) that can be functionally used by the practicing mining engineer. Such a method will hopefully give the coal operator and mining engineer additional flexibility necessary to protect the surface from subsidence damage.

Keyword(s): prediction, coal mining, mine design, prediction theories, empirical model, influence function

Location(s): Illinois Coal Basin, Appalachian Coal Region, United States

Heasley, K. A., L. W. Saperstein. Computer Modeling of the Surface Effects of Subsidence Control Methods. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 189-196.

This paper details the development and application of a system for modeling the effects of subsidence control methods on surface subsidence over longwall coal panels. The term "subsidence control methods" as used in this paper should be understood to cover coal pillars, packwalls or any backfills used to support the mine roof and to limit the effects of surface subsdience. The work began by choosing an appropriate subsidence predictive method on which to superimpose the effects of different control schemes.

Keyword(s): modeling, empirical model, prediction, computer, longwall, influence function, finite element, backfilling, ground control

Location(s): Pennsylvania, Appalachian Coal Region, United States

Heasley, K. A., L. W. Saperstein. An Investigation Into the Use of Backfill Zones and Yielding Pillars for Subsidence Control. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, September, 1986, M.M. Singh, ed., St. Louis, MO, SME, Littleton, CO, p. 19-27.

This paper investigates the use of backfill zones and yielding pillars for subsidence control. The investigation begins by choosing an appropriate subsidence predictive technique to simulate the proposed subsidence-control schemes. Two case studies are performed in order to delineate the accuracy and utility of the chosen predictive technique. The results of these case studies are then used to establish appropriate sets of regional site parameters. Next, a detailed analysis of the major variables affecting the outcome of the subsidence-control simulations is conducted and graphical displays of the exact sensitivity of the surface subsidence to these variables are given.

Keyword(s): backfilling, yielding supports, coal mining, computer, prediction, prediction theories

Location(s): Illinois, Illinois Coal Basin, Appalachian Coal Region, United States

Heasley, K. A., L. W. Saperstein. Recent Insight into Longwall Strata Movements Deduced from Subsidence Analysis. Mining Engineering, v. 39, no. 7, September 1987, p. 872-876; also SME Fall Meeting preprint 86-331, 1986.

A number of novel hypotheses are developed that provide a fresh perspective on the characterization of strata movements associated with longwall mining. Subsidence measurements are analyzed with an influence-function-based computer program. Using an inverse application of the traditional influence-function technique, easily obtained surface displacements are used to analyze some of the complicated, expensive, and difficult-to-measure movements of the intermediate roof strata in a longwall panel.

Keyword(s): coal mining, roof stability, longwall, influence function, empirical model, computer, vertical displacement
Location(s): Illinois Coal Basin, Appalachian Coal Region, United States

Heasley, K. A., K. Barron. A Case Study of Gate Pillar Response to Longwall Mining in Bump-Prone Strata. IN: Proceedings Longwall USA Conference, 1988, Pittsburgh, PA, p. 91-105.
Keyword(s): pillar strength, bumps, longwall

Heathcote, F. W. L. Movement of Articulated Buildings on Subsidence Sites. IN: Proceedings Institute of Civil Engineers, v. 30, February, 1965, p. 347-368.
Keyword(s): surface structural damage, architecture, structural mitigation

Hedley, D.G.F. An Evaluation of Roof Stability at a Canadian Salt Mine. IN: Fifth International Strata Control Conference, London, no. 30, 1972, 6 p.
Keyword(s): roof stability, non-metal mining, ground control
Location(s): Canada

Hellewell, E. G. The Influence of Faulting on Ground Movement Due to Coal Mining: The UK and European Experience. The Mining Engineer, January, 1988, v. 316, p. 334-337.
Keyword(s): geologic features, coal mining
Location(s): United Kingdom, Europe

Helm, D. C. Field-Based Computational Techniques for Predicting Subsidence Due to Fluid Withdrawal. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, The Geological Society of America, 1984, T.L. Holzer, ed., p. 1-22.
Choice of a predictive technique for land subsidence is based on the availability of appropriate field data. If only the depth and thickness of compressible beds can be estimated, a simple hand calculation is available as a predictive technique and for many purposes is adequate.
Keyword(s): fluid extraction, prediction, modeling
Location(s): California, Texas, United States, New Zealand

Helmhacker, R. Land Subsidence at Brux, Bohemia. Transactions Institute of Mining Engineers, London, v. 10, 1895-96, p. 583.
Keyword(s): surface subsidence damage
Location(s): Europe

Henry, F. D. C. Structures Liable to the Effects of Mining Subsidence. IN: The Design and Construction of Engineering Foundations, McGraw-Hill, 1956, Chapter 9, p. 392-412.
The chapter discusses the mechanics of mine subsidence, effects of subsidence on structures, as well as subsidence due to mining of material other than coal, and construction considerations to offset the effects of subsidence.
Keyword(s): surface structural damage, engineering, foundations, coal mining, metal mining, non-metal mining, vertical displacement, horizontal displacement

Henry, J. J. The Geological Input Into Land-Use Planning in Lothian Region, Scotland. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 583-587.
The paper describes the geological input into the land-use planning system at both strategic and local levels in relation to the stability of land and minerals required by the extractive industries.
Keyword(s): land-use planning, geologic features, coal mining, abandoned mines, government, law
Location(s): Scotland, United Kingdom

Henshaw, H., D. W. Phillips. Underground and Surface Strata Movements. Transactions Institute Mining Surveyors, 1942, v. 22, no. 2.
Keyword(s): surface subsidence damage, subsurface subsidence damage, overburden

Herbert, C. A., J. J. Rutledge. Subsidence Due to Coal Mining in Illinois. U.S. Bureau of Mines Bulletin 238, 1927, 59 p.
In 1916, the USBM, Illinois Geological Survey, and University of Illinois, working under a cooperative agreement, began an investigation of the subsidence of the surface above coal-mining operations. Four widely separated places where mining was in progress were selected as observations stations: one in the northern Illinois longwall coal field, one in the central Illinois coal field where the room-and-pillar panel system of mining was being used, and two in the thick coal of southern Illinois where the room-and-pillar panel system of mining was employed. These four points of mining activity gave a rather wide opportunity for observing subsidence when different mining methods were used.

Keyword(s): horizontal displacement, ground control, descriptive theories, backfilling, room-and-pillar, coal mining, historical, subsidence research, surface structural damage, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Herd, W. The Suggested Application of Hydraulic Stowing to Undersea Coal Workings, with Special Reference to the Sydney Coalfield. Canadian Institute of Mining and Metallurgy, Bulletin No. 103, November, 1920, p. 835-845.

Although at the time (1920) the hydraulic stowing of mines to minimize subsidence was used successfully in Europe, South Africa, and Australia, the English-speaking countries were slow to adopt this method.

Keyword(s): hydraulic backfilling, stowing, angle of draw, historical, surface water, coal mining

Location(s): Poland, Europe, Australia, United States

Herring, J. R., S. B. Roberts, R. G. Hobbs. Characterization of Extent of Mining, Mine Fire, and Subsidence: A Case Study at Marshall, Colorado. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 39-80.

Several of the abandoned underground coal mines located near Marshall, Colorado (in the Boulder-Weld Coalfield), were studied to characterize the possibility of subsidence and the hazard posed by those mines, including the few that are on fire.

Keyword(s): abandoned mines, mine fires, surface structural damage, utilities, pipelines, surface water, historical, remote sensing, photography, survey design, survey methods, monitoring design, monitoring methods, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, United States

Herring, J. R. Geologic Road Log from Denver Federal Center to Marshall, Colorado. A Visit to the Boulder-Weld Coal Field and Some Considerations of Burning, Subsiding Coal Mines. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, (appendix) p. 299-315.

The author describes a field trip in the Denver area, focusing primarily on the hazards and problems of land use associated with abandoned underground coal mines and their potential for subsidence and spontaneous combustion.

Keyword(s): abandoned mines, land-use planning, mine fires, surface subsidence damage, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, United States

Herron, T. J. The Detection and Delineation of Subsurface Subsidence by Seismic Methods. Thesis, Geophysics Department, Michigan College of Mines and Technology, 1956.

Keyword(s): seismic, subsurface subsidence damage, geophysical

Location(s): United States

Herwig, H. The Effect of Rock Pressure on Roof Conditions in the Face. Glueckauf, v. 117, no. 21, 1981, p. 1419-1423.

Keyword(s): roof support, roof stability

Hesse, A. W. What Shall We Use for Roof Support in Coal Mines? Coal Age, v. 5, February 28, 1914, p. 354.

This article compares the advantages and disadvantages of oak, pine, chestnut, T-rails, and I-beams.

Keyword(s): roof support, coal mining, historical

Hesse, A. W. The Facts About Draw. Coal Age, v. 63, September, 1958, p. 98-100.

Keyword(s): angle of draw, coal mining

Hetzler, R. T., R. G. Darmody, F. W. Simmons, S. D. Harding. Coal Mine Mitigation: Effectiveness for Agricultural Restoration. IN: Agronomy Abstracts, American Society of Agronomy 81st Annual Meeting, October 15-20, 1989, Las Vegas, NV, p. 37.

A study was initiated in 1988 to evaluate the effectiveness of current methods for mitigation of coal mine subsidence damage for restoring agricultural productivity. Soil and crop samples from 13 mitigated areas were compared to nearby reference areas. Soil texture, bulk density, moisture, and fertility were analyzed. There were no detectable differences in yields between reference and mitigated sites in 1988 despite differences in soil parameters. The unusually dry weather in 1988 may have influenced the results. The research is being continued to eliminate weather as a variable.

Keyword(s): mitigation, coal mining, agriculture, land mitigation, soils, active mines
Location(s): Illinois, Illinois Coal Basin, United States

Hetzler, R. T., R. G. Darmody, F. W. Simmons. Evaluation of Soil Physical Parameters from Mitigated and Undisturbed Cropland. IN: Agronomy Abstracts, American Society of Agronomy/Soil Society of America 82nd Annual Meeting, San Antonio, TX, October 21-26, 1990, p. 39.
Underground coal mining in southern Illinois causes surface land subsidence that can affect crops by disrupting water drainage. Affected areas have been mitigated by cutting drainage ditches, adding fill material, or both. Soil physical properties from mitigated farmland and nearby undisturbed areas were studied.
Keyword(s): agriculture, soils, land mitigation, coal mining, longwall, active mines, hydrology
Location(s): Illinois, Illinois Coal Basin, United States

Hetzler, R. T., R. G. Darmody. Coal Mine Subsidence Mitigation: Effects on Soil and Crop Yields. IN: Proceedings National Symposium on Prime Farmland Reclamation, 1992, R.E. Dunker, R.I. Barnhisel and R.G. Darmody, eds., Department of Agronomy, University of Illinois, Urbana, p. 129-135.
The objective of this study was to test the effectiveness of mitigation in restoring grain yields to their pre-mined levels. Seventeen sites in Jefferson and Franklin Counties in Illinois were selected for the 4-year study. The sites represented conventional mitigation techiques on the predominate soils in the area.
Keyword(s): land mitigation, agriculture, active mines, coal mining, soils
Location(s): Illinois, Illinois Coal Basin, United States

Hetzler, R. T. Coal Mine Subsidence Mitigation: Effectiveness for Agricultural Restoration. M.S. Thesis, University of Illinois, Department of Agronomy, January, 1992, 115 p.
The objective of this study was to assess the effects of mitigation on agricultural soils. Bulk density, soil strength, soil texture, hydraulic conductivity, and soil moisture were measured in an attempt to identify factors which may be limiting crop yields at mitigated sites. Fill material at most mitigation sites had SiL to SiCL textures, massive structure, and traffic-induced compaction interfaces. Additional reclamation work such as installing tiles to provide adequate drainage in fill, or deep tillage to alleviate compaction, may improve current mitigation methods.
Keyword(s): land mitigation, agriculture, active mines, longwall, coal mining, mitigation, soils
Location(s): Illinois, Illinois Coal Basin, United States

Heuze, F. E., R. E. Goodman. Room and Pillar Structures in Competent Rock. IN: Underground Rock Chambers, ASCE Symposium on Water Resources Engineering, Phoenix, AZ, January 13-14, 1971, p. 531-565.
This paper discusses construction of room-and-pillar mine layouts and rock mechanics parameters required for construction.
Keyword(s): room-and-pillar, mine design, rock mechanics
Location(s): United States

Heuze, F. E. Geotechnical Studies for Room and Pillar Mine Design. IN: Proceedings Mini Symposium on Application of Geotechnical Data to Underground Mine Design, SME-AIME Fall Meeting, Mini Symposium Series No. 78-1, 1978, p. 1-15.
Keyword(s): room-and-pillar, mine design, geotechnical
Location(s): United States

Hibberd, P. Transference of Ground Movement to Surface Structures. Transactions Institute Mining Engineers, October, 1961.
This paper is a record of research from three sites in Scotland, where various types of structures were damaged by subsidence, including a church, traditional houses, and brick walls. Theoretical aspects of the transmission of ground movements to structures are considered, including field data. The influence of soil type, type of foundation, and depth to workings are noted.
Keyword(s): surface structural damage, soils, foundations
Location(s): Scotland

Hickmann, T. J., J. R. Nawrot. Potentially Hazardous Abandoned Mine Entries, Summary Report: Phase I, Previously Recorded Problem Sites. Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, 1979.
This report summarizes the Wildlife Laboratory's inventory, investigation, and evaluation of approximately 75 potentially hazardous mine entries.

Keyword(s): abandoned mines, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Higginbottom, I. E. Methods of Development in Areas of Ancient Shallow Coal Mining. IN: Mineworkings 84, Proceedings International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1984, M.C. Forde, B.H.V. Topping, and H.W. Whittington, eds., Engineering Technics Press, p. 273-286.
Keyword(s): coal mining, abandoned mines, land-use planning

Hilbig, R. Lehmann's Trough Theory. Colliery Engineering, v. 34, no. 404, October, 1957, p. 413-416.
This article is a discussion of the general validity of this theory.
Keyword(s): prediction theories, room-and-pillar, coal mining
Location(s): Europe

Hilbig, R. On the General Validity of Lehmann's Trough Theory. IN: Proceedings European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 199-201.
Keyword(s): prediction theories, room-and-pillar, coal mining

Hill, J. G., D. R. Price. The Impact of Deep Mining on an Overlying Aquifer in Western Pennsylvania. Ground Water Monitoring Review, v. 3, no. 1, 1983, p. 138-143.
This study is a site-specific hydrogeologic analysis conducted before, during, and after mining at a site located over a selected longwall mining panel. Data from subsidence and groundwater monitoring networks placed over the study panel were collected, compiled, and analyzed to provide documentation of the mechanics of groundwater fluctuations caused by mining. The study deals specifically with water-level fluctuations in aquifers used for domestic water supplies.
Keyword(s): subsurface water, hydrology, coal mining, longwall, overburden, inflow
Location(s): Pennsylvania, Appalachian Coal Region, United States

Hill, J. L. III. The Influence of Stream Valleys on Coal Mine Ground Control. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 247-258.
Over 50 mines of the Appalachian and Illinois Basins are presently experiencing poor ground conditions believed to be caused by overlying stream valleys. The USBM is conducting research into the causes of this problem with the aim of developing a predictive method for determining the safe limits of mining beneath stream valleys. In addition, the factors that control instability in these regions will be analyzed to provide design guidelines for adjusting support requirements.
Keyword(s): coal mining, ground control, geologic features, mine design
Location(s): Appalachian Coal Region, West Virginia, Illinois Coal Basin, United States

Hill, J. R. M., M. McDonald, L. M. McNay. Support Performance of Hydraulic Backfill: A Preliminary Analysis. U.S. Bureau of Mines RI 7850, 1974, 12 p. (NTIS PB 231 985)
Keyword(s): hydraulic backfilling
Location(s): United States

Hill, L. R., M. Burr. Hydraulic Filling of a Coal Seam at Lens, Pas-de-Calais, France. Engineering and Mining Journal, v. 82, 1906, p. 543.
This article describes hydraulic flushing in which fill material is transported dry to the working level, where it is mixed and gravity fed to the stowing area.
Keyword(s): hydraulic backfilling, stowing, coal mining
Location(s): France

Hill, R. D., E. R. Bates. Acid Mine Drainage and Subsidence. Final Report U.S. Environmental Protection Agency Contract EPA/600/12, Industrial Environmental Research, April, 1978, 38 p. (NTIS PB 281 092)
Keyword(s): environment, mine waste, surface water
Location(s): United States

Hindman, C. A., C. G. Treworgy. Use of a Geographic Information System to Evaluate the Potential for Damage from Subsidence of Underground Mines in Illinois. IN: Proceedings 9th International Symposium on Computer-Assisted Cartography, April 2-7, 1989, Baltimore, MD, p. 483-492.
This paper describes the use of geographic system information (GIS) technology to evaluate the risk of damage to structures from mine subsidence in Illinois. Maps and tables created with the GIS are used to show the coincidence of underground

mines with urban areas and to estimate the number and total value of housing units exposed to subsidence risk.

Keyword(s): computer, coal mining, metal mining, non-metal mining, abandoned mines, land-use planning, insurance, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Hinrichs, D. R. Utilization of Geophysical Logs in the Evaluation of Subsurface Conditions for Mine Subsidence Studies. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 121-131.

Conventional rotary drilling in combination with lithologic and down-hole geophysical logging has proven to be the most cost-effective method for investigating abandoned mine conditions and coal seam geometries along the Colorado Front Range.

Keyword(s): abandoned mines, geophysical, overburden, monitoring methods, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, United States

Hiortdahl, S. N. Hydrologic and Mining Data from an Area of Underground Coal Mining in Garrett County, Maryland. Report of Investigations No. 41-A, Maryland Geological Survey, Baltimore, 1988, 81 p.

The report presents the results of hydrologic monitoring from 1981-1984 in an area removing coal by the room-and-pillar method. At the end of this phase of the study, mining was approximately 50% complete and affected 1,650 acres. Water levels in several observation wells completed in confined zones both above and below the mine declined from tens to hundreds of feet in response to pumpage of mine drainage. Seepage measurements along local streams indicated losses of stream flow to the local groundwater systems occurred and varied in location and magnitude from year to year.

Keyword(s): hydrology, monitoring methods, subsurface water, room-and-pillar, active mines, coal mining, inflow

Location(s): Maryland, Appalachian Coal Region, United States

Hiramatsu, Y., Y. Oka. On the Earth Pressure Phenomena Around a Long Wall Working Place. Journal Mining & Metallurgy Institute Japan, v. 73, 1957, p. 817-822.

Keyword(s): longwall

Location(s): Japan

Hiramatsu, Y., Y. Oka. Stress Measurements in Roofs, Floors, and Pillars. IN: Proceedings 4th International Conference on Strata Control and Rock Mechanics, 1964, Henry Krumb School of Mines, Columbia University, New York, 1965, 13 p.

Investigations were conducted to determine the influence of a longwall working upon stresses in the roof and floor. In addition, theoretical studies were carried out on the method of stress measurement as well as on the implication of the variations in stress.

Keyword(s): longwall, in situ testing, instrumentation, roof stability, floor stability, pillar strength, rock mechanics

Hiramatsu, Y., Y. Oka. Precalculation of Ground Movements Caused by Mining. International Journal Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 5, February, 1968, p. 399-414.

This paper describes the principle and the technique of a new method of precalculating the ground movements caused by mining coal seams or ore bodies. In this method, functions of influence, which by integration give the influence factors, are used. This method is adaptable to computer analysis and can be used to determine subsidence and horizontal displacements, inclinations, strains, and curvatures.

Keyword(s): vertical displacement, horizontal displacement, prediction, computer, rock mechanics, coal mining, metal mining, influence function

Location(s): Japan

Hiramatsu, Y., H. Okamura, K. Sugawara. Surface Subsidence and Horizontal Displacement Caused by Mining Inclined Coal Seams. IN: Proceedings 4th Congress International Society for Rock Mechanics, Montreux, Switzerland, September 2-8, 1979, Balkema, Rotterdam, p. 665-670.

Keyword(s): rock mechanics, horizontal displacement, surface subsidence damage

Hiramatsu, Y. Deep Underground Excavations, Especially Tunnels and Coal Mining, and the Subsidence Caused by Them. IN: Rock Mechanics for Resource Development, Mining and Civil Engineering, Proceedings 5th Congress International

Society for Rock Mechanics, Melbourne, Australia, 1983, Balkema, Rotterdam, v. 3, Section G, p. G167-G184.

This report briefly describes recent research on the geomechanics and geotechnology of deep underground excavations. Special attention is shown to tunnels and coal mining, as well as the ground subsidence caused by them. These are the topics under the Sub-Theme C2, C3 and C4 in this Congress. This report introduces the important part of the papers submitted to this Congress under these Sub-Themes to suggest particular areas for discussion.

Keyword(s): coal mining, tunnelling, rock mechanics, longwall, room-and-pillar, modeling, prediction

Hiramatsu, Y. Deep Underground Excavations: Tunnels, Coal Mining, and Subsidence. IN: Rock Mechanics for Resource Development, Mining and Civil Engineering, Proceedings 5th Congress of International Society for Rock Mechanics, Melbourne, Australia, 1983, Balkema, Rotterdam, p. G207-G208.

This paper gives the state of investigation on rock mechanics on these three topics.

Keyword(s): tunnelling, rock mechanics, coal mining

Hirt, A. M., A. Shakoor. Determination of Unconfined Compressive Strength of Coal for Pillar Design. Mining Engineering, v. 44, no. 8, August, 1992, p. 1037-1041.

The compressive strength of coal and its variation within and between seams was determined for four Pennsylvania coal seams. Large coal blocks were obtained from 12 coal mines. The cubes were tested for compressive strength. The results were then used to compute actual pillar strength.

Keyword(s): pillar strength, coal mining, lab testing, active mines, rock mechanics

Location(s): Pennsylvania, Appalachian Coal Region, United States

Hisatake, M., T. Ito. Three-Dimensional Boundary Element Analysis of Surface Subsidence Caused by Shallow Tunnel Driving. Doboku Gakkai Rombun Hokokushu, no. 327, November, 1982, p. 107-114.

Keyword(s): boundary element, modeling, tunnelling

Hislam, J. L. Site Improvement Techniques--Mine Infilling. IN: Mineworkings 84: Proceedings International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1984, M.C. Forde, B.H.V. Topping, and H.W. Whittington, eds., Engineering Technics Press, p. 121-130.

Keyword(s): coal mining, abandoned mines, backfilling

Hobba, W. A., Jr. Effects of Underground Mining and Mine Collapse on the Hydrology of Selected Basins in West Virginia. West Virginia Geological Survey RI-33, 1982, 84 p.

This report examines the effects of mining and collapse on hydrology in two contrasting situations: where the mined coal is above and below major streams. It includes a glossary.

Keyword(s): coal mining, hydrology, subsurface water, overburden

Location(s): West Virginia, Appalachian Coal Region, United States

Hobbs, D. W. The Strength and the Stress-Strain Characteristics of Coal in Triaxial Compression. Journal of Geology, v. 72, March, 1964, p. 214-231.

Keyword(s): rock mechanics, lab testing, coal mining, pillar strength

Hodkin, D. L., R. K. Dunham, I. W. Farmer. Deformation of Coal Measures Strata Above a Retreating Longwall Face. IN: Proceedings 20th U.S. Symposium on Rock Mechanics, Austin, TX, June 4-6, 1979, University of Texas, p. 517-524.

Vertical settlements at various depths above the centerline of a shallow caving longwall face were measured by levelling and by using an anchor extensometer system installed in two underground boreholes drilled from abandoned pillar workings 75 meters above the face. Differential settlement between the upper and lower levels was found to be greater than expected; this is attributed partly to the presence of strong, good quality sandstones in the Coal Measures cyclothem. Considerable damage and collapse of workings at the upper level occurred 30 to 40 meters after passage of the face at the lower level and coincided with the predicted zone of peak tensile strain.

Keyword(s): longwall, vertical displacement, rock mechanics, survey methods, instrumentation, monitoring methods, overburden, coal mining, active mines

Location(s): United States

Hoffmann, H. The Effects of Direction of Working and Rate of Advance on the Scale-Deformation of a Self-Loaded Stratified Model of a Large Body of Ground. IN: Proceedings 4th International Conference on Strata Control and Rock Mechanics, May 4-8, 1964, Henry Krumb School of Mines, Columbia University, New York, 1965, p. 397-411.

The subsidence model, made of synthetic foam, consisted of several plates separated by paper strips; it was designed to study the effects of subsidence on overburden strata.

Keyword(s): mine design, rock mechanics, modeling, overburden

Holla, L. Empirical Prediction of Subsidence Movements in the Southern Coalfields of New South Wales, Australia. IN: The Developing Science and Art of Minerals Surveying, Proceedings VIth International Congress, International Society for Mine Surveying, Harrogate, September 9-13, 1985, Balkema, Rotterdam, p. 557-567.

The empirical approach has been followed by the New South Wales Department of Mineral Resources for predicting subsidence. In the past, ground movements were predicted making use of the Subsidence Engineers' Handbook prepared by the National Coal Board. An intensive program of subsidence research resulted in the development of prediction curves for New South Wales that were found to be significantly different to the curves in the United Kingdom. This report summarizes the results of research and highlights some problems encountered during the process of standardizing empirical curves for the Southern Coalfields of New South Wales.

Keyword(s): prediction, prediction theories, coal mining, active mines, National Coal Board, longwall, yielding supports, monitoring methods

Location(s): Australia

Holla, L. The Minimisation of Surface Subsidence by Design of Mine Workings. IN: Proceedings Australasian Institute Mining Metallurgy, v. 240, 1985, p. 53-59.

Keyword(s): mine design

Location(s): Australia

Holla, L. Evaluation of Surface Subsidence Characteristics in the Newcastle Coalfield of New South Wales. The Coal Journal, v. 11, 1986, Australia, 12 p.

Keyword(s): coal mining, surface subsidence damage

Location(s): Australia

Holla, L., B. Hughson. State-of-the-Art of Mining Under Public Utilities in New South Wales. IN: Proceedings, Symposium on Ground Movement and Control Related to Coal Mining, Illawarra, Australia, N.I. Aziz, ed., August, 1986, Australasian Institute of Mining and Metallurgy, p. 334-340.

Large amounts of coal lie sterilized under roads, railways, pipelines, and power transmission lines. Mining to extract these resources will cause subsidence, but not necessarily unacceptable damage to the utility. The establishment of acceptable standards of damage, where the value of mined coal is much greater than reparation costs, and means of achieving limited damage are examined. Procedures for mining under each utility are presented. In the light of overseas experience, improvements in current recovery under railways may be possible.

Keyword(s): coal mining, roads, railroads, pipelines, utilities

Location(s): Australia

Holla, L., M. Buizen. The Ground Movement, Strata Fracturing and Changes in Permeability Due to Deep Longwall Mining. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 28, no. 23, 1991, p. 207-217.

Strata movement due to longwall retreat mining was studied in the Southern coalfield, near Sydney, Australia. Subsurface deformation was monitored by recording the movements of a series of anchors, installed at various depths in a borehole drilled over a longwall panel. Bulk strata permeability was measured by packer tests before and after mining. Pre-mining and post-mining fractures were compared. Vertical strains the overburden varied from 0.5 to 4 mm/m. Tensile strains extended from the surface to 112 m depth and were less than 0.5 mm/m. Increases in permeability and number of fractures were seen but no correlation was evident.

Keyword(s): overburden, longwall, instrumentation, monitoring equipment, monitoring methods, coal mining, subsurface water, hydrology

Location(s): Australia

Holla, L. Some Aspects of Strata Movement Relating to Mining Under Water Bodies in New South Wales, Australia. IN: Proceedings 4th International Mine Water Congress, Ljubljana (Slovenia)-Portschach (Austria), September 1991, p. 233-244.

Successful mining layouts for mining coal under large water bodies should ensure that a substantial thickness of overburden strata remains undisturbed to prevent the flooding of mine workings. One of the criteria followed in many countries for controlling sub-surface strata disturbance is to specify a limit on the rockhead tensile strain. However, the generally specified rockhead strains are well in excess of the strain required to cause surface fracturing. It therefore leads to the conclusion that the composition of strata between the cracked zone on the surface and the caved zone above the extracted seam plays an important role in preventing water inflows into the mine workings. Ductile beds like shales, mudstones, and clay bands appear more effective than sandstone beds of the same thickness.

Keyword(s): coal mining, surface water, overburden, geologic features, mine design, longwall, rock mechanics, inflow

Location(s): Australia

Holla, L. Ground Movement Due to the Mining of Thick Coal Seams at Shallow Depths and its Effect on Surface Structures. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 193-208.

The primary objectives of an intensive program of research are to define the ground movement pattern in the coalfields of New South Wales, to develop empirical models capable of predicting surface and subsurface subsidence prior to mining, and to quantify the extent of damage to different types of structures under different levels of ground movement. This paper includes some aspects of subsidence investigation into the effect of mining shallow seams on the surface and surface structures.

Keyword(s): coal mining, surface structural damage, active mines, longwall, monitoring methods, survey methods, survey data processing, horizontal displacement, vertical displacement, pipelines, utilities, railroads

Location(s): Australia

Holland, C. T. Pillar Deformation in a Bituminous Coal Mine. Transactions AIME, v. 130, 1938, p. 333-357.

This is a study of the compressive effect upon adjacent remaining pillars when selected pillars were pulled in the Pittsburgh seam.

Keyword(s): coal mining, pillar extraction, pillar strength, in situ testing, bituminous

Location(s): West Virginia, Appalachian Coal Region, United States

Holland, C. T., E. Thomas. Coal Mine Bumps: Some Aspects of Occurrence, Cause and Control. U.S. Bureau of Mines B 535, 1954, 36 p.

Keyword(s): ground control, room-and-pillar, mine design, bumps, coal mining

Location(s): United States

Holland, C. T. Mineral Content. A Factor in Weathering of Mine Roof. Mining Congress Journal, v. 42, no. 1, 1956, p. 49-54.

Keyword(s): rock mechanics, ground control, roof stability

Holland, C. T., F. L. Gaddy. Some Aspects of Permanent Support of Overburden on Coalbeds. IN: Proceedings West Virginia Coal Mining Institute Spring Meeting, June 22-23, 1956, and 49th Annual Meeting, November 2-3, 1956, West Virginia Coal Mining Institute, 1957, p. 43-65.

This paper considers the support of overburden from these aspects: load on coal bed before mining, stress or load produced by mining, strength of coal and pillars, load capacity of the roof and floor,effect of water on roof and floor material, composition of load-bearing rocks, and safety factors.

Keyword(s): overburden, pillar strength, roof stability, floor stability, mine safety, coal mining

Location(s): United States

Holland, C. T. Cause and Occurrence of Coal Mine Bumps. Transactions SME-AIME, v. 211, 1958, p. 994-1004.

Keyword(s): ground control, room-and-pillar, mine design, coal mining, bumps

Holland, C. T. Notes on the Theory of a Maximum Pressure Arch and Yield Pillar Techniques as Applied to Entry Panel Design. IN: Proceedings Coal Mining Institute of America, 1961, p. 68-78.

The author discusses yield pillar theory of entry design so that some roof problems and rock bursts are eliminated in mines at depths of 400 to 2,000 feet below the surface.

Keyword(s): mine design, roof support, roof stability, yielding supports

Location(s): United States

Holland, C. T. Design of Pillars for Overburden Support, Part I-II. Mining Congress Journal, v. 48, no. 23-24, 1962.

The author uses field tests to support laboratory theories on pillar design for permanent support of overburden in coal beds. The effect of water on floor rock is briefly discussed.

Keyword(s): floor stability, pillar strength, mine design, overburden, coal mining, in situ testing, lab testing

Holland, C. T. The Strength of Coal in Mine Pillars. IN: Proceedings 6th Symposium on Rock Mechanics, University of Missouri at Rolla, 1964, E.M. Spokes and C.R. Christiansen, eds., p. 450-466.

This paper discusses the strength of coal based on the specimen size and the least dimension of the specimen. Various parameters affecting the coal strength are discussed and, based on experimental data, a series of conclusions regarding coal strength are presented.

Keyword(s): rock mechanics, pillar strength, coal mining, lab testing, room-and-pillar

Location(s): United States

Holland, C. T. Final Report on the Effect of Mining Upon and Methods of Protecting Earthfill Dams Located in the Wheeling Creek Area. Report to U.S. Department of Agriculture, Soil Conservation Service, Morgantown, WV, March 20, 1965.

This report describes required support in the form of unmined coal beneath proposed earth dams in Pennsylvania and West Virginia.The current (1965) state of knowledge concerning subsidence parameters and coal strength for the area and seams in question is summarized to justify recommendations presented.

Keyword(s): pillar strength, surface structural damage, coal mining

Location(s): Pennsylvania, West Virginia, Appalachian Coal Region, United States

Holland, C. T., D. A. Olsen. Interfacial Friction, Moisture, and Coal Pillar Strength. Transactions AIME, v. 241, 1968, p. 323-328.

This paper discusses the development of a formula for estimation of coal pillar strength. One of the factors involved in the formula is the coefficient of friction between the coal pillar and the adjacent rock with which it is in contact. The results of studies on sandstone, limestone, shale, and coal, and the coefficient of friction between coal and the preceding three rock types under wet and dry conditions are presented.

Keyword(s): coal mining, pillar strength, in situ testing

Location(s): United States

Holland, C. T. Thirty Years' Experience in Applying Rock Mechanics to Roof Control in Coal Mining. AIME Preprint 71-F-347, 1971.

This paper reviews the historical and current methods of roof control, including pillar/room dimension, rock bolting, geological considerations, and depth of overburden.

Keyword(s): roof stability, roof support, ground control, room-and-pillar, overburden, coal mining

Location(s): United States

Holland, C. T. Mine Pillar Design. IN: SME Mining Engineering Handbook, v. 1, A.B. Cummins and I.A. Givens, eds., 1973, SME-AIME, New York, p. 13-96 to 13-118.

Pillar design presupposes a knowledge of the pertiment geology of the area involved. This takes in the following aspects of the local geology but is not necessarily limited to them: (1) thickness of the overburden and its involved strata, (2) stress field or fields affecting the area, (3) structural strength of the rocks overlying and underlying the bed, (4) jointing system affecting the rocks of the area, and (5) water that might enter the bed and its effects upon the rocks involved.

Keyword(s): pillar strength, ground control, mine design, geologic features, overburden, yielding supports, coal mining

Location(s): United States

Holland, C. T. Pillar Design for Permanent and Semi-Permanent Support of the Overburden in Coal Mines. IN: Proceedings 9th Canadian Rock Mechanics Symposium, Montreal, 1973.

Keyword(s): rock mechanics, mine design, pillar strength, yielding supports, overburden

Holm, J. D. Mine Subsidence Insurance for Colorado: A Risk Management Approach. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 281-298.

The State of Colorado is in the final stages of developing a Subsidence Insurance Program that will be operated by one or more private insurance companies. The state's involement is necessitated by provisions in the federal legislation enabling the program. Also, no specific subsidence risk insurance is currently available in the market place.

Keyword(s): insurance, law, abandoned mines, reclamation, pneumatic backfilling, hydraulic backfilling, structural mitigation, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, Pennsylvania, Illinois, West Virginia, Kentucky, Ohio, United States

Holt, D. N., B. R. Marker. Benefits of Engineering Geology for Land Use Planning in Areas of Past Metalliferous Mining. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 75-80.

Metalliferous mining in the United Kingdom has left an inheritance of subsidence and contamination that can affect the viability and suitability of land for present and future use.

Keyword(s): metal mining, land-use planning, geologic features, mine waste, subsurface water

Location(s): England, United Kingdom

Holzer, T. L. Ground Failure in Areas of Subsidence Due to Groundwater Decline in the United States. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 423-433.

Keyword(s): hydrology, subsurface water, fluid extraction

Location(s): United States

Holzer, T. L., W. Thatcher. Modeling Deformation Due to Subsidence Faulting. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 349-357.

A relation between aseismic surface faulting and groundwater withdrawal from alluvial basins undergoing human-induced land subsidence has been suggested or implied by several investigators. In this paper, an additional approach is proposed and illustrated for analyzing the origin of surface faulting within areas of gorundwater withdrawal. The conceptual basis for the approach is that by modeling surface deformation computed from repeated precise geodetic surveys across faults, the approximate depth of fault rupture may be inferred.

Keyword(s): modeling, fluid extraction, geologic features

Location(s): Arizona

Holzer, T. L. Preconsolidation Stress of Aquifer Systems in Areas of Induced Land Subsidence. Water Resources Research, Washington, D.C., 1981, p. 693-704.

Keyword(s): hydrology, subsurface water, subsurface subsidence damage, overburden

Location(s): United States

Holzer, T. L. Ground Failure Induced by Ground-Water Withdrawal from Unconsolidated Sediment. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, 1984, T.L. Holzer, ed., The Geological Society of America, p. 67-105.

Ground failures, ranging from long tension cracks or fissures to surface faults, are caused by human-induced water-level declines in more than 14 areas in the contiguous United States. These failures are associated with land subsidence caused by compaction of underlying unconsolidated sediment. The greatest economic impact from ground failure is in the metropolitan region of Houston-Galveston, Texas, where more than 86 surface faults have caused millions of dollars of damage and losses of property value.

Keyword(s): subsurface water, fluid extraction, geologic features, land-use planning

Location(s): Texas, California, Arizona, United States

Holzer, T. L. Land Subsidence: Its Impacts and Costs in the U.S. Underground Space, v. 9, no. 5-6, 1985, p. 260-263.

This paper discusses land subsidence of all types which was either directly or indirectly caused by human activity, including subsurface mining, withdrawal of groundwater and petroleum from unconsolidated sediment, drainage of peat and muck soils, groundwater withdrawal from limestone, solution mining, and surface application of water to undercompacted sediment. Human-induced subsidence occurs in at least 38 states in the United States.

Keyword(s): economics, abandoned mines, surface structural damage, surface water, subsurface water, vertical displacement, oil extraction, metal mining, non-metal mining, coal mining, fluid extraction

Location(s): United States, Italy, Illinois, Louisiana, Florida, Texas, Virginia, California

Holzer, T. L., ed. Man-Induced Land Subsidence. Geological Society of America Reviews in Engineering Geology Volume VI, 1984, GSA, Boulder, CO, 221 p.

Recognizing the vital roles of engineering geologists and hydrogeologists in the prediction, control, and mitigation of human-induced land subsidence, a GSA symposium on the subject was held at the annual meeting in 1980. Nine of the papers presented were expanded into this volume, which compiles comprehensive summaries of the mechanisms of land subsidence in the United States and the techniques that have been developed to predict and mitigate it. Papers were arranged into three categories: (1) fluid withdrawal from porous media, (2) drainage of organic soil, and (3) collapse into manmade and natural cavities.

Keyword(s): fluid extraction, engineering, prediction, oil extraction, soils, coal mining, non-metal mining

Location(s): Appalachian Coal Region, Illinois Coal Basin, Rocky Mountain Coal Region, United States

Hood, M., R. T. Ewy, L. R. Riddle, J. J. K. Daemen. Empirical Methods for Subsidence Prediction and Their Applicability to U.S. Mining Conditions. Final Report, Contract No. 62-0200, Department of Material Science and Mining Engineering, University of California, Berkeley, October, 1981, 241 p.

This work program had two major objectives: to update the understanding of European and other relevant subsidence prediction methods, and to evaluate the applicability of these methods to mining conditions in the United States. The scope of the work was broad, calling for a collection of case histories and an examination of the influence of mining methods, mine geometry, and geological features on the various prediction techniques. The empirical subsidence prediction technique can be divided into four categories: an empirical data technique, a profile function technique, an influence function technique, and a stochastic technique.

Keyword(s): prediction theories, empirical model, angle of draw, literature search, prediction, modeling, coal mining, National Coal Board, vertical displacement, horizontal displacement, time factor, profile function, influence function, stochastic model

Location(s): United States

Hood, M., R. T. Ewy, L. R. Riddle. Empirical Methods of Subsidence Prediction--A Case Study. IN: Procedings Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 100-122.

Subsidence profiles above two adjacent panels in Illinois are compared with profiles predicting subsidence behavior obtained using the National Coal Board method, the profile function method, and the influence function method.

Keyword(s): vertical displacement, horizontal displacement, prediction, longwall, empirical model, National Coal Board, profile function, influence function

Location(s): Illinois, Illinois Coal Basin, United States

Hood, M., R. T. Ewy, L. R. Riddle. Empirical Methods of Subsidence Prediction--A Case Study From Illinois. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 20, no. 4, August, 1983, p. 153-170.

Subsidence profiles above two adjacent panels in Illinois are compared with profiles predicting subsidence behavior obtained using the National Coal Board method, the profile function method, and the influence function method.

Keyword(s): prediction, coal mining, prediction theories, empirical model, profile function, influence function, National Coal Board

Location(s): Illinois, Illinois Coal Basin, United States

Hooker, V. E. A Method of Evaluating Room and Pillar or Panel Design. IN: Proceedings U.S. Bureau of Mines Technology Transfer Seminar on Ground Control Aspects of Coal Mine Design, Lexington, KY, March, 1973; U.S. Bureau of Mines IC 8630, 1974, p. 44-48.

Pillar stresses and strengths were measured and used to evaluate the stability of pillars in an underground mine. Uniaxial and triaxial strength tests were conducted both on samples which contained no plane of weakness (solid) and on those which contained planes of weakness. For unconfined specimens containing planes of weakness the strength reduction can be as large as 73%. In situ stress determinations were made in the pillars and rib wall. Results indicated that pillars were not carrying the calculated loads expected from extraction ratios. The vertical stress magnitude in the rib wall was 1.8 times that expected from overburden indicating additional load transmission in this region.

Keyword(s): room-and-pillar, ground control, mine design, pillar strength, lab testing, in situ testing, rock mechanics

Location(s): United States

Hooker, V. E. Stress Fields--What is Known About Them. IN: Ground Control Aspects of Coal Mine Design, Proceedings, Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 22-27.

Results of investigations into the nature and extent of in situ stress fields show that the stresses applied to a rock mass in which mining is done may be composed of gravitational, thermal, or tectonic stresses. The magnitudes and directions of the stress components seem to correlate with geological features. The horizontal components of stress are compressive and generally unequal.

Keyword(s): ground control, geologic features, mine design

Location(s): United States

Hopkins, D. L., N. G. W. Cook. A Model Based on the Minimization of Strain Energy as a Tool in the Design of Coal Pillars. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Golden, CO, Balkema, Rotterdam, p. 177-184.

Stresses in coal pillars have been analyzed using a model based on the minimization of strain energy. In addition to the deformation of the pillars, the model accounts for deformation of the roof and floor and mechanical interaction between pillars. The model is used to calculate the distribution of stress in isolated pillars and arrays of pillars before any yielding has occurred. The effect of mechanical interaction is studied by changing the spacing between pillars and spatial geometry of the arrays.

Keyword(s): coal mining, modeling, pillar strength, mine design, yielding supports

Hopkins, M. E. Coal Geology and Underground Mining, Illinois Coal Basin. IN: Proceedings 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 1-13.

Because of the relatively thick and persistent coal seams, resulting from uniform depositional environments prevailing over wide areas, underground mining conditions in the Illinois Coal Basin are generally favorable for large, highly productive mines. A wide variety of problems, however, result from recognizable geologic conditions. Undoubtedly, the most important group of geologic factors affecting minability relate to the nature of the stratigraphic section over the coal and its amenability to roof control. Significant depositional variations involving competent and non-competent roof strata are present on regional and local scales.

Keyword(s): geologic features, roof stability, coal mining, floor stability

Location(s): Illinois, Kentucky, Indiana, Illinois Coal Basin, United States

House Committee on Interior and Insular Affairs. Surface Mining Control and Reclamation Act of 1977. House Report 95-218, Washington, D.C., 1977.

Keyword(s): reclamation, mitigation, law, coal mining

Location(s): United States

Houser, F. N. Sequence of Surface Movement and Fracturing During Sink Subsidence, Nevada Test Site. U.S. Geological Survey, Report USGS-474-56, 1970.

Keyword(s): surface subsidence damage

Location(s): Nevada, United States

Howard, J. F., R. E. Wright. Evaluation Procedure of Critical Factors of Mining Impact on Ground Water Resources. IN: Water Resources Problems Related to Mining, Proceedings 18th Symposium American Water Resources Association, Minneapolis, June, 1974, R.F. Hadley and D.T. Snow, eds., p. 22-31.

Water resource problems associated with mining activities have commonly been confined either to the acquisition or the disposal of water as needed or as created by the mining process. With the dawn of environmental regulations, the interaction of water and earth systems became a major factor for consideration in the environmental impact assessment that must be prepared to acquire a mining permit.

Keyword(s): hydrology, subsurface water, coal mining, environment, law, government

Location(s): United States

Howell, F. T., P. L. Jenkins. Some Aspects of the Subsidences in the Rocksalt Districts of Cheshire, England. International Association Hydrological Sciences Publication 121, 1977, p. 507-520.

Keyword(s): non-metal mining

Location(s): England

Howell, F. T., P. L. Jenkins. Centrifuge Modelling of Salt Subsidence Features. Application of Centrifuge Modelling to Geotechnical Design, W. H. Craig, ed., Balkema, Rotterdam, 1985, p. 193-202.

Keyword(s): modeling, non-metal mining

Howell, M., C. W. Amos. Improved Geophysical Techniques for Survey of Disturbed Ground. IN: Site Investigations in Areas of Mining Subsidence, F.G. Bell, ed., Newnes-Butterworths, 1975, p. 103-108.

Two new techniques have been developed that appear to provide improved geophysical methods for locating a variety of sub-surface features, particularly old mine workings, filled quarries, cavities, faults, culverts, and similar phenomena.

Keyword(s): survey methods, geophysical, seismic

Howell, R. C., F. D. Wright, J. A. Dearinger. Ground Movement and Pressure Changes Associated with Shortwall Mining. IN: Site Characterization, Proceedings 17th U.S. Symposium on Rock Mechanics, Snowbird, UT, August 25-27, 1976, W.S. Brown, S.J. Green, and W.A. Hustrluid, eds., University of Utah, Salt Lake City, p. 4A31-4A36.

A rock mechanics study of a shortwall mining system was conducted. The objective of the study was to obtain data on surface subsidence over a portion of the mined area, strata subsidence in the mined area, and underground stress changes and displacements in and near natural support elements of the mining system. The mine was located in the moderately rough mountainous terrain of eastern Kentucky.

Keyword(s): rock mechanics, shortwall, ground control, instrumentation, monitoring methods, coal mining, survey methods, overburden

Location(s): Kentucky, Appalachian Coal Region, United States

Howes, M. R., M. A. Culp, H. Greenberg, P. E. VanDorpe. Underground Coal Mines of Centerville, Iowa, and Vicinity. Iowa Department of Natural Resources Open File Report 86-2, 1986, Iowa Geological Survey Bureau, Iowa City, 93 p.

Extensive underground mining occurred in the Centerville area between 1850 and 1971. Coal production was exclusively from the Mystic Coal Member of the Labette Shale (Pennsylvanian). This study documents the location and extent of abandoned coal mines and known occurrences of mine-related problems in the area. A map is included, which shows the location and extent of coal mines and a compilation of mine-related information including historical and physical data.

Keyword(s): coal mining, abandoned mines, historical, land-use planning, longwall, room-and-pillar

Location(s): Iowa, United States

HRB-Singer, Inc. Detection of Abandoned Underground Coal Mines by Geophysical Methods. Water Pollution Control Research Series 14010 EHN, for the Environmental Protection Agency and the Pennsylvania Department of Environmental Resources, April, 1971, 94 p.

Acid drainage produced by abandoned coal mines continues to cause serious water pollution problems. Without knowing the exact location of the concealed openings and the extent of the mine, the application of proven abatement techniques is virtually impossible. Drilling is the only known method for accurately determining the location and extent of the mine voids, but this is extremely expensive. This project attacks the problem through field studies of the following geophysical methods: electrical resistivity, self-potential, infrared radiometry, total field and differential magnetometry, seismic refraction and reflection, very low frequency electromagnetic and induced polarization over well documented drift coal mines.

Keyword(s): geophysical, abandoned mines, environment, coal mining, subsurface water

Location(s): Pennsylvania, Appalachian Coal Region, United States

HRB-Singer, Inc. Proposed Techniques for Evaluating Subsidence Risk and Planning and Engineering Alternatives for Use by Housing and Urban Development (HUD) and Local Governments (Task E). State College, PA, Energy and Natural Resources Program Dept., HUD contract H-2385, June, 1977, 120 p. (NTIS PB 81-100992)

Urban areas in 21 states suffer from problems of subsidence from underground mining operations. Other urban areas along the Atlantic and Gulf coasts suffer from subsidence in wetlands, and about 33 million people live on limestone terrains that also may be affected by subsidence. This report discusses techniques that can be used by Department of Housing and Urban Development and by local government personnel to evaluate risks and planning and engineering alternatives for mitigating hazards resulting from (1) land subsidence, (2) subsidence occurring in organic wetlands and (3) subsidence in carbonate (karst) terrains. Techniques for determining the likelihood and magnitude of these types of subsidence are described, and various planning options available at the state, regional, and local level of government are discussed. Engineering techniques, including subsurface stabilization, stabilization of foundations, and special architectural or structural measures appropriate for the types of subsidence conditions are examined.

Appendices are included on the feasibility of providing technical guidance and on representative costs of hazard mitigation components.

Keyword(s): vertical displacement, horizontal displacement, law, mine design, backfilling, land-use planning, environment, geologic features, surface structural damage, structural mitigation, mitigation, land mitigation, fluid extraction, coal mining, engineering, government, architecture, foundations, economics

Location(s): United States

HRB-Singer, Inc. Community Land Subsidence. Final Report, U.S. Department of Housing and Urban Development, Washington, D.C., Contract H-2385, 1977.

Keyword(s): land-use planning, government, environment

Location(s): United States

HRB-Singer, Inc. The Nature and Distribution of Subsidence Problems Affecting HUD and Urban Areas. Task A, HUD Contract H-2385, 1977, 113 p. (NTIS PB 80-17277-8)

Keyword(s): government, land-use planning, surface subsidence damage

Location(s): United States

Hsiung, S. M., S. S. Peng. Chain Pillar Design for U.S. Longwall Panels. SME-AIME Preprint 84-323, SME-AIME Fall Meeting, Denver, CO, October 24-26, 1984, 18 p.

Chain pillar design formula under weak roof condition was developed by statistically analyzing the results from the three-dimensional finite element parametric analyses. The parameters such as mechanical properties of the roof and floor strata, overburden depth, panel width and length, and coal strength were incorporated in the formula. A conversion formula that transfers a rectangular chain pillar into a square chain pillar of equal strength is proposed. The influence of high in situ horizontal stresses, which are often encountered in the coalfield, on chain pillar stability is discussed.

Keyword(s): longwall, coal mining, mine design, finite element, rock mechanics, roof stability, pillar strength, geotechnical

Hsiung, S. M., S. S. Peng. Design Guidelines for Multiple Seam Mining. Coal Mining, Part I, v. 24, no. 9, September 1987, p. 42-46; Part II, v. 24, no. 10, October 1987, p. 48-50.

Causes of ground control problems in multiple-seam mining can be classified into five types. These problems cannot be eliminated completely without sacrificing coal reserves. Problems can be reduced, however, if the interaction effects are fully understood and proper mining plans are correctly implemented.

Keyword(s): multiple-seam extraction, active mines, coal mining, geologic features, mine design, mine operation, pillar strength, finite element, longwall, room-and-pillar, ground control, subsurface water, partial extraction

Location(s): West Virginia, Appalachian coal Region, United States

Hsiung, S. M., S. S. Peng. Control of Floor Heave with Proper Mine Design--Three Case Studies. Mining Science and Technology, v. 4, 1987, p. 257-272.

The results of three case studies on the control of floor-heave problems are presented. Finite element modeling was employed to identify causes of excessive floor heave, propose remedial measures, and evaluate the effectiveness of mine layout design in controlling floor heave. Five chain pillar designs were modeled in this third study.

Keyword(s): floor stability, active mines, mine design, finite element, modeling, geologic features, overburden, pillar strength, roof stability, bumps, longwall

Location(s): United States

Hsiung, S. M., P. M. Lin, S. S. Peng. Structure and Ground Surface Damages Due to Subsidence. IN: Proceedings Conference on Mine Drainage and Surface Mine Reclamation, U.S. Bureau of Mines IC 9184, v. 2, 1988, p. 362-371. (NTIS PB 90-269457)

Keyword(s): surface structural damage

Location(s): United States

Hubbard, J. S. Longwall Experience at the Gateway Mine. Mining Congress Journal, v. 57, no. 10, 1971, p. 43-47.

The installation of a longwall system in the Pittsburgh seam is described. The author states that when the system is specifically designed for a seam, it is one of the safest methods of mining coal. One of the reasons for the increased safety is the use of self-advancing hydraulic roof supports.

Keyword(s): coal mining, longwall, mine design, roof support, mine safety

Location(s): Pennsylvania, Appalachian Coal Region, United States

Huck, P. J., Y. P. Chugh, M. Jennings. Subsidence Control in Abandoned Coal Mines: U.S. Practices. IN: Proceedings, Conference on Ground Control in Room-and-Pillar Mining, Southern Illinois University, Carbondale, August 6-8, 1980, Y. P. Chugh, ed., SME-AIME, New York, 1982, p. 151-154.

Large areas of coal reserves in the United States have been undermined by the room-and-pillar method during the past century. These abandoned mines generally cause subsidence of the ground surface many decades after mining. The authors discuss the methods by which subsidence in abandoned mines may be controlled, including point support methods and areal backfilling.

Keyword(s): coal mining, abandoned mines, local backfilling, grouting, pneumatic backfilling, hydraulic backfilling, room-and-pillar

Location(s): United States

Huck, P. J. Monitoring Techniques for Blind Backfilling - Overview. IN: Proceedings National Symposium and Workshops on Abandoned Mine Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 117-125.

A variety of techniques and instruments may be used to monitor the progress of blind backfilling in abandoned mines. No single ideal system is available that will fill the needs of the variety of backfilling methods used and site conditions encountered. The current art is reviewed and candidate systems that have potential under given circumstances are identified. In many cases, a combination of several techniques provides the optimum monitoring system. Possible directions for future development are identified.

Keyword(s): backfilling, abandoned mines, grouting, pneumatic backfilling, hydraulic backfilling, instrumentation, monitoring methods

Huck, P. J. Numerical Model of Pumped Slurry Backfilling. IN: Proceedings National Symposium and Workshops on Abandoned Mine Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 126-144.

Anomalous behavior of injection pressures was observed during experimental monitoring of a pumped slurry backfilling operation near Scranton, Pennsylvania. Variations in the grain size of slurry solids was suspected as the cause of the unexpected behavior. To explore the effect of grain size upon deposition of solids, an existing model was modified to permit simulation of injection pressure histories and deposit depths for slurries containing well graded grain size distributions.

Keyword(s): hydraulic backfilling, modeling, backfilling

Huck, P. J., Y. P. Chugh. Analysis and Process Monitoring of Pumped Slurry Backfilling for Subsidence Control. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, v. 2, p. 5-12.

A pumped slurry backfilling process developed in the United States has been successfully used to control surface subsidence effects of underground mining. During the past 5 years, the USBM has directed studies to evaluate concepts for remote monitoring of the process and model the mechanisms of slurry deposition. This paper discusses process monitoring and analytical modeling studies of the backfilling process. The results indicate that process monitoring of injection pressure and flow rate can be very useful in providing information on backfill deposit geometry and mechanisms of slurry deposition.

Keyword(s): hydraulic backfilling, ground control, abandoned mines, mine waste, coal mining, modeling, computer

Location(s): United States

Huck, P. J., S. Bhattacharya. Instrumentation to Monitor Subsidence Associated With High Extraction Mining in the Illinois Coal Basin. Final Report to U.S. Bureau of Mines, Contract HO256005, Engineers International, Inc., June 1988, 60 p.

Engineers International, Inc. undertook a program from the USBM Twin Cities Research Center to select and emplace appropriate subsidence instrumentation over a high-extraction mine panel selected by cooperating Illinois state agencies. This instrumentation was to provide subsidence data for both short-term and long-term subsidence and hydrological effects of mining. The instrumentation included multipoint borehole extensometers (MPBX), observation wells, piezometers, subsidence monuments, and control monuments to provide local horizontal and vertical control. A suite of laboratory tests was conducted on specimens recovered during drilling, and rock properties data were culled from published and Engineers International file data.

Keyword(s): instrumentation, high-extraction retreat, monitoring equipment, monitoring installation, monitoring methods, monitoring design, horizontal displacement, vertical displacement, active mines, coal mining, geotechnical, rock mechanics

Location(s): Illinois, Illinois Coal Basin, United States

Hucka, V. J., C. K. Blair, E. P. Kimball. Mine Subsidence Effects on a Pressurized Natural Gas Pipeline. Preprint No. 83-386, for presentation at the SME-AIME Fall Meeting and Exhibit, Salt Lake City Utah, October 19-21, 1983, 10 p.

A 20-inch-diameter high-pressure natural gas pipeline crosses over a coal mine in central Utah. The room-and-pillar method with pillar extraction is being used to extract the coal from the seams. The pillars beneath the pipeline will not be extracted. An attempt has been made to predict subsidence in the area where pillars may collapse; a network of survey points has been installed along the pipeline to detect ground movements.

Keyword(s): utilities, pipelines, survey methods, survey design, multiple-seam extraction, pillar strength, coal mining, pillar extraction

Location(s): Utah, Rocky Mountain Coal Region, United States

HUD Challenge. Backfilling Abandoned Mines. v. 4, no. 9, September 1973, p. 30.

This paper describes the use of the Dowell process at Rock Springs, WY.

Keyword(s): hydraulic backfilling, abandoned mines

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Hudgings, R. A., R. M. Bennett, L. A. Sneed. Experimental Testing of Damage Mitigation Techniques. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 173-176.

Two sets of six linear footings are constructed over an advancing longwall panel in southern Illinois. One set is located parallel to and directly above the centerline, while the other set is in the predicted zone of maximum tension. Each set contains a plain concrete control footing, footings with plastic-sand and plastic interface, and a reinforced concrete, post-tensioned concrete, and steel fiber reinforced concrete footing. This paper describes the preliminary analysis and construction of the test foundations.

Keyword(s): foundations, active mines, longwall, instrumentation, engineering, surface structural damage, monitoring methods, monitoring equipment, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Hudspeth, H. M., D. W. Phillips. Forces Induced by the Extraction of Coal and Some of Their Effects on Coal-Measure Strata. Transactions, Institute of Mining Engineers, v. 85, 1932-33, p. 37-57, 186-190.

This paper describes general and mathematical considerations of fractures forming in coal measure strata. Results are given of experiments with models.

Keyword(s): overburden, modeling, coal mining

Hudspeth, H. M. Ground Movement in Advance of Longwalls. Iron and Coal Trades Review, v. 126, 1933, p. 1-3.

Roadways were driven in the coal in advance of the working faces of two mines. Telescoping measuring rods were used to record raise in floor and convergence of roof.

Keyword(s): longwall, monitoring equipment, coal mining, floor stability, roof stability

Hudspeth, H. M., D. W. Phillips, A. Walker. North of England Institute of Mining and Mechanical Engineers' Support of Workings in Mines Committee--Fourth Progress Report. Transactions, Institute of Mining Engineers, v. 91, 1935-36, p. 349-367.

This paper discusses the effects of depth, width of working, strength of roof, sides, and/or floor on roof falls.

Keyword(s): roof stability, room-and-pillar, floor stability

Location(s): England

Huff, L. L., G. Jarrell, S. Jarrell. Assessment of Future Economic Tradeoffs Between Coal Mining and Agriculture. Illinois Department of Energy and Natural Resources Doc. No. 81/29, July 1982, Project No. 80.214, Springfield, IL, 406 p.

Illinois is a state with substantial energy reserves in the form of coal and is a leader in agricultural output. Of the 24.4 million acres available as the cropland base, approximately 80% (19.1 million acres) is considered prime farmland. Coal mining in Illinois has occurred since the 1860s and will continue in the future because of the vast quantity of reserves remaining. This report discusses the reserves and potential of both surface coal mining and prime agricultural land. It goes on to analyze the potential conflict between these two activities in the future, as well as the environmental and economic impact of each.

Keyword(s): coal mining, agriculture, economics, environment, land-use planning, reclamation, surface water, subsurface water, government, law, land values

Location(s): Illinois, Illinois Coal Basin, United States

Hughes, R. E. The Use of Ordnance Survey Bench Marks for the Study of Large-Scale Mining Subsidence. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 185-205.

To demonstrate the methods of bench mark surveys, the value of their readings, and their limitations, five case histories are presented. The case histories were chosen to demonstrate the use and shortcomings of such surveys. Case history 1 records an investigation where different amounts and rates of mining subsidence can be seen around the town center. Case history 2 demonstrates the relationship of surface settlement patterns and geology/mining features. Case history 3 shows the difficulty of using such surveys in rural areas, and case history 4 shows that the Ordnance Survey information can be wrong. Case history 5 illustrates how bench mark information, post dating the subsidence, can be misleading.

Keyword(s): monitoring methods, monitoring design, survey methods, survey design, survey data processing

Location(s): United Kingdom

Hunt, S. R., C. G. Treworgy. Geologic Constraints on the Mining of Shallow Coals in Illinois. SME-AIME, St. Louis, October, 1977.

Keyword(s): geologic features, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Hunt, S. R. Characterization of Subsidence Profiles Over Room-and-Pillar Coal Mines in Illinois. IN: Proceedings, Illinois Mining Institute, October 19-20, 1978, p. 50-66.

This paper summarizes some preliminary results of current ISGS investigations into surface subsidence resulting from coal mining in Illinois. The purpose of the study is to characterize the vertical movements that may result from various types of underground coal mining. The findings of this study, based on mining operations in a variety of geologic settings, delineate the magnitude, shape, and position of the subsidence profile. Comparisons of case histories of subsidence are based primarily on the extraction ratio and the general geometry of the mine (depth, panel width, and mining height).

Keyword(s): vertical displacement, coal mining, geologic features, room-and-pillar, high-extraction retreat, longwall

Location(s): Illinois, Illinois Coal Basin, United States

Hunt, S. R. Characterization of Subsidence Profiles Over Room-and-Pillar Coal Mines In Illinois. Presented at Society of Mining Engineers of AIME Annual Meeting, New Orleans, LA, February 18-22, 1979, SME-AIME Preprint 79-126, 15 p.

Keyword(s): room-and-pillar, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Hunt, S. R. Characterization of Subsidence Profiles Over Room-and-Pillar Coal Mines in Illinois. Illinois State Geological Survey Reprint 1979F, 1979, reprinted from Proceedings of Illinois Mining Institute, 86th Annual Meeting, p. 50-65.

This paper summarizes some preliminary results of ISGS investigations into surface subsidence resulting from coal mining in Illinois. The purpose of the study is to characterize the vertical movements that may result from various types of underground coal mining. The findings of this study, based on mining operations in a variety of geologic settings, delineate the magnitude, shape, and position of the subsidence profile. Comparisons of case histories of subsidence are based primarily on the extraction ratio and the general geometry of the mine (depth, panel width, and mining height.)

Keyword(s): coal mining, geologic features, active mines, abandoned mines

Location(s): Illinois, Illinois Coal Basin, United States

Hunt, S. R. Surface Subsidence Due to Coal Mining in Illinois. Ph.D. Dissertation, University of Illinois, Urbana, 1980, 129 p.

Subsidence of the land surface has been associated with coal mining in Illinois since the early days of the industry. Illinois Supreme Court rulings dating from 1880 testify to the extent of the concern. However, over the years there has been very little scientific or engineering documentation of subsidence in Illinois. In Europe, on the other hand, knowledge of coal mine subsidence has progressed to a fairly advanced state, for longwall mining in particular. This study began in 1975 as a result of an investigation of roof problems in Illinois coal mines. At that time, inquiries about subsidence in Illinois lead to the realization that the literature only covered longwall mining, which was not practiced in Illinois. In addition, there was virtually no documentation of subsidence events within Illinois. Thus, comparison of subsidence occurrences either within Illinois or between Illinois and other mining districts was impossible. This study was based on a need to document subsidence in Illinois, to identify the conditions causing subsidence, and to establish a basis of characterizing the subsidence that has taken place. The investigation was primarily a field study of subsidence development.

Keyword(s): coal mining, longwall, room-and-pillar, National Coal Board, vertical displacement, geologic features, active mines, abandoned mines, overburden, soils, angle of draw, literature search, high-extraction retreat, roof support, pillar strength, floor stability, roof stability

Location(s): Illinois, Illinois Coal Basin, England, United States

Hunt, S. R., R. A. Bauer, P. B. DuMontelle. Surface Subsidence Due to Coal Mining in the Illinois Coal Basin. U.S. DOE Contract Final Report, Contract No. ET-78-G-01-3085, February 23, 1981, by Illinois State Geological Survey.

The principal goals of the study were to document subsidence case histories in terms of the mode, magnitude, and areal distribution of subsidence movements; identify geologic conditions and mining practices in Illinois and their influence on subsidence; characterize subsidence profiles for various methods of mining in Illinois; produce a data retrieval system for coal mine and subsidence information and case histories in Illinois; and investigate the coordination of land use and various underground mining methods.

Keyword(s): coal mining, abandoned mines, geologic features, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Hunter, J. Pneumatic Stowing at Bullcroft Main Colliery. Transactions Institution of Mining Engineers, v. 105, 1945-46, p. 111.

This paper reviews packing of mined out areas in the subject mine prior to pneumatic backfilling; it also details backfilling devices and methods.

Keyword(s): pneumatic backfilling

Hunter, R. Longwall Mining. IN: Proceedings, 1st National Coal Association/Bituminous Coal Research Symposium on Mining Methods, Harrogate, October 30-November 1, 1974, p. 57-64.

Keyword(s): mine design, ground control, longwall, roof stability, roof support, coal mining

Location(s): United Kingdom

Hurst, G. Avoiding Subsidence Effects in Surface Buildings. Colliery Engineering, v. 25, no. 291, May 1948, p. 158-163; v. 25, no. 292, June 1948, p. 194-198; v. 25, no. 293, July 1948, p. 230-234.

The author describes the effects of subsidence on surface structures with particular emphasis on tensional and compressional forces. Various types of buildings constructed to combat the effects of subsidence are discussed in detail.

Keyword(s): surface structural damage, foundations, engineering, construction, architecture, structural mitigation

Hurst, G. Protection of the Surface in Mining Areas. Colliery Engineering, v. 25, no. 287, January 1948, p. 14-22; v. 25, no. 288, February 1948, p. 43-46.

Keyword(s): surface subsidence damage, ground control

Hurst, G. The Lorraine Coalfield. Colliery Engineering, v. 35, September 1958, p. 374-381; v. 35, October 1958, p. 445-450.

This paper discusses the working of a nearly vertical coal seam in a French coalfield that maintained one of the highest production rates in Europe at the time. The system employed stope caving with hydraulic sand filling.

Keyword(s): hydraulic backfilling, coal mining

Location(s): France

Hurst, G., F. Owen, C. Bayrac. Some Observations on the Behavior of a Large School Subject to Mining Subsidence. Colliery Engineering, v. 43, July, 1966, p. 295-301, and August 1966, p. 343-350.

This paper describes a study of subsidence damage to a school underlain by limestone, which in turn was underlain by mine workings of two seams. The foundation of the school was constructed specially to guard against subsidence effects, but it was still damaged extensively.

Keyword(s): surface structural damage, multiple-seam extraction, foundations, architecture, structural mitigation
Location(s): England

Hurst, R. E., L. D. Boughton. Subsidence Control--Backfilling of Waterfilled Mines. IN: Proceedings Environmental Quality Conference, Washington, D.C., June 7-9, 1971, SME-AIME, Littleton, CO, p. 129-136.
Keyword(s): backfilling
Location(s): United States

Hurst, R. E. Statement Before the U.S. Senate Interior Committee on Minerals, Materials, and Fuels. December 2, 1971.
The author compared controlled and blind backfilling with the Dowell process.
Keyword(s): hydraulic backfilling
Location(s): United States

Hustrulid, W. A. A Review of Coal Pillar Strength Formulas. Rock Mechanics, v. 8, 1976, p. 115-145.
Keyword(s): pillar strength, ground control, rock mechanics, coal mining

Hutchings, R., M. Fajdiga, D. Raisbeck. The Effects of Large Ground Movements Resulting from Brown Coal Open-Cut Excavations in the Latrobe Valley, Victoria. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 136-161.
Large earth movements accompanied the development of brown coal open cut excavations in the Latrobe Valley, Victoria. These movements became widespread over an area exceeding 100 square km since the late 1960s. The main regional movement was subsidence caused by dewatering associated with coal winning. Other factors contributing to the observed earth movements included pressure relief, geometry of the open cuts, geologic structure of the coal deposits, lowering of the free groundwater table close to the open cuts, and water pressures in tension cracks initiating block movements of coal on clay layers.
Keyword(s): ground control, subsurface subsidence damage, surface subsidence damage, coal mining, geologic features, subsurface water
Location(s): Australia

Hyett, A. J., J. A. Hudson. In Situ Stress for Underground Excavation Design in a Naturally Fractured Rock Mass. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 293-300.
This paper discusses the contribution of items related to discontinuities to the total stress variability of a moderately fractured rock mass.
Keyword(s): mine design, rock mechanics, geologic features

Hylbert, D. K. Developing Geological Structural Criteria for Predicting Unstable Mine Roof Rocks. Appalachian Coal Mining Institute, Morehead State University, Contract HO133018, U.S. Bureau of Mines OFR 9-78, 1977, 249 p. (NTIS PB 276-735/AS)
Keyword(s): roof stability, coal mining, geologic features
Location(s): United States

Hylbert, P. K. The Classification, Evaluation, and Projection of Coal Mine Roofs in Advance of Mining. Mining Engineering, December, 1978, v. 30, p. 1667-1676.
Keyword(s): roof stability, coal mining

Hynes, J. L. Tri-Towns Subsidence Investigation, Weld County, Colorado: A Community-wide Approach to Hazard Evaluation and Land Use in Undermined Areas. Colorado Geological Survey Open File Report 87-3, for Division of Mined Land Reclamation, Inactive Mine Program, Department of Natural Resources, Denver, CO, 1984.
This study was undertaken for two principal reasons. The first was a response to requests by local governments to provide them with some usable data to guide them in future land-use decisions in the extensively undermined tracts within their jurisdictions. The second was to use the opportunity to test and evaluate various ideas and theories currently used in data acquisition and analysis of undermined areas, in a sense, to perform a prototype study on which further investigations could rely as a model or guide.
Keyword(s): abandoned mines, coal mining, land-use planning, reclamation, land mitigation, surface structural damage, geologic features, prediction
Keyword(s): Colorado, Rocky Mountain Coal Region, United States

Hynes, J. L. Essential Components of a Mine Subsidence Investigation. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 81-86.

Many factors affect the reliability, accuracy, and usefulness of the results of a subsidence investigation above abandoned mines. Within control of the investigator are several organizational and data acquisition requirements which are critical to the success of the study, including mapping, drilling, down-hole geophysics, sampling and testing, a site survey, and site evaluation.

Keyword(s): abandoned mines, monitoring methods, survey methods, geophysical, surface structural damage, modeling, prediction, lab testing

Location(s): Colorado, Rocky Mountain Coal Region, United States

Hynes, J. L., ed. Proceedings of the 1985 Conference on Coal Mine Subsidence in the Rocky Mountain Region. Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, CO, 1986.

Impacts of subsidence are especially significant in the Rocky Mountain West where population growth and rapid community expansion have increased development pressure on significant areas of subsidence-prone ground. The present consequences of unrecognized and poorly managed subsidence hazards are much more serious in the emerging urban and suburban environment than they were in the past where they occurred primarily in agricultural lands.

Keyword(s): reclamation, abandoned mines, historical, mine fires, surface structural damage, remote sensing, photography, backfilling, grouting, hydraulic backfilling, modeling, prediction, room-and-pillar, monitoring design, structural mitigation, land mitigation, architecture, ground control, land-use planning, insurance, coal mining

Location(s): Rocky Mountain Coal Region, Colorado, Wyoming, United States

IAHS-AIHS. Land Subsidence--Affaissement du Sol. Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publications No. 88 and No. 89.

IASH-AIHS. Land Subsidence Symposium. Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, December, 1976, IASH-AIHS Publication No. 121, 1977.

Iannacchione, A. T. Behavior of a Coal Pillar Prone to Burst in the Southern Appalachian Basin of the U.S. IN: Proceedings, 2nd International Symposium of Rockburst and Seismicity in Mines, Minneapolis, MN, 1988, p. 427-439.

Keyword(s): pillar strength, bumps, coal mining

Location(s): Appalachian Coal Region, United States

Iannacchione, A. T. Numerical Simulation of Coal Pillar Loading with the Aid of a Strain-Softening Finite Difference Model. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, A.W. Khair, ed., 1989, Balkema, Rotterdam, p. 775-782.

Numerical simulation of coal pillar loading has traditionally been a difficult task because of the unique and highly variable properties of coal and the inability of numerical procedures to duplicate these properties. This simulation was based upon material properties developed from laboratory tests of coal cubes and examined against coal pillar strength data developed from actual underground measurements. The coal cube measurements indicated the coal followed a nonlinear Mohr-Coulomb failure criterion. The in situ measurements showed that a pillar yield zone developed similar to Wilson's hypothesis and, at high confinements, the pillar core seemed to follow a psuedo-ductile behavior. The strain-softening model simulated coal cube and pillar behavior at moderate load conditions. However, at high loads the models were inaccurate, due to an inadequate failure mechanism and/or to changes in the pillar constraints at the coalbed interface.

Keyword(s): coal mining, modeling, pillar strength, rock mechanics, lab testing, in situ testing, longwall

Location(s): United States

Iannacchione, A. T. The Effects of Roof and Floor Interface Slip on Coal Pillar Behavior. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, June 18-20, 1990W.A. Hustrulid and G.A. Johnson, eds., Golden, CO, Balkema, Rotterdam, p. 153-160.

This paper discusses the importance of an interface slip mechanism between the coalbed and the surrounding strata in controlling the extent and pattern of stresses and deformations in a coal pillar.

Keyword(s): coal mining, pillar strength, rock mechanics, overburden, modeling, geologic features

Ilijn, A. S. Earth Surface Subsidence at the Areas of Gas and Oil Pumping Out. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, 1977, International Association Hydrological Sciences Publication, v. 121.

Keyword(s): fluid extraction, oil extraction

Illinois Abandoned Mined Lands Reclamation Council. Progress Report, 1979/1980. Abandoned Mined Lands Reclamation Council, Springfield, IL, 1980, 77 p.

In the 2 years covered by this report, the AML Reclamation Council undertook 33 reclamation projects throughout the state. Nine of those were emergencies related to abandoned mines.

Keyword(s): abandoned mines, coal mining, reclamation, structural mitigation, land mitigation, surface structural damage, law

Location(s): Illinois, Illinois Coal Basin, United States

Illinois Abandoned Mined Lands Reclamation Council. Quarterly Progress Report, January 1-March 31, 1981. Abandoned Mined Lands Reclamation Council, Springfield, IL, April 30, 1981, 49 p.

Keyword(s): abandoned mines, structural mitigation, land mitigation, reclamation

Location(s): Illinois, Illinois Coal Basin, United States

Illinois Abandoned Mined Lands Reclamation Council. Quarterly Progress Report, April 1 to June 30, 1981. Abandoned Mined Lands Reclamation Council, Springfield, IL, 1981, 35 p.

This report summarizes activities in the areas of design and reclamation, subsidence, and administration and planning for the quarter.

Keyword(s): abandoned mines, reclamation, coal mining, surface structural damage, structural mitigation, land mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Illinois Abandoned Mined Lands Reclamation Council. Illinois State Reclamation Plan for Abandoned Mined Lands. Abandoned Mined Lands Reclamation Council, Springfield, IL, July, 1980, revised January 1982; supplementary resource document by Southern Illinois University Cooperative Wildlife Research Laboratory, Carbondale (2 volumes).

Section 405 of P.L. 95-87 and the respective Federal Rules identified 18 key elements that must be addressed in a State Reclamation Plan. The Illinois AML Reclamation Council addressed these elements in 18 separate sections contained in this volume.

Keyword(s): abandoned mines, coal mining, reclamation, structural mitigation, land mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Illinois Abandoned Mined Lands Reclamation Council. Mine Subsidence Report, Our Lord's Lutheran Church, Collinsville, Illinois. Abandoned Mined Lands Reclamation Council, Springfield, IL, 1982, 42 p.

Data presented in this technical report are intended to describe the existing site conditions at a church that has been stabilized since an initial subsidence event in 1978. The specific methods of structural repair are being developed by an architect for the church. During the course of this study, data were provided by the AML Reclamation Council to the architect to assist development of plans and specifications for the necessary repair work.

Keyword(s): abandoned mines, coal mining, structural mitigation, surface structural damage, architecture, construction, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Illinois Abandoned Mined Lands Reclamation Council. Quarterly Progress Report, April 1 to June 30, 1983. Abandoned Mined Lands Reclamation Council, Springfield, IL, 1983, 68 p.

This report summarizes design and reclamation, subsidence and emergencies, and planning activities for the designated time period.

Keyword(s): reclamation, abandoned mines, coal mining, surface structural damage, land mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Illinois Abandoned Mined Lands Reclamation Council. Quarterly Progress Report, July 1 through September 30, 1983. Abandoned Mined Lands Reclamation Council, Springfield, IL, 1983, 72 p.

This report summarizes activities in the areas of design and reclamation, including construction grants, subsidence and emergencies, and planning. The Subsidence Response Team responded to 14 inquiries involving potential subsidence and emergency situations; only four were actually subsidence related, and one qualified for emergency abatement.

Keyword(s): abandoned mines, coal mining, structural mitigation, land mitigation, reclamation

Location(s): Illinois, Illinois Coal Basin, United States

Illinois Abandoned Mined Lands Reclamation Council. A Homeowner's Guide to Mine Subsidence in Illinois. State of Illinois, April, 1992.

This brochure describes sag-type subsidence and the services provided by the Abandoned Mined Lands Reclamation Council and the Illinois Mine Subsidence Insurance Fund. It is intended to provide the homeowner with sufficient direction and background information to serve as a starting point in making future decisions.

Keyword(s): abandoned mines, coal mining, surface structural damage, insurance, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Illinois Department of Mines and Minerals. The Surface Coal Mining Land Conservation and Reclamation Act. PA 81-1015, Amendment No. 3, Illinois Register, 1982.

Keyword(s): law, government, reclamation, environment, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Illinois Department of Mines and Minerals. The Surface Coal Mining Land Conservation and Reclamation Act, June 1, 1980. Land Reclamation Division, Springfield, IL, 1983, 40 p.

Section 4.02 gives a brief description of the mine operator's responsibilities for the treatment of subsidence resulting from underground mining in Illinois.

Keyword(s): law, mine operation, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Illinois Department of Mines and Minerals. Citizen's Guide to Coal Mining and Reclamation in Illinois. Land Reclamation Division, Springfield, IL, 1985, 43 p.
Keyword(s): coal mining, active mines, reclamation, structural mitigation, land mitigation, law
Location(s): Illinois, Illinois Coal Basin, United States

Illinois House Executive Subcommittee on Mine Subsidence. Research Report and Recommendations. Illinois Legislative Council, November 29, 1976, 37 p.
This report presents an overview of Illinois subsidence problems and coal mining history, and recommends options to protect homeowners from catastrophic damage.
Keyword(s): government, law, coal mining, surface structural damage, insurance, abandoned mines, land-use planning, active mines
Location(s): Illinois, Illinois Coal Basin, United States

Illinois Mine Subsidence Insurance Fund. Annual Report, 1986. Illinois Mine Subsidence Insurance Fund, Chicago, IL, 1987, 12 p.
In Illinois, insurance against the damage caused to homes and other structures by the collapse of underground mines is handled by the state's private insurance industry, according to guidelines established by the legislature.
Keyword(s): insurance, coal mining, surface structural damage, abandoned mines, active mines
Location(s): Illinois, Illinois Coal Basin, United States

Illinois State Geological Survey, Department of Mining Engineering, University of Illinois, U.S. Bureau of Mines. Preliminary Report on Organization and Method of Investigations. Illinois State Geological Survey, Mining Investigation Bulletin 1, 1913, 71 p.
The 47th Illinois General Assembly and the Secretary of the Department of the Interior authorized an investigation of coal mining under a cooperative agreement between the ISGS, University of Illinois Mining Department, and USBM. It was believed that more efficient mining methods would save a large portion of the coal resources of the state, cut down on the rate of deaths and accidents, and make for safer mining investments. The bulletins that followed described the resources and mining practices throughout the state.
Keyword(s): coal mining, historical
Location(s): Illinois, Illinois Coal Basin, United States

Illinois State Geological Survey. Research Needs of Illinois' Coal Industry. Illinois State Geological Survey, Mining Investigation Bulletin 33, 1930, 89 p.
This report contains seven papers presented at a symposium at the Quarter Centennial of the ISGS. One paper discusses coal recovery and suggests mining systems that would be less wasteful.
Keyword(s): coal mining, historical
Location(s): Illinois, Illinois Coal Basin, United States

Imim, H. I. Memorandum of Evidence to the Committee on Mining Subsidence. Transactions, Institution of Mining Engineers, London, v. 107, 1947, p. 50-64.
This document contains observations and recommendations pertaining to subsidence legislation, legal settlements, building construction, etc., with respect to coal mining.
Keyword(s): law, construction, coal mining
Location(s): United Kingdom

Imim, H. I. A Viscoelastic Analysis of Mine Subsidence in Horizontal Laminated Strata. Ph.D. Dissertation, University of Minnesota, Minneapolis, 1965, 63 p.
Keyword(s): continuum mechanics, modeling, phenomenological model, viscoelastic model

Indraratna, B., S. Naguleswary, A. S. Balasubramaniam. Application of Physical and Mathematical Modelling in Underground Excavations. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 301-308.
The scope of this paper is to introduce a mathematical model based on matrix algebra in order to determine similitude quantities, which can be arranged in specific formats to simulate the field conditions and associated behavior. The formulation of a typical mathematical model applicable to geomechanics is demonstrated here. The examples provided are intended to facilitate comprehension and application of the proposed model in practice.
Keyword(s): modeling, mathematical model, physical model, tunnelling

Ingram, D. K., G. M. Molinda. Relationship Between Horizontal Stresses and Geologic Anomalies in Two Coal Mines in Southern Illinois. U.S. Bureau of Mines RI 9189, 1988, 18 p.

In situ horizontal stresses were measured to determine the influences of geologic anomalies on the regional horizontal stress field in two coal mines in southern Illinois. Stress measurements were obtained near a normal fault having a 121-foot displacement at the AMAX Wabash Mine and a large coalbed want at the Kerr-McGee Galatia No. 5 Mine. Horizontal stress measurements were completed using a USBM borehole deformation gauge. Generally, geologic anomalies appeared to have no dramatic effect on the regional horizontal stresses. However, subtle differences between stress measurements suggest an influence by the fault zone at the Wabash Mine. The larger anisotropic stress conditions at the Galatia No. 5 Mine could be responsible for the increase in kink zones and directional roof failures.

Keyword(s): geologic features, coal mining, active mines, monitoring equipment, roof stability, mine design, roof support

Location(s): Illinois, Illinois Coal Basin, United States

Ingram, D. K., M.A. Trevits, J. S. Walker. A Comparison of Subsidence Prediction Models for Longwall and Room-and-Pillar Conditions. IN: Coal Mining Technology, Economics and Policy 1989, American Mining Congress Coal Convention, Pittsburgh, June 19-21, 1989, p. 545-560.

Keyword(s): prediction, prediction theories, longwall, room-and-pillar, coal mining, active mines

Location(s): United States

Ingram, D. K. Surface Fracture Development Over Longwall Panels in South-Central West Virginia. U.S. Bureau of Mines RI 9242, 1989, 18 p.

This report focuses on the development of large open surface fractures over mined-out coal longwall panels. The research concentrates on defining the fractures characteristics and their controlling variables. The investigation was conducted at two mines in south-central West Virginia.

Keyword(s): coal mining, longwall, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

Ingram, D. K., G. M. Molinda. Geologic Discontinuities and Their Influence on the Regional Horizontal Stress Field in Southern Illinois. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 18-38.

Previous investigations have documented that southern Illinois is influenced by a regional east-northeast to west-southwest horizontal compressional stress field. The USBM measured in situ horizontal stresses to determine the influences of geologic discontinuities on the regional horizontal stress field in two southern Illinois coal mines.

Keyword(s): geologic features, coal mining, roof stability, instrumentation, in situ testing

Location(s): Illinois, Illinois Coal Basin, United States

Ingram, D. K., M. A. Trevits. Characteristics of Overburden Deformation Due to Longwall Mining. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 280-289.

The objective of this investigation was to characterize overburden response due to longwall mining. Subsurface strata and surface deformations were monitored during the mining of two adjacent 900-foot-wide longwall panels in southeastern Ohio.

Keyword(s): overburden, longwall, coal mining, active mines, instrumentation, monitoring methods, monitoring equipment, geologic features, rock mechanics, horizontal displacement, vertical displacement

Location(s): Ohio, Appalachian Coal Region, United States

Institute of Civil Engineering (London) Ground Subsidence. Thomas Telford Ltd., 1977, 99 p.

This book provides guidance to good practice for the civil engineer who is not a specialist in the area of ground subsidence. It is divided into seven sections dealing with the causes and effects of both natural and induced surface subsidence.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, surface water, mine design, backfilling, ground control, engineering

Location(s): England

Institution of Civil Engineers. Report on Mining Subsidence. London, 1959, 52 p.; reprinted 1962.

Four subcommittees were set up to deal with bridges, public utilities, roads, and structures. Each of these subcommittees made extensive inquiries

and studied the various published reports. In some cases experts attended meetings to give evidence. From the information collected, the subcommittees prepared individual reports that were integrated to produce this report. Each subcommittee considered the subject under the following main headings: (1) types of movement, (2) effects of movement, (3) precautionary measures, (4) remedial measures, and (5) research. Certain matters, particularly under (1) and (3), which are commonly applicable, were made the subject of part 1of this report.
Keyword(s): surface structural damage, backfilling, engineering, pillar strength, coal mining, utilities, pipelines, roads, structural mitigation, mitigation, law
Location(s): United Kingdom

Institution of Mining and Metallurgy. CARE '88 Conference on Applied Rock Engineering, Newcastle upon Tyne, January, 1988. Institute of Mining and Metallurgy, Brookfield, VT, No. 0 900488 99 9, 1988, 290 p.
Papers in this volume were written by an international authorship and cover a wide range of subjects dealing with problems in rock engineering, including mine subsidence, backfilling, and monitoring.
Keyword(s): backfilling, engineering, coal mining, metal mining, monitoring methods, mine safety, modeling, prediction, rock mechanics, mine operation, foundations, tunnelling, in situ testing, soil mechanics, lab testing, mine waste
Location(s): Australia, United Kingdom, South Africa, Canada, Finland

Institution of Mining Engineers. Effects of Stowing on Surface Subsidence. Transactions, Institution of Mining Engineers, v. 107, no. 58, 1947.
Keyword(s): stowing

Institution of Municipal Engineers. Report of Special Committee on Mining Subsidence. London, 1947, 80 p.
Keyword(s): United Kingdom

Ireland, R. L., J. F. Poland, F. S. Riley. Land Subsidence in the San Joaquin Valley, California, as of 1980. U.S. Geological Survey Professional Paper 431-I, 1984, 93 p.
Keyword(s): fluid extraction
Location(s): California, United States

Irving, C. J. Some Aspects of Ground Movements. Chemical, Metallurgical, and Mining Society of South Africa Journal, v. 46, May-June, 1946, p. 278-317.
Keyword(s): surface subsidence damage
Location(s): South Africa

Irwin, R. W. Subsidence of Cultivated Organic Soil in Ontario. IN: Proceedings American Society Civil Engineers 103, 1R2, 1977, p. 197-205.
Keyword(s): soils, engineering
Location(s): Canada

Isaac, A. K., P. Neve, T. J. Bradbury. Ground Control in British Longwall Mining. Journal of Mines, Metals & Fuels, September 1983, Special Number on Update on Longwall Mining--Evolving Trends, p. 423-436.
This paper presents a brief review of ground control developments within the British longwall system and highlights two areas of research with which the authors have been closely involved. Some aspects are presented of work conducted in the South Wales Coalfield relating to (1) design of gateroad support at fast retreating longwall faces, and (2) assessment of powered support performance at longwall faces.
Keyword(s): ground control, coal mining, longwall, mine design, roof support
Location(s): United Kingdom, India

Isaac, A. K., B. G. D. Smart, P. Neve, A. D. Mayer. Gateroad Design at Fast Retreating Longwall Coal Faces. IN: Proceedings, 18th International Symposium on Application of Computers and Mathematics in the Mineral Industries, March 26-30, 1984, London, p. 681-693.
The successful application of numerical modeling in the general area of engineering design encouraged the development of a two-dimensional, elastic finite difference model for simulation of strata behavior around the gate roadways of fast retreating longwall coalfaces. An assessment is made of the suitability of such a model for a "soft rock" environment. Emphasis is placed on derivation of input data with a careful assessment of the physical properties of proximate strata and the elements of the permanent support system.
Keyword(s): coal mining, longwall, modeling, mine design, finite element, rock mechanics, monitoring methods, in situ testing, geotechnical, geologic features
Location(s): United Kingdom

Isaac, A. K., I. L. Follington. Geotechnical Influences Upon Longwall Mining. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, 1988, F.G. Bell, et al., eds., p. 233-242.

This paper describes geotechnical influences upon the planning, development, and implementation of the longwall mining system. The effects of these factors have been assessed from a series of comprehensive investigations carried out in the South Wales and South Nottinghamshire Coalfields. All the investigations involved the setting up of monitoring sites employing specially designed instrumentation to monitor the parameters outlined in the paper. In addition, detailed structural and lithological investigations have been carried out involving underground mapping, diamond drilling and logging, geotechnical core logging, and physical rock property determinations.

Keyword(s): longwall, coal mining, geotechnical, monitoring methods, instrumentation, mine design, geologic features, rock mechanics, ground control, floor stability, roof stability

Location(s): United Kingdom

Ishijima, Y., T. Isobe. The Simulation to Analyze Surface Subsidence Using Three Dimensional Finite Element Method. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed. Australasian Institute Mining & Metallurgy, Illawarra Branch, Paper 11, 1973, p. 11-1--11-5.

Finite element method is applied to the model study using a computer to simulate the ground movements caused by mining of a horizontal coal seam. Both "open type" and "closed type" conditions are taken into account as the boundary condition on the periphery of the excavated panel. The rock material is assumed to be elastic; however, the heterogeneous aspect of the strata and the weakening of the stiffness of the rock material by failure are also taken into account. Ground movements including surface subsidence predicted by the proposed model show considerable agreement with the field observations in the coal districts. It is emphasized that a model study taking into account the effect of face advance is needed when the formation of the fractured zone around the excavation is to be simulated.

Keyword(s): finite element, modeling, computer, coal mining, prediction

Location(s): Japan

Ivey, J. B. Guidelines for Engineering Geologic Investigations in Areas of Coal Mine Subsidence: A Response to Land-Use Planning Needs. Bulletin Association of Engineering Geologists, v. 15, no. 2, 1978, p. 163-174.

The discussion is based on work done in the Boulder-Weld coalfield located in central Colorado. However, much of what is discussed and concluded here will apply in principle to other areas in which material is removed from its natural subsurface location, particularly in low dipping bedded sedimentary rocks.

Keyword(s): engineering, land-use planning, coal mining, abandoned mines, surface structural damage

Location(s): Colorado, Rocky Mountain Coal Region, United States

Ivey, J. B. Coal Mine Subsidence, Past, Present, and Future, in the Rocky Mountains. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 1-14.

The emphasis is on Colorado in this paper. Much of what is said, however, generally and philosophically applies to the other Rocky Mountain states. Subsidence is primarily a man-made hazard that has adversely affected many types of man-made works. The potential for additional subsidence effects to be manifested exists particularly in areas where inactive mines are found.

Keyword(s): historical, land-use planning, law, surface structural damage, coal mining, abandoned mines

Location(s): Colorado, Rocky Mountain Coal Region, Wyoming, United States

Jack, B., J. J. Steijn, N. C. Gay. The Effect of Subsidence as a Result of Shallow Mining Operations on Surface Structures--A Quantitative Case Study. Monitoring for Safety in Geotechnical Engineering, August 10, 1984, p. 67-78.

This paper describes the effects of subsidence, as a result of shallow coal mining operations, on structures at ground surface.

Keyword(s): survey methods, geotechnical, photography, instrumentation, surface structural damage, longwall, monitoring equipment, coal mining

Location(s): South Africa

Jack, B. W. Case Studies of the Effects of Surface Subsidence on Gravel and Provincial Bituminous Roads. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 97-114.

Total extraction of coal seams can cause damage to the surface and structures undermined. Roads of various types are the predominant structures that traverse the coalfields of South Africa. Instrumentation and monitoring techniques for case studies are described and the findings given.

Keyword(s): coal mining, monitoring methods, survey methods, instrumentation, roads

Location(s): South Africa

Jack, B. W. The Effects of the Undermining of a Farmhouse by a Longwall Panel and the Subsequent Extraction of the Adjacent Longwall Panel. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 109-114.

A farm complex was recently undermined in the Standerton district. The ground surface and house were monitored to record changes in elevation, tilt, and strain. The condition of the buildings was assessed prior to undermining by one longwall panel and again after the extraction of an adjacent panel separated by a 30-m-wide interpanel pillar. The house was situated inside the extraction area of the first longwall panel, 12 to 35 meters in from the ribside. When the adjacent longwall was extracted, this ribside formed an interpanel pillar. After the initial undermining, the house experienced a small amount of subsidence and a very slight tilt. Extraction of the second panel increased the subsidence above the first panel and induced subsidence above the interpanel pillar. This increased subsidence at the house by a factor of four, at the same time reducing the tilt back to zero. The house was not damaged.

Keyword(s): surface structural damage, longwall, active mines, monitoring methods, horizontal displacement, vertical displacement, instrumentation

Location(s): South Africa

Jackson, G. H., J. H. Soule. Measurements of Surface Subsidence, San Manuel Mine, Pinal County, Arizona. U.S. Bureau of Mines RI 6204, 1963, 36 p.

Keyword(s): monitoring equipment, modeling, metal mining

Location(s): Arizona, United States

Jackson, P. D., D. M. McCann, D. L. Russell. Geophysical Mapping During the Planning of New Roads: An Aid to the Detection of Mine-Workings. IN: Planning and Engineering Geology, Proceedings of 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 447-452.

Magnetic field strength and electrical conductivity surveys have been made over an extensively mined area north of Dalton-in-Furness along parts of a proposed by-pass route. This approach was successful in detecting shafts and other workings, which were brick-lined and back-filled with debris and ash, since the magnetic field and electrical conductivity values are normally higher in the vicinity of such areas.

Keyword(s): abandoned mines, roads, geophysical, land-use planning

Location(s): United Kingdom

Jacobsen, W. E., J. S. Bhutani, J. C. Elliott. Subsidence Monitoring in Conjunction with Underground Mine Flushing Operations. Contract SO144073, Mitre Corp. U.S. Bureau of Mines OFR 34-76, 1975, 154 p. (NTIS PB 250 818)

Keyword(s): monitoring design, backfilling, monitoring methods

Location(s): United States

Jacobsen, W. E., J. P. Morris. Surface Subsidence from Mining--Reduction of Trigonometric Leveling Data. Mitre Corporation, Report MTR-6899, June 1975, 24 p.

Keyword(s): survey data processing

Jacquin, C., M. T. Poulet. Study of the Hydrodynamic Pattern in a Sedimentary Basin Subject to Subsidence. Society of Petroleum Engineers Paper 2988, 45th Annual Fall Meeting SPE-AIME, Houston, TX, 1970.

Keyword(s): hydrology, oil extraction

Location(s): United States

Janes, J. A Demonstration of Longwall Mining. Final Report, U.S. Bureau of Mines Contract JO333949 with Old Ben Coal Company, 1983, OFR No. 86(1)-85, 105 p., and 86(2)-85 (Appendix).

Longwall coal mining had been conducted by Old Ben Coal Company intermittently from June 1962 to April 1970. All six attempts were abandoned before the completion of the entire panel. The most serious problem was failure to control the roof with the chock-type supports available at the time. The USBM and Old Ben entered into a cost-sharing contract to demonstrate longwall mining in the Herrin No. 6 seam in southern Illinois in April 1975. Results obtained from the first panel indicated that roof could be controlled by sheild-type supports.

Keyword(s): longwall, roof support, roof stability, floor stability, coal mining, active mines, rock mechanics, geologic features, mine safety, finite element, geotechnical

Location(s): Illinois, Illinois Coal Basin, United States

Jansen, R. B. Earth Movement at Baldwin Hills Reservoir. ASCE Journal Soil Mechanics & Foundation Division, v. 93, No. SM4, Paper 5330, July 1967, p. 551-575.

Keyword(s): surface water

Jarosz, A., M. Karmis. Control of Surface Movements Above Active Coal Mines in Appalachia. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 122-133.

This study shows that the mining geometry and configuration of panels, as well as the extraction sequence can have a substantial impact on the surface ground movement. As opposed to "fixed" mine design parameters (such as depth or mining height), other parameters are "variable" design parameters and thus can be planned accordingly. Further work must be directed towards improving these principles and examine their practical implementation so that, subsidence control can be included in mine planning and design.

Keyword(s): coal mining, vertical displacement, horizontal displacement, mine design, geologic features, surface structural damage, time factor, prediction, influence function, empirical model, active mines

Location(s): Appalachian Coal Region, United States

Jarosz, A. P. Development of A Computer System for Prediction of Subsidence. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 67-71.

The prediction of subsidence due to underground mining, the assessment of its impact on surface structures, and its control to meet acceptable levels of surface deformations are all important considerations during the mine design process. The paper briefly reviews and compares the different prediction techniques, as well as their advantages and drawbacks. The main focus is placed on the development of a comprehensive computer system, able not only to predict the vertical and horizontal components of the ground movement, but also to assess the induced surface damages and costs related to subsidence prevention and compensation. Such an approach will make it very useful for mine planning and cost analysis of mining operations where protection of the surface and surface structures is required.

Keyword(s): prediction, surface structural damage, prediction, prediction theories, vertical displacement, horizontal displacement, economics, survey data processing, computer

Location(s): South Africa

Jenike, A. W., T. Leser. Caving and Underground Subsidence. Transactions, AIME, v. 223, no. 1, 1962, p. 67-73.

The problems of caving and underground subsidence can be considered as the failure of a highly compacted rock and its subsequent flow in the form of broken rock. The problem is complex because the propagation of failure and flow have to be considered simultaneously; the yield strength of the virgin rock and the broken rock are different; and, while under certain conditions it is sufficient to consider the virgin rock as homogeneous, the density and the yield function of broken rock are both pressure and time dependent.

Keyword(s): rock mechanics, overburden

Location(s): United States

Jenkins, H. C. Gob-Stowing Practices. Transactions, Institute of Mining Engineers, v. 81, 1931, p. 120.
Keyword(s): stowing, mine waste

Jenkins, J. D. Mechanics of Floor Penetration in Mines. Iron and Coal Trades Review, v. 171, no. 4560, 1955, p. 541-547.
Keyword(s): floor stability

Jenkins, J. D. The Bearing Capacities of Mine Floors. Colliery Guardian, v. 195, no. 5039, 1957, p. 397-400.
Keyword(s): floor stability

Jenkins, J. D. Some Investigations into the Bearing Capacities of Floors in the Northumberland and Durham Coalfields. Transactions, Institution of Mining Engineers, v. 117, part II, 1958, p. 725-738.
Keyword(s): floor stability, coal mining
Location(s): United Kingdom

Jenkins, J. R. Some Notes on Science of Roof Caving and Its Practice on Longwall Machine Faces. Transactions, AIME, v. 100, October 1940, p. 2-19.
Keyword(s): mine design, ground control, longwall, roof stability
Location(s): United States

Jennings, J. E., A. B. A. Brink, A. Louw, G. D. Gowan. Sink-Holes and Subsidence in the Transvaal Dolomites of South Africa. IN: Proceedings 6th International Conference on Soil Mechanics and Foundation Engineering, Montreal, 1965, p. 51-54.
Keyword(s): geologic features, soil mechanics
Location(s): South Africa

Jerabek, F. A. Investigations of Segregation in Discharge Fill Slurry and Compressibility of Small Sized Fill Material. M.S. Thesis, Department of Mining, The Pennsylvania State University, 1963.
This paper is an extensive study of size segregation during fill emplacement by hydraulic flushing. The author discusses sedimentation regimes, angle of repose, and compressive strength as related to particle size.
Keyword(s): hydraulic backfilling, lab testing

Jerabek, F. A., H. L. Hartman. Hydraulic Backfilling: A Method of Ground Support. AIME preprint, presented at Annual Meeting, Chicago, IL, February 14-18, 1965.
This paper discusses problems and practical applications of mine backfilling, as well as characteristics and relationships between the deposited fill material and overlying ground.
Keyword(s): hydraulic backfilling, ground control
Location(s): United States

Jerabek, F. A., H. L. Hartman. Mine Backfilling with Pneumatic Stowing. Mining Congress Journal, May and June, 1966.
These articles describe the state of the art of pneumatic backfilling based on European practices, mainly from Germany.
Keyword(s): pneumatic backfilling
Location(s): Germany, Europe

Jeran, P. W., T. M. Barton. Comparison of the Subsidence Over Two Different Longwall Panels. IN: Mine Subsidence Control, Proceedings Bureau of Mines Technology Transfer Seminar, Pittsburgh, September 19, 1985, U.S. Bureau of Mines IC 9042, p. 25-33.
The subsidences over two longwall sections operating in the northern Appalachian coal region were monitored. The panels differed in dimensions, overburden thickness, and coalbed mined. Although the final subsidence profiles differed, analysis of the data indicated the same process of subsidence operated at each panel.
Keyword(s): longwall, survey data processing, coal mining
Location(s): Pennsylvania, West Virginia, Appalachian Coal Region, United States

Jeran, P. W., V. Adamek. Subsidence Over Chain Pillars. IN: Eastern Coal Mine Geomechanics, Proceedings Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, November 19, 1986, U.S. Bureau of Mines IC 9137, p. 65-71.
Subsidence over two or more adjacent longwall panels and the intervening chain pillars was monitored at four mines in the Northern Appalachian Coal Basin. The magnitude of the subsidence over the chain pillars ranged from 0.06 to 1 foot. The width of the chain pillars affects the shape of the subsidence curve. Wider chain pillars yield a wider area of minimum subsidence. Comparison of the field-measured subsidence with precalculated subsidence over the chain pillars indicates a range of pillar deformation. The data show that, at three of the sites, additional subsidence was induced over the first panel by the mining of the second panel. Curves of the additional

subsidence are similarly shaped for these sites. This indicates that a model to predict subsidence over chain pillars could be developed with sufficient data.

Keyword(s): coal mining, pillar strength, mine design, surface subsidence damage, prediction, geologic features, survey equipment, survey equipment, survey data processing

Location(s): Pennsylvania, West Virginia, Appalachian Coal Region, United States

Jeran, P. W., V. Adamek, M. A. Trevits. A Subsidence Prediction Model for Longwall Mine Design. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 3-8.

Lithological conditions over the Pittsburgh Coalbed cause the subsidence coefficient to vary within the area of the subsidence trough. This precludes the use of European predictive models, which are based upon a constant subsidence coefficient. Regression analysis of the distribution of subsidence coefficients from 11 USBM longwall panel studies on the location relative to the edge of the panel has yielded a third degree polynomial equation. This equation has been incorporated into a BASIC computer program for use on a PC, which allows users with no previous knowledge of the theory of subsidence to predict vertical movements over typical longwall panels in the northern Appalachian coal basin.

Keyword(s): prediction, longwall, coal mining, mine design, geologic features, computer, angle of draw, overburden, modeling

Location(s): Appalachian Coal Region, United States

Jeran, P. W., V. Adamek. Subsidence Due to Undermining of Sloping Terrain: A Case Study. U.S. Bureau of Mines RI 9205, 1988, 10 p.

Subsidence over a series of longwall panels undermining sloping terrain in southwestern Pennsylvania was monitored to verify the USBM subsidence prediction model for the northern Appalachian coal region. Comparison of the field data to model output showed close agreement. Vertical movements over each panel ceased with the mining of the adjacent panel. Horizontal movements were significantly affected by topographic slope. The distribution of horizontal strains over each panel were similar, with a zone of compression occurring over the center of each panel. The zones of compression were flanked by zones of tension toward the rib. The magnitude of the tensions were affected by the slope. The strains developed at the completion of each panel were not significantly altered by the mining of subsequent panels.

Keyword(s): longwall, prediction, modeling, coal mining, geologic features, horizontal displacement, vertical displacement

Location(s): Pennsylvania, Appalachian Coal Region, United States

Jeran, P. W., V. Adamek. Subsidence Over the End of a Longwall Panel. U.S. Bureau of Mines RI 9338, 8 p.

Subsidence was monitored by the USBM over the ends of longwall panels operating in the Pittsburgh, Kittanning, and No. 2 Gas Coalbeds of the northern Appalachian Coal Basin. The final subsidence over the finishing ends of three panels in the Pittsburgh Coalbed are compared with the subsidence measured over the rib. The characteristics of subsidence are different. Data from the start of a longwall panel shows similar characteristics to the subsidence measured over the rib. A subsidence prediction model based on data gathered over the rib of a panel will not yield accurate results if it is applied to the finishing end of a longwall panel. Acceptable results may be obtained along the centerline over the starting end of a panel.

Keyword(s): monitoring methods, longwall, coal mining, active mines, prediction, modeling

Location(s): West Virginia, Pennsylvania, Appalachian Coal Region, United States

Jeremic, M. L. Subsidence Problems Caused by Solution Mining of Rock-Salt Deposits. IN: Proceedings 10th Canadian Rock Mechanics Symposium, Kingston, September 2-4, 1975, Department of Mining Engineering, Queen's University, v. 1, p. 203-223.

Several things make it difficult to estimate subsidence that will result from solution mining. Unlike the excavations formed by underground mining methods, the outlines of the cavities formed by solution mining are not controlled and generally are not accurately known, although overall recovery can be determined (often about 12% of the formation). Moreover, the rheological properties of the assemblage of rocks and overburden above the extraction horizon and the nature of the existing stress fields are usually unknown. For these reasons, forecasts of subsidence caused by solution mining are often made by analogy with known occurrences.

Keyword(s): non-metal mining, rock mechanics, prediction, surface structural damage
Location(s): Yugoslavia, Canada

Jeremic, M. L. Influence of Shear Deformation Structures in Coal on Selecting Methods of Mining. Rock Mechanics, v. 13, 1980, p. 23-28.
Keyword(s): coal mining, rock mechanics, mine design

Jermy, C. A., F. G. Bell. Coal Bearing Strata and the Stability of Coal Mines in South Africa. IN: Proceedings International Congress on Rock Mechanics, Aachen, 1991, W. Wittke, ed., v. 2, p. 1125-1131.

Subsurface coal mining is affected by a number of properties of the strata involved: the lithological character of the rocks immediately above and below the coal seam; the sedimentary features contained within the strata; the mechanical properties of the rocks involved, notably their strength and deformation moduli; the durability of the rocks on exposure; and the incidence and geometry of discontinuities. Accordingly, core material was obtained from a number of coalfields in South Africa to investigate the influence of certain rock properties on the roof and floor stability of mines. This showed the existence of numerous distinct sedimentary facies that have different character and geotechnical properties which, in turn, influence the design and development of mines.
Keyword(s): geologic features, coal mining, mine design, floor stability, roof stability
Location(s): South Africa

Jessop, J. A., R. E. Thill. Engineering Properties of Coal Measure Rocks in the Danville Region of the Illinois Basin. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, v. 2, p. 18-26.

Coal mining operations require information of engineering property data for all phases of mining from exploration through processing and waste disposal. Such properties are of particular concern in mine planning and design. As part of an effort by the USBM to obtain representative engineering properties for major coal-producing regions in the United States, a program was undertaken to determine the mechanical and geophysical properties of roof, floor, and overburden rocks for coal mines in the Illinois Basin. Example applications for the use of the data in mining are given for assessing pillar, roof, and floor instability.
Keyword(s): coal mining, geotechnical, geophysical, rock mechanics, engineering, roof stability, pillar strength, floor stability, modeling, abandoned mines, active mines, lab testing, in situ testing, ground control, geologic features
Location(s): Illinois, Illinois Coal Basin, United States

Jessop, J. A., C. L. Cumerlato, K. M. O'Connor. Characterizing Longwall Coal Mine Subsidence with High Resolution Seismic Reflection. IN: Proceedings, 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 391-400.

High-resolution seismic-reflection surveys were conducted at a coal mine site in southern Illinois. Premine and postmine surveys conducted above longwall panels consisted of common-depth-point data collection. Drill core and sonic logs from a nearby borehole and mine maps were used in the interpretation of the data. Processed sections show a number of interesting features that may aid in characterizing subsurface subsidence. The mined and unmined areas at these sites are clearly discernible, and seismic signatures associated with fracture zones and voids can be interpreted. In addition, reflection events from subsided areas have been identified that corroborate recently advanced theories of bridging potential of the overburden.
Keyword(s): seismic, overburden, longwall, coal mining, geophysical
Location(s): Illinois, Illinois Coal Basin, United States

Ji-xian, C. The Effects of Mining on Buildings and Structural Precautions Adopted. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 404-419.

The paper gives a general description of Chinese practice during the past two decades for coal mining under surface structures. Reference is made to the effects induced by surface strain, the structural precautions used and their effectiveness, and basic guidelines for use when mining under buildings.

Keyword(s): surface structural damage, coal mining, active mines, structural mitigation, horizontal displacement, vertical displacement
Location(s): China

Jian, Z., L. Monglin. Computer Program for Use in Designing Masonry Buildings in a Subsidence Region. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 338-343.

Studies of structural calculations for buildings in subsidence regions are relatively rare. In many countries, masonry buildings are often encountered in subsidence regions. For these reasons a computer program has been developed for the purpose of calculating the stresses and strains in masonry structures in subsidence regions.

Keyword(s): surface structural damage, coal mining, finite element, foundations, horizontal displacement, prediction
Location(s): China

Jingmin, X., E. Topuz. A Simulation Model for Longwall Mining Operations. SME-AIME Preprint No. 83-387, SME-AIME Fall Meeting and Exhibit, Salt Lake City, UT, October 19-21, 1983, 7 p.

This paper is to develops a stochastic model to simulate the production operations in longwall mining. The activities and parameters that affect the production potential of the longwall operations and the relationships between the activities are identified. An attempt is made to verify these relationships through the use of existing data. The model is then used as a computer simulator to investigate the effects of various activities and parameters on the production capacity of a panel.

Keyword(s): modeling, longwall, stochastic model, coal mining, computer

Jixian, C., H. Leting. Study of Deformation Resistant Structural Systems for Buildings in Coal Mining Areas. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 356-369.

This paper presents a description of the study of deformation resistant structural systems for buildings in mining areas. The technology has been applied successfully in several areas in China for various kinds of one- to five-story buildings of reinforced brick. In each of the areas mentioned, mining operations were carried out in one to five seams that were nearly level, inclined, or steeply inclined. Comprehensive observations were conducted of various movements, deformations, and stresses experienced by the ground surface and the buildings during subsidence. A large amount of measured data was obtained.

Keyword(s): surface structural damage, coal mining, structural mitigation, active mines, multiple-seam extraction, foundations, construction
Location(s): China

Johnson, A. M., R. J. Hodek, G. E. Frantti. Piping Induced Subsidence Over an Underground Mine. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., West Virginia University, 1982, p. 268-273.

Researchers at Michican Technological University have been studying mine subsidence in the Iron River District of Northern Michigan since 1974. The district, which was active from 1881 to 1978, has had numerous cases of subsidence. Much of the subsidence resulted from rock mass failure, but some appeared to have developed primarily in the thick glacial overburden, which is a typical feature of this area. This latter observation led to the recognition that some of the surface subsidence was due to piping, i.e., loss of overburden material to the mine voids by groundwater flow.

Keyword(s): abandoned mines, metal mining, overburden, subsurface water, monitoring methods
Location(s): Michigan, United States

Johnson, C. J., C. J. Bise. Determining the Effects of New Technology on Room-and-Pillar Productivity. Mining Engineering, January 1989, v. 41, no. 1, p. 45-47.

As the coal industry in the United States moves into the next century, it is becoming more apparent that the effective application of new technology is the only way it can remain competitive in the energy marketplace. The focus of this new technology is directed toward improvements in health and safety, cost control, and productivity. Room-and-pillar mining accounts for approximately 68% of the nation's underground coal production; this percentage is not expected to decrease markedly in the near future. As such, this paper analyzes the impacts of the changing technological climate on future room-and-pillar operations by comparing a base-case section (current) to three scenarios incorporating new or emerging technology.

Keyword(s): coal mining, economics, room-and-pillar, mine safety

Location(s): United States

Johnson, G. H., J. H. Soule. Measurement of Surface Subsidence, San Manuel Mine, Pinal County, Arizona. U.S. Bureau of Mines RI 6204, 1963.

This report discusses an investigation of the surface effects of block caving used in an Arizona copper mine. Surface survey methods included reference pins, triangulation surveying, and air photographs.

Keyword(s): survey methods, monitoring equipment, photography, surface subsidence damage, metal mining

Location(s): Arizona, United States

Johnson, J. C., M. E. Poad. Premining Stability Analysis of a Shaft Pillar at the Homestake Mine. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 175-182.

High-grade ore found in a shaft pillar at the Homestake Mine prompted a request for a USBM study to determine if selected areas of the shaft pillar could be mined without jeopardizing the shaft. The design approach was to perform a finite-element study of the shaft pillar. Plan view and vertical sections were developed using two-dimensional, elastic, plane strain assumptions. Input into the model consisted of in situ stress measurements, geologic mapping, rock mass properties, and previous mining history. Results from the study indicated that ore-bearing sections of the shaft pillar could be removed within the displacement tolerances acceptable for the shaft.

Keyword(s): metal mining, pillar extraction, finite element, geologic features, rock mechanics, engineering, modeling

Location(s): South Dakota, United States

Johnson, J. R. Reclamation of Abandoned Mine Site. ASCE Journal of Environmental Engineering Division, v. 105, June, 1979, p. 597-603.

Public Act 78-1293 provided for the creation of the Abandoned Mined Lands Reclamation Council (AMLRC). In early 1976, the AMLRC began to address the problem of restoring the thousands of wasted acres of abandoned mine properties, both surface and underground, to renewed productive uses. From the initial list of approximately 50 sites recommended by reclamation experts in Illinois, the Council selected three underground sites to be reclaimed in accordance with the new law.

Keyword(s): abandoned mines, reclamation, law, environment, historical, economics, mine waste

Location(s): Illinois, Illinois Coal Basin, United States

Johnson, K. L. Influence of Topography on the Effects of Longwall Mining on Shallow Aquifers in the Appalachian Coal Field. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, S.S. Peng, ed., June 1-4, 1992, Morgantown, WV, p. 197-203.

Networks of monitoring wells were established prior to mining at four longwall mine sites in the Appalachians to monitor the effect of mining on water levels, water quality and well yield. Two of the sites were located in stream valleys and the other two sites were located on hilltops.

Keyword(s): subsurface water, hydrology, longwall, active mines, coal mining, monitoring methods, modeling

Location(s): Appalachian Coal Region, United States

Johnson, K. S. Development of the Wink Sink in West Texas Due to Salt Dissolution and Collapse. IN: Karst Hydrogeology: Engineering and Environmental Applications. Proceedings 2nd Multidisciplinary Conference on Sinkholes and the Environmental Impacts of Karst, Orlando, 1987, B.F. Beck and W.L. Wilson, eds., Balkema, Rotterdam, p. 127-136.

Keyword(s): hydrology, geologic features, engineering

Location(s): Texas, United States

Johnson, W., G. C. Miller. Abandoned Coal-Mined Lands: Nature, Extent, and Cost of Reclamation. U.S. Bureau of Mines, Special Publications, 6-79, no. 3, 1979.

Keyword(s): reclamation, abandoned mines, economics, coal mining

Location(s): United States

Johnson, W. L., T. P. Brunsing, G. F. Dana. An Area Wide Approach to Ground Stabilization. IN: Proceedings, Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 307-328.

This paper describes drilling and cementatious grouting projects undertaken in Rock Springs, Wyoming, in an attempt to stabilize residential units on an individual structure basis.

Keyword(s): coal mining, abandoned mines, mitigation, grouting, structural mitigation, historical, pillar extraction, surface structural damage, geologic features, overburden

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Johnston, G. C. Subsidence and Pillar Recovery in West Area of Marquez Mine, New Mexico. New Mexico Bureau of Mines Mineral Research Memoir No. 15, 1963, p. 256-263.

Keyword(s): pillar extraction

Location(s): New Mexico, United States

Jones, C.J.F.P. The Performance of a Clasp System School Subjected to Mining Subsidence. M.S. Thesis, University of Newcastle-Upon-Tyne, 1963.

Keyword(s): architecture, construction, surface structural damage, coal mining, structural mitigation

Location(s): United Kingdom

Jones, C.J.F.P., J. B. Bellamy. Computer Prediction of Ground Movements Due to Mining Subsidence. Geotechnique, v. 23, no. 4, 1973, p. 515-530.

This article examines a method of determining displacement, strain, and stress components of ground deformation due to underground mining based upon the theory of elasticity and the principle of superposition.

Keyword(s): vertical displacement, horizontal displacement, prediction, computer

Jones, C.J.F.P., W. J. Spencer. The Implications of Mining Subsidence for Modern Highway Structures. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 515-526.

The M1 and M62 motorways in Yorkshire pass through active coalfields. It was recognized during the initial design stages of these roads that bridges and structures would be subject to large ground movements caused either by the collapse of old uncharted mine workings or as a result of active mining. To cater for this, it was established that (1) methods of predicting the extent of the ground movement would have to be developed and (2) design techniques able to accommodate these movements would be required to prevent damage or even the collapse of the bridges and structures to be built on the motorway.

Keyword(s): engineering, construction, roads, active mines, abandoned mines, coal mining, empirical model, prediction

Location(s): United Kingdom

Jones, C.J.F.P., T. D. O'Rourke. Mining Subsidence Effects on Transportation Facilities. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 107-126.

This paper presents case history information about mining subsidence effects on transportation facilities, including bridges, pavements, and culverts. Most of the field observations pertain to longwall coal mining in the United Kingdom, with commentary on how these experiences may apply to practice in the United States. Mining subsidence deformations are discussed in relation to the lengths of affected structures.

Keyword(s): roads, longwall, coal mining, National Coal Board, room-and-pillar, horizontal displacement, surface structural damage, engineering, active mines, abandoned mines

Location(s): United Kingdom, United States

Jones, D. B., H. J. Siddle, D. J. Reddish, B. N. Whittaker. Landslides and Undermining: Slope Stability Interaction with Mining Subsidence Behaviour. IN: Proceedings International Congress on Rock Mechanics, Aachen, 1991, W. Wittke, ed., v. 2, p. 893-898.

The paper reports on the findings of research into the relationship between landslide phenomena and the process of undermining sloping ground surfaces in the South Wales Coalfield. The analyses involved examination of field data from landslide sites supported by a program of investigations using physical and numerical modeling. Interaction of mining and geological influences is demonstrated to be significant. General principles of stability and the response of hill slopes to undermining are discussed.

Keyword(s): geologic features, coal mining, physical model, modeling, finite element

Location(s): Wales, United Kingdom

Jones, D. C., J. W. Hunt. Coal Mining. The Pennsylvania State University, State College, v. 3, 1950, 535 p.

Keyword(s): backfilling, coal mining

Location(s): United States

Jones, D. H. Two Case Histories of Ground Instability Caused by the Interaction Between Brick Clay Quarrying and Underground Mining. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 39-45.

Two case histories are presented to illustrate the geotechnical interactions occurring between relatively shallow quarrying for brickmaking materials and underground mining operations. Although the intervening vertical distances between the different quarry floors and the underground workings may differ from less than 20 meters to more than a kilometer, sinkholes are a common occurrence. Brief diagnoses are made of the mechanisms responsible for the unstable ground conditions in each instance.

Keyword(s): geotechnical, non-metal mining, abandoned mines, subsurface water, coal mining, metal mining, surface structural damage

Location(s): South Africa

Jones, S. Pneumatic Backfilling--A Method for Controlling Abandoned Mine Subsidence. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 215-219.

Minor subsidence damage to a school building and grounds in Pennsylvania prompted an investigation of a site. This investigation determined that subsidence over an abandoned coal mine was occurring and that additional damaging subsidence would occur if reclamation measures were not taken.

Keyword(s): pneumatic backfilling, abandoned mines, surface structural damage, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Jones, T. J. Strata Movements Induced by Mining. Transactions, Institute of Mining Surveyors, January, 1945, v. 25, Pt. 1.

Keyword(s): subsurface subsidence damage

Jones, T. Z., K. K. Kohli. Subsidence Over a Room and Pillar Mine in the Appalachian Coal Province and the Use of Subsidence Predictive Methods--A Comparative Analysis. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 179-187.

This paper summarizes the results of a subsidence monitoring program, and provides a comparative analysis of the subsidence data collected with three popular subsidence prediction models that have been used in the region. The monitoring was conducted over a room-and-pillar panel in south-central West Virginia.

Keyword(s): prediction, prediction theories, modeling, National Coal Board, profile function, finite element, room-and-pillar, monitoring design, survey data processing, coal mining, empirical model, angle of draw

Location(s): West Virginia, Appalachian Coal Region, United States

Joshi, R. C., D. W. Horsfield. Surface Subsidence Due to Water Seepage and the Presence of Old Mine Workings in Southern Alberta, Canada. IN: Land Subsidence, Proceedings, 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., IAHS Publication No. 151, 1986, p. 669-673.

Surface subsidence, caused by underground coal extraction and subsequent flooding of the mine by groundwater, has occurred in southern Alberta, Canada. Records of mining activity in the area are incomplete, complicating the evaluation of the overall stability and safety of the site.

Keyword(s): railroads, abandoned mines, coal mining, geologic features, historical, room-and-pillar, floor stability, roof stability, time factor, surface structural damage, utilities

Location(s): Canada

Josien, J. P. Methods of Investigation in Longwall Faces. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 23, 1975, p. 341-345.

Keyword(s): longwall, rock mechanics

Jung, J., H. H. Jung. Safeguarding Structures in Subsidence Areas. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 411-429.

Developments in mining techniques, especially great increases in the speed of mining, have lead to a measurable increase in deformations at the ground surface, causing undulations or discontinuities and subsequently heavy damage to buildings and structures, sometimes even to the

point of their total loss. Buildings sensitive to deformation e.g. without sufficient elasticity, to be erected in areas of extreme subsidence movements have to be made safe in their entirety. Such a procedure is not acceptable for most of these buildings for economic reasons.

Keyword(s): surface structural damage, active mines, structural mitigation, foundations, horizontal displacement, soils, vertical displacement, coal mining

Location(s): Germany

Juntunen, R., M. Hiel, B. Mundie. Reclaiming Orphaned Lands Using a Pneumatic Backfill Process. American Society of Agricultural Engineers Summer meeting, Bozeman, MT, June 26, 1983, ASAE Paper No. 83-2035, 12 p.

Keyword(s): pneumatic backfilling

Kalia, H. N. Understanding Coal Geology Can Improve Underground Mine Productivity and Safety. Presented at AIME Annual Meeting, Las Vegas, NV, February 22-26, 1976. Preprint No. 76-AM-19, 14 p.

Keyword(s): mine safety, geologic features, coal mining

Location(s): United States

Kane, W. F., R. M. Bennett, P. A. Lee. Testing Program for Earth-Structure Analysis of Mine Subsidence. Report for U.S. Bureau of Mines Contract Number SO27058 and Illinois Mine Subsidence Insurance Fund, Geomechanics Engineering Group, Department of Civil Engineering, University of Tennessee, Knoxville, March 1988, 55 p.

In order to fully characterize material behavior at an Illinois subsidence test foundation site, a series of tests were performed. The results will be used in future numerical analysis of subsidence events. An extensive series of direct shear tests indicate that the construction technique of using sand and plastic under the foundation to minimize mining-induced damage may not be necessary for all situations. The ideal interface is a function of the stiffness and shear strength parameters.

Keyword(s): foundations, active mines, soil mechanics, engineering, soils, coal mining, surface structural damage, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Kane, W. F., T. L. Triplett, R. E. Yarbrough, E. W. Murphy. Earth-Structure Interaction Analysis for Subsidence Damage Mitigation. IN: Proceedings, Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 79-98.

Keyword(s): structural mitigation, foundations, computer, insurance, surface structural damage, modeling, finite element, high-extraction retreat, soils, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Kane, W. F., R. M. Bennett, E. C. Drumm. Construction and Instrumentation of Test Foundations for Subsidence Damage Assessment. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 311-321.

Research into the effects of subsidence on structures is limited. A site above a longwall panel in southern Illinois was selected to construct test foundations. Several shallow foundation designs were built to investigate various damage mitigation schemes. Foundation designs included the use of plain concrete, reinforced concrete, post-tensioned concrete, concrete with plastic and sand underlayment, and concrete mixed with steel fibers. The project includes six parallel strip foundations at two test sites: one group is on the centerline of the approaching longwall panel and the other is in the predicted zone of maximum tension. To measure behavior during the event, the foundations and surrounding soil were monitored with survey monuments, strain gages, tilt meters, extensometers, soil strain gages, and inclinometers.

Keyword(s): foundations, coal mining, active mines, construction, instrumentation, surface structural damage, longwall, structural mitigation, architecture, finite element, computer, survey methods, horizontal displacement, vertical displacement, monitoring equipment, monitoring methods

Location(s): Illinois, Illinois Coal Basin, United States

Kaneshige, O. Methods of Underground Excavation to Avoid Damage to Existing Structures or Their Removal Because of Subsidence. IN: Geological and Geographical Problems of Areas of High Population Density, Proceedings of Symposium at Annual Meeting of Association of Engineering Geologists, Washington, D.C., October 23, 1970.

The author reviews subsidence parameters and specific Japanese mining considerations such as high population densities, dipping seams, and local geology. In reference to preventing or reducing subsidence damage, the author discusses safety pillars, a pillar system of coal mining, full stowing, and harmonic extraction. Various applications of these methods are reviewed.

Keyword(s): ground control, pillar strength, stowing, land-use planning, surface structural damage

Location(s): Japan

Kanlybayeva, Z. M. Dynamics of Displacement of a Stratum Under the Influence of Working Gently Dipping Coal Seams Based on Geological Data. IN: Proceedings 4th International Conference on Strata Control and Rock Mechanics, May 4-8, 1964, Henry Krumb School of Mines, Columbia University, New York, 1965, Supplementary volume, 12 p.

Keyword(s): coal mining, geologic features, ground control

Kantner, W. H. Surface Subsidence Over the Porphyry Caving Blocks, Phelps Dodge Corporation, Copper Queen Branch. AIME Technical Publication 552, 1934, 13 p.; also, Transactions, AIME, v. 109, 1934, p. 181-194.
Keyword(s): metal mining, surface subsidence damage
Location(s): United States

Kapp, W. A., R. C. Williams. Extraction of Coal in the Sydney Basin from Beneath Large Bodies of Water. IN: Proceedings, Conference of the Australasian Institute of Mining & Metallurgy, 1971.
Keyword(s): surface water, subsurface water, coal mining
Location(s): Australia

Kapp, W. A. Subsidence Due to Underground Coalmining. Mine and Quarry Mechanisation, 1972, p. 115-121.
This paper presents general characteristics of subsidence over underground coal mines, including subsidence mechanics, surface effects and protection, and precautions for mining under water.
Keyword(s): surface structural damage, mine design, coal mining, surface water
Location(s): Australia

Kapp, W. A. Mine Subsidence. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute Mining & Metallurgy, Illawarra Branch, Paper 1, p. 1-1 - 1-9.
Ground movements occur in areas where fluids or minerals are removed from below the surface. The types of movements and their magnitudes depend mainly on the nature and extent of the mining operation.
Keyword(s): coal mining, metal mining, fluid extraction, vertical displacement, horizontal displacement, geologic features

Kapp, W. A. Subsidence Kemira Colliery, New South Wales. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute Mining & Metallurgy, Illawarra Branch, Paper 7, p. 7-1 - 7-9.
Subsidence investigations are being conducted over longwall panels and areas of pillar extraction in the coalfields around Sydney. The investigations will assist in future mine planning in areas where surface movement should be considered. One of the subsidence studies is at Kemira Colliery, where the investigations covered five longwall panels. The surface is rugged over these panels, and the depth of cover over the seam varies considerably. Some surface cracking developed. The maximum observed subsidence was 1.1 meters, and the pillars that were left between the panels affected the subsidence profile. The curves associated with the subsidence movements were calculated from the survey observations and show the effects of surface topography, geology, and the mining operations on ground movements. A comparison of the observed movements with corresponding predicted values shows that there was significantly less subsidence than that expected from the calculated values.
Keyword(s): surface subsidence damage, coal mining, longwall, pillar extraction, survey data processing, prediction, surface water
Location(s): Australia

Kapp, W. A. Study and Evaluation of the Elements of Surface Subsidence Observed at Kemira Colliery, New South Wales. M.S. Thesis, University of Sidney, Australia, 1974, 105 p.
Keyword(s): coal mining
Location(s): Australia

Kapp, W. A. The Characteristics of Subsidence Due to Underground Coal Mining at Newcastle, New South Wales. International Association of Hydrological Sciences Publication 121, 1976, p. 409-421.
Keyword(s): coal mining
Location(s): Australia

Kapp, W. A. The Characteristics of a Subsidence Trough Over an Area of Underground Coal Mining. IN: Proceedings, 2nd International Symposium on Land Subsidence, No. 2, December 13-17, 1976, Anaheim, CA. (NTIS Accession No. 78-03117)
Keyword(s): coal mining
Location(s): Australia

Kapp, W. A. Subsidence Investigations in the Northern Coalfield, New South Wales, and Their Application to the Design of Mine Layouts in Residential Areas. Presented at 11th Commonwealth Mining and Metallurgy Congress, Hong Kong, May 1978, Institute Mining and Metallurgy, London, Paper 32, 11 p.

This paper summarizes results of subsidence surveys over longwall, shortwall, and room-and-pillar panels in New South Wales, Australia. Underground extraction is related to surface subsidence.

Keyword(s): vertical displacement, horizontal displacement, mine design, coal mining, longwall, shortwall, room-and-pillar

Location(s): Australia

Kapp, W. A. A Study of Mine Subsidence at Two Collieries in the Southern Coalfield, New South Wales. IN: Proceedings, Australasian Institute Mining & Metallurgy, no. 276, December, 1980, p. 1-11.

Urban development to the south of Sydney is approaching areas of current and proposed coal mining. Already some structures and residential areas are affected by mining subsidence. Subsidence resulting from either conventional pillar extraction methods or longwall mining has been monitored for 15 years to enable the characteristics of the surface deformation to be determined. The vertical and horizontal displacements of survey stations on the surface are monitored and the results are used to calculate subsidence, changes in slope of the surface, curvatures along the subsidence profile, and the tensile and compressive strains. These features are in turn related to the underground extraction to give a description of surface subsidence and the development of subsidence with time.

Keyword(s): coal mining, vertical displacement, horizontal displacement, active mines, monitoring methods, time factor, longwall, pillar extraction

Location(s): Australia

Kapp, W. A. Subsidence from Deep Longwall Mining of Coal Overlain by Massive Sandstone Strata. IN: Proceedings, Conference of Australasian Institute Mining & Metallurgy, July, 1981, Sydney, New South Wales, p. 229-246.

Mining is taking place at increasing depths of cover on the Southern Coalfield beneath predominantly massive sandstone strata. Within the next 20 years, there will be longwall mining at depths greater than 600 m. As the Sydney metropolitan area continues to expand and as coal mining approaches these urban areas subsidence will continue to become an increasingly important aspect of coal mining research.

Keyword(s): longwall, coal mining, geologic features, prediction, surface structural damage, land-use planning, pillar extraction, survey methods, vertical displacement, horizontal displacement, pillar strength, monitoring methods, pipelines

Location(s): Australia

Kapp, W. A. A Review of Subsidence Experiences in the Southern Coalfield, New South Wales, Australia. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, September, 1982, Y.P. Chugh and M. Karmis, eds., SME-AIME, p. 167-182.

Coal is being mined from beneath residential areas, structures, bodies of water and other surface features in the coalfields to the north, south and west of Sydney. The particular problems faced by mine operators in these areas vary considerably due to differences in the overlying strata, the variation in the depths of cover and also depend on the number of seams being mined.

Keyword(s): coal mining, surface structural damage, surface water, geologic features, multiple-seam extraction, prediction, empirical model, inflow

Location(s): Australia

Kapp, W. A. Mine Subsidence in the Newcastle District, New South Wales. Transactions Institution of Engineers, Australia, CE27, no. 4, 1985, p. 331-340.

Coal is being mined from seams below urban areas around the City of Newcastle. When subsidence occurs as a result of this mining, homes and other structures can be affected. The massive and strong conglomerates of the Newcastle area have a significant effect on the value of the maximum subsidence, and an empirical method to predict subisdence and strain has been developed. Panel and pillar mining layouts are designed for maximum coal recovery consistent with small values of maximum subsidence. Longwall extraction is now taking place, using empirically established guidelines, beneath the Pacific Ocean, Lake Macquarie, and their shorelines.

Keyword(s): coal mining, prediction, empirical model, survey methods, vertical displacement, horizontal displacement, surface structural damage, geologic features, longwall

Location(s): Australia

Kapp, W. A. Mine Subsidence in New South Wales: Its Effects on Surface Features and Structures. IN: Proceedings, SANGORM Symposium: The Effect of Underground Mining on Surface, Sandton, South Africa, October, 1986, International Society for Rock Mechanics-South African Group, 18 p.

Coal is being mined from beneath residential areas, structures, bodies of water and other features in the coalfields to the north, south and west of Sydney. The mining layout and the local geological setting are the two main factors influencing the nature of ground movements and subsidence. Locally established empirical guidelines assist in the planning of mine layouts in areas where subsidence is an important consideration.

Keyword(s): surface structural damage, coal mining, pillar extraction, surface water, mine design, finite element, mathematical model, modeling, land-use planning, inflow

Location(s): Australia

Kapp, W. A., P. Kennerley. Subsidence and Strata Control Under Stored Waters in the Southern Coalfield, New South Wales. IN: Proceedings, Symposium on Ground Movement and Control Related to Coal Mining, Illawarra, Australia, August, 1986, N.I. Aziz, ed., Australasian Institute of Mining and Metallurgy, p. 341-351.

Valuable coal reserves in the Southern Coalfield lie beneath stored waters. A study was made of two different mining methods, bord-and-pillar and pillar extraction, for use under stored waters within the limits specified by the NSW Dam Safety Committee. Pillar monitoring and mathematical modeling approaches demonstrate that recovery of coal using these layouts can be improved above that specified, without affecting long-term stability of the surface structures.

Keyword(s): coal mining, surface water, room-and-pillar, pillar extraction, monitoring methods, modeling, mathematical model, active mines

Location(s): Australia

Karfakis, M. G. Mechanisms of Chimney Subsidence Over Abandoned Coal Mines. IN: Proceedings, 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 195-203.

Chimney subsidence is defined, and the factors controlling the development of subsidence sinkholes are identified. The mechanisms involved in chimney development and means of early identification of impending chimney subisdence are discussed.

Keyword(s): abandoned mines, surface structural damage, coal mining, roof stability

Location(s): Pennsylvania, Wyoming, North Dakota, Illinois, Colorado, Appalachian Coal Region, Illinois Coal Basin, Rocky Mountain Coal Region, United States

Karfakis, M. G., G. Beach, J. C. Case. Subsidence Problems in Wyoming and Their Social Impact. IN: Proceedings National Symposium on Mining, Hydrology, Sedimentology and Reclamation, December 7-11, 1987, Springfield, IL. University of Kentucky, Lexington, p. 209-215.

The paper gives a brief background on the geology of the Wyoming mining districts and on the mining method used. Subsidence characteristics, types, possible mechanisms and factors are discussed. The potential socio-economic impacts on communities are presented. Subsidence occurrences in various locations are reviewed. Past, present and future subsidence mitigation projects are outlined. Future needs of subsidence prone areas, such as prediction, risk evaluation, and monitoring are assessed.

Keyword(s): abandoned mines, coal mining, surface structural damage, land-use planning, land mitigation, historical, hydraulic backfilling, grouting

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Karfakis, M., S. Barnard, J. Murphy. Subsidence Abatement Projects in Wyoming--An Overview. IN: Conference on Mine Induced Subsidence: Effects on Engineered Structures, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 33-52.

Abatement projects were undertaken to prevent or minimize further subsidence in Wyoming communities. The paper gives a brief historical background on local mining activity. Subsidence characteristics and occurrences in various communities are presented. Locations of key abatement projects and reasons for their selection is given. Selection criterion for backfilling and grouting methods and the techniques themselves are presented. Problems encountered are discussed. Successful projects are analyzed. Recommendations for future projects are given.

Keyword(s): hydraulic backfilling, grouting, abandoned mines, coal mining, engineering, land mitigation, reclamation

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Karfakis, M. G., K. D. Basham, B. A. Suprenant, W. L. Johnson. Specifications and Recommendations for Residential Construction Subject to Ground Movements Related to Mine Subsidence. Report to Department of Environmental Quality by University of Wyoming, Mining Engineering, 1988, contract no. 5/38781.

This document is intended as a simplified guide to help contractors, building inspectors, city officials, and homeowners. The purpose is to provide guidelines, principles, criteria, and recommendations that will enable the architectural engineering and construction professions to design and construct buildings to minimize damage due to ground movements related to mine subsidence.

Keyword(s): insurance, surface structural damage, construction, foundations, utilities, abandoned mines

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Karfakis, M. G., E. Topuz. Mechanism of Residual Subsidence Triggered by Post-Abandonment Flooding. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting of the Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 21-25.

Residual subsidence is a major concern over abandoned mine lands. The risk and duration of residual subsidence is of particular importance from the standpoint of damage to structures built after the mine has been abandoned, especially in cases where the surface land is believed to be stabilized. This paper presents an analytical evaluation of the interaction of various factors contributing to subsidence and includes the effects of water on the geotechnical properties of mine rocks.

Keyword(s): abandoned mines, surface structural damage, subsurface water, coal mining, pillar strength, overburden, geotechnical

Location(s): United States

Karfakis, M. G., E. Topuz. Post Mining Subsidence Abatements in Wyoming Abandoned Coal Mines. Mining Science and Technology, v. 12, no. 3, May, 1991, p. 215-231.

Coal has been mined continuously in Wyoming since 1865. Nearly all the coal produced in the first 90 years of mining was from underground bituminous mines. Subsidence has been a threat in Wyoming since the beginning of coal mining, constituting an extreme danger to public health, safety, and property. As a consequence, Wyoming mine subsidence problems qualify for the highest priority of funding under the Surface Mine Control Reclamation Act of 1977.

Keyword(s): abandoned mines, coal mining, bituminous, hydraulic backfilling, grouting, historical, room-and-pillar, pillar extraction, land-use planning

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Karlsrud, K., L. Sander. Subsidence Problems Caused by Rock-Tunnelling in Oslo. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 197-213.

A new railroad tunnel connecting the east and west bound lines out of the city of Oslo is presently under construction. One part of this tunnel goes through bedrock at a depth of 20 to 40 meters below ground surface. Above and along the tunnel, there are a number of clay filled depressions in the bedrock. Past experience has shown that leakage in connection with tunnels or excavations very easily can cause reduction of pore water pressures in a relatively thin sandy layer normally found at the bottom of these depressions and thus cause consolidation (subsidence) of the clay layer.

Keyword(s): surface subsidence damage, subsurface subsidence damage, tunnelling, geologic features

Location(s): Norway

Karmis, M., C. Haycocks, I. Eitani, B. Webb. A Study of Longwall Subsidence in the Appalachian Coal Region Using Field Measurements and Computer Modeling Techniques. IN: Proceedings 1st Conference on Ground Control in Mining, July 27-29, 1981, S.S. Peng, ed., West Virginia University, Morgantown, p. 220-229.

This paper describes the use of field measurements and computer-modeling techniques to develop basic relationships between longwall subsidence and related parameters. It summarizes subsidence trends of the Appalachian Coal Region, with a brief reference to the zone-area method of prediction.

Keyword(s): vertical displacement, horizontal displacement, survey data processing, longwall, computer, ground control, prediction, modeling, survey methods, zone area, coal mining

Location(s): Appalachian Coal Region, United States

Karmis, M., G. Goodman, C. Haycocks, I. Eitani. Computer Modeling of Mining Subsidence Using the Zone Area Method. IN: Proceedings, 22nd U.S. Symposium on Rock Mechanics, Cambridge, MA, June 29-July 2, 1981, Massachusetts Institute Technology, Cambridge, p. 272-277.

Keyword(s): rock mechanics, computer, zone area, modeling
Location(s): United States

Karmis, M., G. Goodman, C. Haycocks, T. Triplett. The Development and Testing of a Regionalized Subsidence Prediction Model. IN: Proceedings, 17th International Symposium on Computer Applications in the Mining Industry, Denver, CO, April 19-23, 1982, p. 240-252.
Keyword(s): computer, prediction, modeling
Location(s): United States

Karmis, M., C. Haycocks, B. Webb, T. Triplett. Potential of the Zone Area Method for Mining Subsidence in the Appalachian Coalfield. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 48-59.
This paper deals with the development and testing of a subsidence prediction model, based on the zone area method. The latter technique is a refined development of the influence function and is well suited for computer analysis. Furthermore, such modeling is capable of handling uniform as well as non-uniform extraction patterns and can facilitate both longwall and room-and-pillar mining systems. In addition, since the objective of this study was to develop regional subsidence trends, a comprehensive subsidence data bank is being established for the Appalachian coalfield, which includes published as well as unpublished information on subsidence measurements.
Keyword(s): zone area, coal mining, modeling, influence function, prediction, longwall, room-and-pillar
Location(s): Appalachian Coal Region, United States

Karmis, M., C. Haycocks. Computer Simulation of Mining Subsidence Using the Zone Area Method. Department Mining and Mineral Engineering, Virginia Polytechnic Institute and State University, March, 1983, 62 p.
This report presents a zone area method computer program designed to predict a complete subsidence profile for seam gradients up to 20 degrees. It describes the method and how the program was developed to use it for both longwall and room-and-pillar mining operations.
Keyword(s): vertical displacement, zone area, computer, prediction, longwall, room-and-pillar, modeling
Location(s): Appalachian Coal Region, Illinois Coal Basin, Rocky Mountain Coal Region, United States

Karmis, M., T. Triplett, C. Haycocks, G. Goodman. Mining Subsidence and its Prediction in the Appalachian Coalfield. IN: Proceedings, 24th U.S. Symposium on Rock Mechanics, Texas A & M University, June 20-23, 1983, p. 665-675.
Keyword(s): prediction, coal mining, rock mechanics
Location(s): Appalachian Coal Region, United States

Karmis, M., C. Haycocks, T. Triplett. Ground Settlement and Deformation Characteristics Above Undermined Areas--Experiences from the Eastern U.S. Coalfields. IN: Proceedings 4th Australia-New Zealand Conference on Geomechanics, Perth, Australia, May 14-18, 1984, p. 647-653.
Keyword(s): coal mining, overburden
Location(s): Appalachian Coal Region, United States

Karmis, M., T. Triplett, P. Schilizzi. Recent Developments in Subsidence Prediction and Control for the Eastern U.S. Coalfields. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th U.S. Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 713-721.
This paper presents a summary of the major findings derived from a substantial research effort on mining subsidence carried out, during the past few years, in the southern Appalachian coalfield. The research program encompassed the following major tasks: identification of the most significant factors influencing ground movements above mined openings, collection of subsidence case studies for the southern Appalachian coalfield, development of subsidence and strain prediction techniques for that region, and initiation of a subsidence monitoring program in southwestern Virginia.
Keyword(s): prediction, ground control, coal mining, active mines, rock mechanics
Location(s): Virginia, Appalachian Coal Region, United States

Karmis, M., G. Goodman, G. Hasenfus. Subsidence Prediction Techniques for Longwall and Room and Pillar Panels in Appalachia. IN: Proceedings, 2nd International Conference on Stability in Underground Mining, AIME and University of Kentucky, August 6-8, 1984, p. 541-553.

Keyword(s): prediction, longwall, room-and-pillar, active mines, coal mining

Location(s): Appalachian Coal Region, United States

Karmis, M., P. Schillizzi. Development of a Subsidence Monitoring Program for the Southern Appalachian Coalfield. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, July 1984, J.D. Geddes, ed., Pentech Press, London, 1985, p. 223-239.

The growing recognition of mining subsidence and its associated effects has provoked numerous investigations into the analysis, prediction, and modeling of this phenomenon, using theoretical as well as empirical techniques. However, a careful review of the most prevalent of these techniques demonstrated clearly that such subsidence studies do not describe satisfactorily the type and magnitude of the ground movements experienced in the Appalachian coalfield. The characteristic topographic conditions, the complex lithologic and structural geologic environment, and the local mining methods have all greatly contributed to the rather distinctive subsidence trends encountered in that region. Consequently, to meet the need for representative and accurate subsidence and strain prediction methods, the development of empirical ground deformation models was attempted for the Appalachian region. This task was based on a comprehensive analysis of existing case studies as well as on a detailed and complete subsidence monitoring program.

Keyword(s): survey equipment, survey methods, monitoring methods, monitoring methods, coal mining, active mines, prediction, empirical model, longwall, room-and-pillar

Location(s): Virginia, Appalachian Coal Region, United States

Karmis, M., P. Schilizzi, A. Jarosz. The Development of Ground Subsidence Above Underground Coal Mines in the Appalachian Coalfield and its Prediction Using Empirical Techniques. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 127-137.

In the past years numerous investigations have been undertaken for the modeling and prediction of surface subsidence, using theoretical as well as empirical techniques. A review of the most prevalent of these techniques demonstrated clearly that such subsidence studies do not describe satisfactorily the type and magnitude of the ground movements experienced in the Appalachian coalfield. To develop a subsidence prediction method applicable to the topographic conditions and the complex lithologic and structural geological environment of coalfields in the eastern United States, a systematic surface movement monitoring program was initiated. This was conducted in Virginia over eight underground coal mines and included seventeen panels.

Keyword(s): coal mining, prediction, empirical model, monitoring equipment, monitoring methods, monitoring design, pillar extraction, room-and-pillar, National Coal Board, influence function

Location(s): Virginia, Appalachian Coal Region, United States

Karmis, M., P. Schilizzi, A. Jarosz. Development and Comparison of Subsidence Prediction Methods for the Eastern U.S. Coalfields. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 9-18.

This paper is concerned with subsidence prediction methods and in particular with two techniques, one based on profile functions and the other on influence functions. Profile function methods provide a tool for fast calculation of subsidence on a line across a mine panel. Influence function methods, on the other hand, allow for a more detailed calculation of ground movements, in any mode and at any depth, on a grid or at any specific point.

Keyword(s): coal mining, prediction, profile function, influence function, prediction theories, computer, empirical model, room-and-pillar, longwall

Location(s): Appalachian Coal Region, United States

Karmis, M., A. Jarosz, P. Schillizzi. Monitoring and Prediction of Ground Movements Above Underground Mines in the Eastern US. IN: Proceedings, 6th International Conference on Ground Control in Mining, 1987, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 184-194.

Surface deformations above underground mines and their prediction and control have been the topics of an extensive research effort by Virginia Polytechnic Institute and State University over the past few years. During the initial stages of this research, a number of case studies were collected from the literature, the mining industry, and various government and state agencies. Based on the analysis of this information, appropriate proediction methods were proposed. Although the prediction methods were based on sound concepts, it became evident that their accuracy and implementation were a reflection of the size and quality of the collected case studies and that the data bank was insufficient. In an effort to alleviate these problems, a comprehensive monitoring program was initiated in the coal mines of southwest Virginia.

Keyword(s): monitoring methods, prediction, longwall, room-and-pillar, monitoring design, monitoring equipment, vertical displacement, horizontal displacement, profile function, influence function, zone area, high-extraction retreat, computer

Location(s): Virginia, Appalachian Coal Region, United States

Karmis, M. Predicting Subsidence with a Computer. Coal, December, 1989, p. 54-61.

The prediction of ground movements due to underground mining, the assessment of their impact on surface structures, and their control within acceptable environmental levels are all important considerations during the mine design process. Recent progress in subsidence technology in the United States, particularly that due to an intensive effort in the collection and monitoring of case studies involving subsidence in the coalfields of the eastern United States, has been manifested in the development of some unique capabilities, including the establishment of sound empirical parameters from an extensive data bank. Evaluation of these field data has resulted in the development and validation of subsidence prediction methods, and the incorporation of regional geological as well as mining factors in subsidence predictions.

Keyword(s): prediction, computer, modeling

Location(s): Appalachian Coal Region, United States

Karmis, M., Z. Yu, A. Jarosz. Design Considerations for Subsidence Control. International Journal of Mining and Geological Engineering, v. 8, no. 4, December 1990, p. 357-368.

Procedures for subsidence planning during the mine design stage are presented. The Surface Deformation Prediction System (SDPS) incorporates three different subsidence prediction methods, based on the concepts of the influence function, profile function, and zone area methods. Data from the SDPS are used in the Subsidence Response Modelling Program (SRMP), a large displacement, small strain, nonlinear finite element code, to determine damage levels to surface structures resulting from subsidence. An example is presented of use of the SDPS and SRMP in subsidence design and control.

Keyword(s): modeling, prediction, influence function, profile function, zone area, finite element, surface structural damage, coal mining, mine design, active mines, land-use planning

Karmis, M., Z. Agioutantis, A. Jarosz. Recent Developments in the Application of the Influence Function Method for Ground Movement Predictions in the U.S. Mining Science and Technology, v. 10, no. 3, May, 1990, p. 233-245.

The influence function method was applied to calculate ground deformations caused by underground mining. Empirical subsidence parameters have been developed to facilitate the application of the method to various mining and geological conditions, although site-specific parameters can also be used. Comparisons between measured and predicted subsidence and strain values are presented for different case studies, and demonstrate the applicability of the influence function formulation for predicting surface deformations.

Keyword(s): prediction, influence function, coal mining, horizontal displacement, vertical displacement, geologic features

Location(s): Appalachian Coal Region, United States

Karmis, M., C. Haycocks, Z. Agioutantis. The Prediction of Ground Movements Caused by Mining. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, Morgantown, WV, S.S. Peng, ed., p. 1-9.

This paper reviews the fundamental concepts involved in the development, application, and validation of ground movement prediction methods developed by Virginia Polytechnic Institute and State University. Prediction techniques include empirical or semi-empirical methods, such as the profile function, influence function, and zone area methods, as well as numerical methods, based on a finite element formulation that uses field subsidence data. These techniques have been integrated in a software package for personal computers, which allows for the calculation of any component of ground movement in any direction.

Keyword(s): prediction, computer, prediction theories, empirical model, profile function, influence function, zone area, finite element, modeling, survey data processing, vertical displacement, horizontal displacement, longwall, room-and-pillar

Location(s): Appalachian Coal Region, United States

Karmis, N., C. Y. Chen, D. E. Jones, T. Triplett. Some Aspects of Mining Subsidence and its Control in the US Coalfields. Minerals and the Environment, v. 4, December, 1982, p. 116-130.

This article discusses the influence of geological controls on subsidence, and the effects of subsidence on humans and their environment. A historical review of rules and regulations governing subsidence-related problems is given.

Keyword(s): historical, law, environment, vertical displacement, horizontal displacement, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Kauffman, P. W., S. A. Hawkins, R. R. Thompson. Room and Pillar Retreat Mining--A Manual for the Coal Industry. U.S. Bureau of Mines IC 8849, 1981, 228 p.

Keyword(s): room-and-pillar, mine design, mine operation, high-extraction retreat, active mines, coal mining

Location(s): United States

Kawulok, M. Investigation of a Precast Concrete Panel Structure Subjected to Mining Subsidence. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 606-620.

This paper describes an investigation of the influence of ground deformation caused by coal extraction on a block of flats near Katowice in the Upper Silesian Coal Basin. Information on deformation of the ground surface, and on deformation and accompanying stresses in some typical constructional elements of the building is presented on the basis of the obtained results. The paper concludes with a suggested method to interpret the results.

Keyword(s): surface structural damage, coal mining, foundations, construction, active mines, monitoring methods

Location(s): Poland

Kawulok, M. The State of Stress in a Building Constructed of Large Precast Wall Panels Subjected to Mining Subsidence. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 251-263.

A complex investigation was carried out on the effect of coal extraction on a five-story block constructed of large precast wall panels, which included measurements of the deformation of the terrain around the building as well as of the resultant strains in the structure.

Keyword(s): surface structural damage, coal mining, horizontal displacement, vertical displacement, survey data processing, modeling, construction, engineering

Location(s): Poland

Kawulok, M. Protection of a Church Building from the Intensive Influences of Coal Mining. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 19884, J.D. Geddes, ed., Pentech, London, 1985, p. 314-323.

This paper presents an account of the precautions adopted for a church against predicted ground movements, where the function of the building determined the choice of the practical structural solutions.

Keyword(s): surface structural damage, coal mining, multiple-seam extraction, vertical displacement, horizontal displacement, structural mitigation

Location(s): Poland

Kawulok, M. The Protection of Existing Buildings Subjected to Large Ground Movements. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 344-355.

Ground deformations caused by coal extraction usually develop as a regular subsidence basin with smooth, continuous edges, although in the case of large ground movements local discontinuities of the terrain appear in the subsidence profile. These deformations pose a great danger to brick buildings that are not protected against nonuniform subsidence of the ground. For the purpose of effective protection of small buildings erected where such ground conditions may develop, a steel truss may be arranged around the perimeter of the external walls. The truss acts like a corset, which braces and strengthens the walls of the building and improves their interaction with the floors.

Keyword(s): coal mining, surface structural damage, structural mitigation, engineering

Location(s): Poland

Kay, D. R., K. E. McNabb, J. P. Carter. Numerical Modelling of Mine Subsidence at Angus Place Colliery. IN: Computer Methods and Advances in Geomechanics, Proceedings 7th International Conference, Cairns QLD Australia, G. Beer, May 6-10, 1991, v. 2, J.R. Booker, and J.P. Carter, eds., Balkema, Rotterdam, p. 999-1004.

A joint case study was initiated in 1987 to improve the prediction of coal mining induced subsidence using mathematical models. Nine different models predicted the subsidence movements of pegs along several surface cross sections and anchors located in a subsurface borehole over a new longwall panel at the Angus Place Colliery, New South Wales, Australia. The study was phased so that later predictions could use the results of earlier monitoring to perform progressive calibrations of the models. The modeling involved an appreciation of complex time dependent subsidence deformation mechanisms over small and large extraction areas with partially yielding chain pillars.

Keyword(s): modeling, mathematical model, longwall, active mines, coal mining, monitoring methods, prediction, time factor, yielding supports, vertical displacement, horizontal displacement, geotechnical

Location(s): Australia

Kay, F. H. Coal Resources of District VII (Southwestern Illinois) (Coal No. 6 West of Duquoin Anticline). Illinois State Geological Survey, Mining Investigation Bulletin 11, 1915, 233 p. Reprinted 1922.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Kay, F. H., K. D. White. Coal Resources of District VIII (Danville). Illinois State Geological Survey, Mining Investigation Bulletin 14, 1915, 68 p.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Kay, S. R. The Effect of Subsidence Due to Coal-Workings Upon Bridges and Other Structures. IN: Institute of Civil Engineers, Minutes of Proceedings, London, v. 135, 1898, p. 114-174.

Keyword(s): surface structural damage, coal mining, historical

Kaye, R. D., E. R. Wooley. Grouting Old Mine Workings. Civil Engineering and Public Works Review, August, 1963, p. 1005.

A 16-story apartment building was constructed on a site with multiple mined-out coal seams.

Keyword(s): surface structural damage, grouting, multiple-seam extraction, engineering, abandoned mines, coal mining, architecture

Kazmann, R. G., M. M. Heath. Land Subsidence Related to Ground-Water Offtake in the New Orleans Area. Gulf Coast Associated Societies Transactions, v. 18, 1968, p. 108-113.

Keyword(s): fluid extraction

Location(s): Louisiana, United States

Keenan, A. M. Longwall Mining of Coal Pitching 30 Degrees. AIME Preprint No. 71-F-336, 1971.

This article discusses the use of longwall mining in seams dipping too steeply for conventional room-and-pillar equipment. Experimental systems have increased production and appear to be especially applicable where depth of cover has previously limited extraction.

Keyword(s): longwall, mine design, geologic features, coal mining

Location(s): United States

Keinhorst, H. Considerations on the Problem of Mining Damages. Gluckauf, v. 70, 1934, p. 149-155 (in German).

Keyword(s): modeling, empirical model, influence function, surface subsidence damage

Location(s): Germany

Keith, H. D., R. C. Batra, P. J. Conroy. Finite Element Analysis of a Longwall Mine. IN: Rock Mechanics: A State of the Art, Proceedings 21st Symposium on Rock Mechanics, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 9-15.

The work reported herein represents the first phase of an effort to develop finite element modeling techniques that can be used to design the geometry of longwall panel development entries. Three dimensional finite element models of a longwall mine geometry should provide results close to the field observations.

Keyword(s): rock mechanics, finite element, modeling, longwall, mine design, coal mining, lab testing

Location(s): Illinois, Illinois Coal Basin, United States

Kelleher, J. T., D. J. Van Roosendaal, B. B. Mehnert, D. F. Brutcher, R. A. Bauer. Overburden Deformation and Hydrologic Changes Due to Longwall Coal Mine Subsidence in the Illinois Basin. IN: Land Subsidence, Proceedings 4th International Symposium, Houston, TX, May 1991, A.I. Johnson, ed., IAHS Publication no. 200, p. 195-204.

Subsidence-induced deformation and hydrologic changes were studied at two active longwall coal mines in Illinois using surveying and geotechnical monitoring. Surface subsidence characteristics fall into a range common to other Illinois longwall operations. Subsidence-induced water level fluctuations correlated with mining activity and the passing of the dynamic subsidence wave. Aquifer thickness and lateral extent affected these fluctuations.

Keyword(s): coal mining, longwall, survey methods, monitoring methods, instrumentation, subsurface water, hydrology, geotechnical, vertical displacement, horizontal displacement, overburden, rock mechanics, geophysical, monitoring equipment, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Kelley, G. C., J. L. Craft. Areawide Mine Subsidence Investigations. IN: Proceedings National Symposium and Workshops on Abandoned Mine Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 31-41.

The Office of Surface Mining initiates areawide subsidence investigations in communities where past coal mining has produced multiple surface subsidence events and where there is a likelihood of future subsidence-induced surface effects that represent extreme danger to the public. The purposes of the investigation are to collect all available information concerning the potential for subsidence in the area; identify potential high risk subareas; and, if requested by the state Abandoned Mine Land (AML) authority, recommend remedial abatement. The accumulated information allows a more rapid response time when subsequent subsidence events occur. Studies are implemented only after concurrence of the responsible AML authority.

Keyword(s): abandoned mines, coal mining, reclamation, land mitigation, surface structural damage

Location(s): United States

Kenny, P. The Caving of the Waste on Longwall Faces. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 6, 1969, p. 541-555.

A set of definitions, which has been found useful in describing the manner of caving on longwall faces, is proposed. A method of quantifying the description of the caving zone by means of simple observations and measurements is described. The relevance of the manner of caving to roof control is discussed and it is shown that information on the nature and extent of the supported roof may be obtained from studies of caving. Such studies may also yield information on face support requirements, the workability of the coal, the effect of different roof, e.g. massive sandstone, and the in situ strength of rock beds.

Keyword(s): longwall, coal mining, overburden, roof stability

Location(s): United Kingdom

Kent, B. H. Geologic Causes and Possible Preventions of Roof Fall in Room-and-Pillar Coal Mines. Pennsylvania Geological Survey IC 75, Harrisburg, 1974, 17 p.

Keyword(s): roof stability, ground control, room-and-pillar, coal mining, geologic features

Pennsylvania, Appalachian Coal Region, United States

Kentucky Department for Natural Resources and Environmental Protection, Bureau of Surface Mining Reclamation and Enforcement. Permanent Program Regulations for Surface Coal Mining and Reclamation Operations and Coal Exploration Operations. 405 KAR 8:040E, Sec. 26, April, 1982, 52 p.

The subsidence control section covers the legal considerations of subsidence for the state of Kentucky.

Keyword(s): law, mine operation, reclamation, environment

Location(s): Kentucky, Appalachian Coal Region, United States

Kertis, C. A. Reducing Hazards in Underground Coal Mines Through the Recognition and Delineation of Coalbed Discontinuities Caused by Ancient Channel Processes. U.S. Bureau of Mines RI 8987, 1985, 23 p.

Because coalbed discontinuities often pose serious economic and safety problems in underground coal mines, criteria were documented for the recognition and prediction of discontinuities in advance of mining.

Keyword(s): geologic features, mine design, mine safety, coal mining, overburden

Location(s): Pennsylvania, Appalachian Coal Region, United States

Kester, W. M., Y. P. Chugh. Premining Investigations and Their Use in Planning Ground Control in the Illinois Basin Coal Mines. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 33-43.

The authors conducted premining investigations for four virgin areas and studied ground control problems in several operating coal mines in the basin. Premining investigations involved detailed geologic descriptions of cores and preparation of maps pertinent from a ground control point of view. Specifically, facies changes in the immediate roof, interval to limestone bed, if any, thickness of limestone bed and thickness and nature of shales were mapped. Moisture sensitivity of shales, thickness and nature of underclays, presence of channels, etc. were also considered. Based on geologic description and physical property data on roof, coal, and floor rocks, the authors have developed rating scales for delineating areas with ground control problems overying the Herrin seam.

Keyword(s): geologic features, ground control, floor stability, roof stability, coal mining, geotechnical, lab testing, rock mechanics

Location(s): Illinois, Illinois Coal Basin, United States

Kettren, L. P., K. A. Johnston. Rock Mechanics Studies at Old Ben Coal Company Mine 24. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, June, 1980, p. 208-213.

Rock mechanics studies were performed by Dames & Moore in Old Ben Coal Company's Mine No. 24 as part of a longwall mining demonstration with the U.S. Department of Energy. The demonstration project was designed to introduce longwall techniques to the Illinois Basin where earlier attempts with longwall had failed. Six earlier attempts with longwall methods by Old Ben had been unsuccessful due to roof control problems. The present demonstration included a rock mechanics study designed to observe unusual situations so that corrective action could be taken, to develop guidelines for future longwall efforts, and to evaluate surface subsidence and develop criteria to assist in its prediction.

Keyword(s): rock mechanics, coal mining, longwall, monitoring methods, monitoring equipment, instrumentation

Location(s): Illinois, Illinois Coal Basin, United States

Key, S. W., Z. E. Beisinger, R. D. Krieg. HONDO II--A Finite Element Computer Program for Large Deformation Dynamic Response of Axisymmetric Solids. SAND78-0422, Sandia National Laboratories, Albuquerque, NM, 1978.

Keyword(s): finite element, computer, modeling

Location(s): United States

Khair, A. W., S. S. Peng. Causes and Mechanisms of Massive Pillar Failure in a Southern West Virginia Coal Mine. Preprint 83-378, SME-AIME fall meeting, Salt Lake City, UT, October, 1983, 11 p.

This paper deals with the causes and mechanisms of pillar failure in a coal mine in southern West Virginia. The conclusions are made on the basis of in-mine observations and analysis of mining methods, eyewitness accounts of the sequence of events, topographic and geologic conditions, and mechanical properties of mine roof, coal, and floor.

Keyword(s): coal mining, pillar strength, geologic features, room-and-pillar, roof stability, finite element

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W., R. D. Begley. Model Studies to Develop Criteria of Subsidence Due to the Room and Pillar Mining of Coal. Preprint No. 84-92, SME-AIME Annual Meeting, Los Angeles, CA, February 26-March 1, 1984, 13 p.

Subsidence in room-and-pillar mining was analyzed using models of various extraction ratios and overburden depths along with two types of overburden model material.

Keyword(s): coal mining, modeling, room-and-pillar, mine design, abandoned mines, time factor, overburden

Location(s): Illinois, Illinois Coal Basin, Pennsylvania, West Virginia, Appalachian Coal Region, United States

Khair, A. W., G. S. Begley, R. D. Begley. Study of Subsidence Characteristics Due to Underground Mining of Coal Using a Physical Modeling Technique. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 270-282.

This paper presents an analysis of surface subsidence characteristics in room-and-pillar mining using physical models and laser holographic interferometry (holometry). The analysis included the effect of various geometric parameters and different overburden materials and resulted in the formulation of a more realistic model material for laboratory simulation of typical geologic overburden.

Keyword(s): modeling, coal mining, room-and-pillar, overburden, physical model

Khair, A. W., R. D. Chaffins, M. K. Quinn. Study of Ground Movements Over a Longwall Mine. IN: Proceedings, 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., West Virginia University, Morgantown, p. 141-155.

This paper presents an analysis of ground movements recorded from longwall operations in the northern Appalachian region in West Virginia. The site chosen for the investigation was selected due to varying heights of overburden and topography and was instrumented for both surface and subsurface measurements. The instrumentation areas consisted of two panels covering various sections with unique geologic and topographic features.

Keyword(s): longwall, monitoring methods, instrumentation, survey methods, survey equipment, horizontal displacement, vertical displacement, monitoring equipment, overburden, prediction, geologic features, finite element

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W., M. K. Quinn, R. D. Chaffins. Effect of Topography on Ground Movement Due to Longwall Mining. Preprint 87-142, SME-AIME Annual Meeting, Denver, CO, February 24-27, 1987.

This paper presents an analysis of the effects of topography on quasi-static and dynamic ground movements and the severity of damage inflicted on surface structures.

Keyword(s): geologic features, surface structural damage, subsurface structural damage, horizontal displacement, instrumentation, angle of draw, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W., M. K. Quinn, R. D. Chaffins. Effect of Topography on Ground Movement Due to Longwall Mining. Mining Engineering, August, 1988, p. 820-822.

This paper presents an analysis of the effects of topography on static and dynamic ground movements and severity of damage inflicted on surface structures. A typical site containing varying topographical features (i.e., mountains, hillsides, valleys, and flat bottom land) representing the northern Appalachian region was chosen for the study. Typical subsidence monitoring techniques were employed. Frequent measurements were made as the face advanced.

Keyword(s): coal mining, surface structural damage, geologic features, monitoring methods, active mines, horizontal displacement, vertical displacement, foundations, overburden, instrumentation, survey methods, survey equipment, surface subsidence damage

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W. Prediction of Ground Subsidence in Longwall Mining Areas. IN: Proceedings, 5th International Symposium on Deformation Surveys and 5th Canadian Symposium on Mining Surveying and Rock Deformation Measurements, 1988.

Keyword(s): prediction, longwall

Khair, A. W., P. J. Molesky. Surface Ground Movements Over Longwall Mining in the Pittsburgh Seam. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., p. 303-313.

This paper presents an analysis of surface ground movements recorded from two longwall mines in northern West Virginia that operate in the Pittsburgh seam. The instrumentation areas consisted of four panels, two at each mine, covering various sections with unique topographic features. Vertical and horizontal ground movements were measured at specified intervals to determine subsidence rate, developing and final subsidence profiles, angle of draw, horizontal displacements, and associated strain profiles. A relationship between panel depth and width and the subsidence factor was also developed.

Keyword(s): longwall, coal mining, monitoring methods, instrumentation, vertical displacement, horizontal displacement, survey methods, angle of draw

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W., R. D. Begley. Assessment of Modeling Techniques for Prediction of Subsidence Over Longwall Areas. Preprint 89-14, SME Annual Meeting, Las Vegas, NV, February 27-March 2, 1989, 7 p.

This paper presents an assessment of modeling techniques in predicting subsidence over longwall areas. Extensive instrumentation, both at the surface and subsurface of three longwall mines in northern West Virginia have been made. Ground movements were monitored during a 3-year period until subsidence ceased in these areas. A comparative analysis of empirical subsidence prediction techniques including, graphical (NCB), profile function, and influence functions are presented. A brief geologic and topographic description of each site along with the instrumentation and monitoring program are also presented.

Keyword(s): modeling, prediction, longwall, instrumentation, empirical model, National Coal Board, profile function, influence function, zone area, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W., Y. S. Ro. Assessment of Surface Fracture Depth and Intensity Due to Subsidence Over the Longwall Panel Using a Sonic Technique. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed.,Balkema, Rotterdam, p. 723-730.

This paper presents an analysis of fracture depth and intensity due to subsidence over the longwall panel. Sonic reflection techniques were used to determine fracture depth, and a variation of p-wave velocity was used as an indication of the fracture intensity. Instrumentation has been tested for consistency and accuracy first in the laboratory using small scale models, then applied in the field in two mine sites with differing mining geometry and geologic conditions. A new sonic viewer was used for sonic velocity measurements. Regular hammering method was an acoustic source. The results were concurrent with monitored horizontal strain profiles and measured open fractures over the longwall panels.

Keyword(s): longwall, overburden, instrumentation, modeling

Location(s): United States

Khair, A. W. Evaluation of Monitoring Techniques for Ground Movements Over the Longwall Areas. International Symposium on Land Subsidence, December 11-15, 1989, Central Mining Research Station, India, p. 3-17.

This paper presents highlights of the research associated with monitoring surface and subsurface ground movements over longwall mining areas. Extensive instrumentation and measurements have been made over three longwall mines in northern West Virginia during a 3-year period. Various monitoring techniques including full profile borehole extensometers, full profile borehole inclinometers, time domain reflectometry, sonic reflection technique, and a unique mechanical grouting method in addition to standard surveying and water level measurements were used.

Keyword(s): coal mining, longwall, monitoring methods, monitoring equipment, monitoring design, monitoring installation, geotechnical, survey methods, active mines, instrumentation, geologic features, overburden

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W., H.-U. Lim, S. J. Jung. Application of Rock Mechanics Principles to Alleviate a Complex Rock Engineering Problem in a Coal Mine--A Case Study. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds.,Golden, CO. Balkema, Rotterdam, p. 77-84.

This paper presents an analysis of complex ground control problems in a coal mine and potential solutions to alleviate the problems. The analysis includes the study of geology and lithology of the mine, determination of the mechanical properties of the rock and coal associated with the mine, apparent in situ stresses, in-mine observation, and study of the behavior of the roadways through instrumentation and monitoring.

Keyword(s): ground control, coal mining, geologic features, rock mechanics, longwall, roof support

Location(s): Pennsylvania, Appalachian Coal Region, United States

Khair, A. W., S. S. Peng. Engineering to Reduce the Cost of Roof Support in a Coal Mine Experiencing Complex Ground Control Problems. Mining Engineering, August 1991, p. 1062-1066. Discussion by S. Serata and K. Fuenkajorn, November 1992, p. 1369, reply p. 1370.

The mine has a history of cutter roof problems in the entries that has delayed the advance rate of entry development considerably, and the cost of maintaining those entries is very high due to the requirement of very heavy artificial supports.

Keyword(s): engineering, roof stability, roof support, yielding supports, active mines, coal mining, geologic features, longwall, roof bolting

Location(s): Pennsylvania, Appalachian Coal Region, United States

Khair, A. W., R. D. Begley. Mechanistic Subsidence Prediction Model (MSPM). IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 56-65.

A model was developed to predict maximum possible subsidence and subsidence profiles at any cross section within the subsidence influence zone. The model considers mine geometry and geologic and geotechnical properties of the associated areas. Based on extensive field measurements and mechanics of strata behavior, under the action of overburden pressure in the vicinity of the large underground excavation, the vertical plane of influence zone has been divided into five areas: (1) excavated, (2) caved, (3) fractured, (4) highly deformed but continuous, and (5) subsided zones.

Keyword(s): modeling, prediction, geologic features, geotechnical

Location(s): Pennsylvania, Virginia, West Virginia, Appalachian Coal Region, Illinois, Illinois Coal Basin, United States

Khanna, R. R., V. K. Talwar. Despoliation of Surface Lands of Jharia Coalfield by Mining Operations and Underground Fires. Journal Institute of Engineers (India), Mining & Metallurgy Division v. 56, pt. MM, November 2, 1975, p. 57-60.

Keyword(s): surface subsidence damage, coal mining, mine fires

Location(s): India

Kicker, D. C., Z. T. Bieniawski. Improving Design Methodology for Innovative Rock Mechanics Design. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 279-284.

This paper introduces the concept of design theory and methodology as applied to rock mechanics for more innovative and efficient design. This is a "frontier" research area in rock mechanics because although design is a fundamental foundation to all engineering branches, very little attention has been paid to this aspect in mining. In discussing the theoretical premise of design, this paper identifies the principles that form the basis of design activity. Also, from a practical standpoint, the findings from a series of interviews with mine design engineers are presented. These findings lead to the identification of needs arising from overlooked design methodology in practice.

Keyword(s): rock mechanics, mine design, engineering

Kiefner, J. F. Monitoring and Intervention on Pipelines in Mining Subsidence Area. Report to Line Pipe Research Supervisory Committee of the Pipeline Research Committee of the American Gas Association, NG-18 Report No. 155, Task SI 5.0-85, "Monitoring and Intervention on Pipelines in Mining Subsidence Areas," August 8, 1986, American Gas Association Catalog No. L51515, Battelle, Columbus Division, OH, 62 p. plus appendix.

The objectives of this study were to review the effects of longwall mining subsidence on pipelines and to develop concepts for preserving the integrity of pipelines affected by such subsidence. The usual effects on a pipeline of mining-induced subsidence are increased axial and flexural strains affecting its longitudinal strength. In the presence of severe circumferentially oriented defects and added tensile strain, buckling of the pipe may occur. Pipeline operators can use available predictive methods and geophysical data to estimate the potential effects of longwall mining, and they can monitor their pipelines and intervene if necessary to prevent a pipeline failure due to subsidence. The options available to pipeline operators faced with a subsidence problem range from doing nothing to shutting down the line and relaying it after subsidence. More likely, however, the operator will choose to leave the line in service and monitor it with the idea of intervening if necessary to preserve the integrity of the pipeline.

Keyword(s): pipelines, utilities, longwall, coal mining, prediction, structural mitigation, monitoring methods, monitoring equipment, monitoring design, National Coal Board

Location(s): United States

Kiefner, J. F. Pipelines and Subsidence: Effects of Pipeline Strains from Longwall Mining are Analyzed; Exposing Line Reduces Strain During Subsidence. Oil & Gas Journal, June 22, 1987, v. 85, no. 25, p. 44-49; June 29, 1987, v. 85, no. 26, p. 66-68. (Based on a paper presented to the 7th Symposium on Line Pipe Research, American Gas Association, Houston, October 14-16, 1988.)

Adequate monitoring and proper intervention can significantly increase a the chances of a pipeline surviving the strains of soil subsidence in an area of longwall mining. The first of the two articles on the effects of longwall mining on underground pipelines presents a technique for monitoring those effects. The concluding article examines intervention options and discusses the benefits of exposing pipelines in longwall mining areas.

Keyword(s): pipelines, longwall, geophysical, prediction, monitoring methods, monitoring design, monitoring installation, monitoring equipment, National Coal Board, angle of draw, coal mining, utilities, survey methods, instrumentation

Location(s): United States

Kilburg, J. A., J. M. Alvi. Report of Subsurface Exploration and Geotechnical Engineering Investigation, Canterbury Manor Mine Subsidence Investigation, Belleville, Illinois. Geo-Mechanics, Inc., Belle Vernon, PA, GMI Project no. 81114, Report to U.S. Bureau of Mines, March 15, 1982.

This investigation was undertaken to determine the cause of structural damage to at least nine dwellings. Two subsurface aspects which were investigated were the soil conditions and the mining conditions. These conditions were examined to determine which one (or both) may have caused the surface subsidence and accompanying structural damage to the houses. This report contains the results of the investigation as well as recommendations for stabilizing the area to minimize the potential for future subsidence or settlement and damage.

Keyword(s): surface structural damage, abandoned mines, coal mining, geotechnical, engineering, geologic features, room-and-pillar, grouting

Location(s): Illinois, Illinois Coal Basin, United States

King, H. J., H. G. Smith. Surface Movement Due to Mining. Colliery Engineering, v. 31, 1954, p. 322-329.

Laboratory experiments used gelatin models to determine surface effects of mine subsidence.

Keyword(s): surface subsidence damage, modeling, lab testing

King, H. J., M. B. Jones. The Measurement of Mine Subsidence. Mine and Quarry Engineering, v. 22, no. 3, March, 1956, p. 106-113.

The authors discuss a new technique for measuring subsidence and include a detailed description of two instruments constructed by the authors: one designed to measure tilt and strain and the other a simplified model for measuring only strain.

Keyword(s): monitoring equipment, monitoring installation, monitoring methods

Location(s): England

King, H. J., J. T. Whetton. Mechanics of Mine Subsidence. IN: Proceedings, European Congress on Ground Movement, University of Leeds, 1957, p. 27-38.

Experiments were conducted with a gelatin model to determine the relationship between subsidence parameters. Three groups of subsidence factors related to longwall mining are defined: dimensional, geological, and rate factors.

Keyword(s): modeling, longwall, geologic features, lab testing

King, H. J. An Investigation Into the Factors That Control Mine Subsidence. Ph.D. Thesis, University of Leeds, England, October 1958.

Keyword(s): geologic features

King, H. J., J. T. Whetton. Mechanics of Mining Subsidence. Colliery Engineering, pt. 1, June, 1958, p. 247-252; pt. 2, July, 1958, p. 285-288.

The authors intended to study the effect of the longwall extraction process by means of model tests, using a geometrically similar type. Three models were designed and constructed, each of which controlled different variables such as depth, width, and length of panel, and amount of lowering at the level of the panel. The first article summarizes the results obtained from the three models in respect to surface behavior. As a result of the experimental work, and in view of the reproducibility of the patterns of movement, the second article describes attempts to obtain some empirical expressions in terms of certain variables for flat panels of lowering.

Keyword(s): modeling, longwall, coal mining, geologic features

Location(s): United Kingdom

King, H. J., R. J. Orchard. Ground Movement in the Exploitation of Coal Seams. Colliery Guardian, v. 198, April 16, 1959, p. 471-477; v. 198, April 23, 1959, p. 503-508.

This article reviews early experience and observations of subsidence in Great Britain. The authors point out the concern by the National Coal Board about non-subsidence damage, since in legal disputes, the burden of proof rests with the National Coal Board.

Keyword(s): surface subsidence damage, National Coal Board, law, coal mining

Location(s): England

King, H. J. An Examination of the Elements of Surface Displacements Due to Coal Mining Subsidence. Chartered Surveyor, v. 96, no. 8, February 1964, p. 406-411.

Keyword(s): coal mining, survey data processing

King, H. J., B. N. Whittaker, C. H. Shadbolt. Effects of Mining Subsidence on Surface Structures. IN: International Symposium on Mining and the Environment, London, June 4-7, 1974, Institute of Mining & Metallurgy, London, 1975, p. 617-642.

This paper describes monitoring techniques used to determine the effectiveness of trenching to reduce the amount of damage to surface structures from underground mining.

Keyword(s): surface structural damage, structural mitigation, monitoring methods, active mines

King, R. P., D. W. Gentry. Development of Subsidence and Horizontal Strain Model for Longwall Mining at the York Canyon Mine. Preprint 79-85, SME-AIME Annual Meeting, New Orleans, February 18-22, 1979, 5 p.

The York Canyon Subsidence and horizontal strain models are based on actual field data obtained by monitoring three adjacent longwall panels. These models show that at York Canyon subsidence results in greater ground curvature than predicted by the National Coal Board, and subsidence is located more centrally over the longwall panel. Because of this, greater horizontal strains can be expected. It should be noted that these represent an intensive effort in a restricted area and are not necessarily intended to predict subsidence and horizontal strain results in other mining environments.

Keyword(s): longwall, coal mining, modeling, horizontal displacement, vertical displacement, National Coal board

Location(s): New Mexico, Rocky Mountain Coal Region, United States

King, R. P. Evaluation of Surface Subsidence and Horizontal Strain at York Canyon Mine, New Mexico. M.S. Thesis, Colorado School of Mines, Golden, 1980, 197 p.

The author presents the results of a rock mechanics instrumentation program designed to determine surface response due to longwall mining in thick coal at the York Canyon Mine, near Raton, New Mexico.

Keyword(s): coal mining, instrumentation, vertical displacement, horizontal displacement, monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, survey data processing, rock mechanics, longwall

Location(s): New Mexico, Rocky Mountain Coal Region, United States

King, R. U. A Study of Geologic Structure at Climax in Relation to Mining and Block Caving. Transactions, AIME, 1946, v. 163, p. 145-155.

Keyword(s): mine operation, overburden, geologic features

Location(s): United States

King, W. P., N. W. Green. Mine Subsidence Surveys. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute Mining & Metallurgy., Illawarra Branch, Paper 2, 1973, p. 2-1--2-12.

Detailed investigations of subsidence phenomena were commenced on the Southern and the Northern Coalfields (Australia). The principal aim of the work at the Southern Coalfields was to investigate the possibility of more extensive coal extraction than is at present permitted from beneath certain bodies of water contained by dams.

Although some precise surveys of both levels and distances were carried out, most of the work was to third order standards. To handle the massive amount of data produced from the surveying, it was finally decided that all data storage, handling, and processing would be handled by computer. Simple survey methods were used and electronic data processing was applied to the handling of mine subsidence data.

Keyword(s): survey methods, survey data processing, survey equipment, survey design, surface water, coal mining, active mines, longwall, surface structural damage

Location(s): Australia

Kirchner, B. H., G. J. Colaizzi. Remote Video Inspection of Abandoned Coal Mines: Investigation and Backfill Monitoring. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 133-142.

The use of remote video for abandoned mine investigations and backfill monitoring is a relatively new concept. Information obtained from the video recordings has been useful for determing the location and concentration of drilling necessary for reclamation measures, orientation and condition of pillars and mine passages, extraction ratios, shaft closure design, etc.

Keyword(s): remote sensing, abandoned mines, photography, backfilling, reclamation, coal mining, monitoring equipment, monitoring methods

Location(s): Rocky Mountain Coal Region, United States

Kistamas, L. Comparative Study of Solid Stowing Methods. Colliery Guardian, v. 207, no. 5350, October, 1963; v. 207, no. 5351, November, 1963, p. 586.

Keyword(s): stowing

Kiusalaas, J., E. K. Albert. SPASID: A Computer Program for Predicting Ground Movement Due to Mining. Report on U.S. Bureau of Mines Contract No. JO295031, August, 1983, The Pennsylvania State University, University Park, 201 p.

This report is a self-contained User Manual for a computer program called SPASID--Subsidence Prediction and System Identification. The program has two primary functions: (1) precalculation of ground movements due to underground mining operations using the influence function method, and (2) computation of influence function and site parameters from measured displacements. The program is written in FORTRAN and does not assume previous knowledge of the influence function method or programming competence.

Keyword(s): computer, prediction, modeling, influence function

Location(s): Pennsylvania, Appalachian Coal Region, United States

Klepikov, S. N., F. N. Borodatcheva, I. V. Matveev. Non-Linear Foundation Behaviour in the Analysis of Frameless Buildings Under the Action of Foundation Displacements. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, 1981, p. 275-287.

In this paper, a method is proposed for the three-dimensional design of multi-storied frameless buildings under the action of external loads and horizontal displacements of their footings, taking into account non-linear behaviour. The essence of the method is a conversion of the modules of the building into a system of cross beams whose properties are selected so that the forces and displacements in the beams and the corresponding walls differ by insignificant amounts. The design philosophy for the footings is based on a model with a variable stiffness coefficient.

Keyword(s): surface structural damage, foundations, architecture

Location(s): Soviet Union

Klepikov, S. N., A. V. Mashkin. Soil Mechanics Problems in Undermined Areas. Scientific-Research Institute of Constructional Elements (NIISK) of the Government Committee for Construction (Gosstroi) of the USSR. Translated from Osnovaniya, Fundamenty i Mekhanika Gruntov, no. 1, January-February, 1984, p. 3-5.

Soils in undermined areas experience single or repeated action from rock movements due to underground excavation of useful minerals or construction of different types of underground structures by the covered work method. This paper investigates basic problems in the field of mechanics of undermined soils.

Keyword(s): soils, soil mechanics, surface structural damage

Location(s): Soviet Union

Klezhev, P. E., R. A. Muller, S. E. Shalagov. Investigations of Piled Foundations for Buildings in Areas of Mining Subsidence. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 264-274.

The construction of two five-story experimental residential buildings on piled foundations was carried out to prove the possibility and expediency of building in areas to be undermined in the Karaganda basin. One building is a 56-flat, frameless, large-panel building, and the other is a 68-flat brick building. The series of coal seams being developed at the basin run under the experimental buildings. The seam being mined is at an average depth of 410 meters, and its thickness is 1.4 meters; the roof control method is complete caving.

Keyword(s): foundations, surface structural damage, structural mitigation, construction, coal mining, active mines, geologic features

Location(s): Soviet Union

Kneisley, R. O., K. Y. Haramy. Large-Scale Strata Response to Longwall Mining: A Case Study. U.S. Bureau of Mines RI 9427, 1992, 25 p.

This report summarizes a study of large-scale strata response to longwall mining at a coal mine in the western United States. The study used surface and subsurface measurements, geologic mapping, in situ stress measurements, and pressure cell readings to characterize strata behavior. Preliminary analysis of surface subsidence and time-domain reflectometry (TDR) was used to determine a suggested caving sequence for the main roof. Coal ejected from the face apparently resulted from brittle failures that occurred because of the lack of significant yield zone development. The combination of a strong coal with pronounced directional behavior, low overburden pressures, a good caving roof, and a high-production environment that minimized time-dependent loading apparently reduced yielding of the longwall face.

Keyword(s): active mines, coal mining, longwall, monitoring methods, monitoring equipment, instrumentation, overburden, geotechnical, yielding supports

Location(s): Colorado, Rocky Mountain Coal Region, United States

Knight, A. L., J. G. Newton. Water and Related Problems in Coal-Mined Areas of Alabama. U.S. Geological Survey, Water-Resources Investigations 76-130, April 1977, 51 p. (NTIS PB 271 527)

Keyword(s): hydrology, surface water, subsurface water, coal mining

Location(s): Alabama, United States

Knill, J. L. Rock Conditions in the Tyne Tunnels, North Eastern England. Bulletin Association of Engineering Geologists, v. 10, 1973, p. 1-20.

Keyword(s): tunnelling, geologic features

Location(s): England

Knill, J. L. Foundations on the Coal Measures. IN: Site Investigations in Areas of Mining Subsidence, F.G. Bell, ed., Newnes-Butterworths, London, 1975, p. 149-164.

Keyword(s): foundations, overburden, coal mining

Location(s): United Kingdom

Knothe, S. Rate of Advance and Ground Deformation. Bergakademie, v. 5, no. 12, 1953, p. 513-518 (in German).

Keyword(s): surface subsidence damage

Knothe, S. The Displacement of the Surface Under the Influence of Mining Extraction and Their Theoretical Interpretations. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 210-218.

Keyword(s): surface subsidence damage, modeling

Knothe, S. Observations of Surface Movements Under Influence of Mining and Their Theoretical Interpretation. Colliery Engineering, v. 36, 1959, p. 24-29.

This article presents formulas for the prediction of surface subsidence movements. These formulas are basically trough profile functions derived for critical or super-critical extraction of rectangular areas. The author mentions the influence of partial extraction and stowing on subsidence factors and the use of precalculation methods in the design of harmonious mining systems. The article is primarily directed at a presentation of prediction formulas.

Keyword(s): vertical displacement, prediction theories, empirical model, profile function, influence function, coal mining, partial extraction, stowing, mine design

Knox, G. The Hydraulic Stowing of Goaves. Transactions, Institute of Mining Engineers v. 45, 1912, p. 13.
Keyword(s): stowing, hydraulic backfilling

Knox, G. Hydraulic Filling as Roof Support. Colliery Engineering, v. 34, 1913, p. 225.
This article advocates the adoption of hydraulic backfilling in Britain; filling techniques in Europe are discussed.
Keyword(s): hydraulic backfilling, roof support
Location(s): England, Europe

Knox, G. The Relation Between Subsidence and Packing with Special Reference to the Hydraulic Stowing of Goaves. Transactions Institute of Mining Engineers, London, v. 44, 1912-1913, p. 527-552.
This paper discusses the need for better support systems in mine operations to reduce the number of fatalities caused by roof falls and damage to ground surface due to subsidence.
Keyword(s): hydraulic backfilling, stowing, mine safety, roof support
Location(s): England

Knox, G. Mining Subsidence. IN: Proceedings, 12th International Geological Congress, Ottawa, Canada, 1913, Imprimerie du Government, 1914, p. 797-806.
The ratio between subsidence and draw must be the joint result of forces liberated by the withdrawal of support from underneath strata in the mined area. The larger the proportion of settlement resulting in subsidence, the less can occur in the form of draw, and vice versa. Subsidence will be at a maximum in flat seams and draw at a maximum in vertical seams. The more effective the packing, the less the amount of settling that can take place either as subsidence or draw. As the settlement would be likely to occur slowly, the strata would bend without fracturing.
Keyword(s): vertical displacement, angle of draw, backfilling, overburden, bumps, geologic features
Location(s): United Kingdom

Knox, G., J. D. Pato. Hydraulic Stowing. IN: Proceedings, South Wales Institute of Engineering, v. 27, no. 4, 1921-22, p. 283.
This paper is a history of hydraulic backfilling, with a general resume of techniques employed in Poland.
Keyword(s): hydraulic backfilling
Location(s): Poland

Knox, G. Notes on Mining Subsidence. Colliery Guardian, v. 138, 1929, p. 825-827, 933-935.
Keyword(s): angle of draw, subsurface water, mine design, time factor

Ko, K. C., D. A. Ferguson. Geotechnical and Mine Design Considerations in Multiple Seam Mining. IN: Proceedings, Mini Symposium on the Application of Geotechnical Data to Underground Mine Design, SME-AIME fall meeting, FL, September, 1978, p. 21-32.
Keyword(s): multiple-seam extraction, mine design, geotechnical
Location(s): United States

Kochmanski, T. Integral Theory of Ground Movements Resulting from Extraction. Freiberger Forschunshefte, v. A118, 1959, p. 36-56 (in German).
Keyword(s): modeling, empirical model, influence function, prediction theories

Kochmanski, T., T. Lubina. Analiza Mozliwosci Eksploatacji Pokladu 510 Pod Osiedlem I Rzeka (Feasibility Analysis of Exploiting with Hydraulic Stowage Coal Seam No. 510 Under a Village and River). Przeglad Gorniczy, v. 27, no. 9, 1971, p. 417-423.
Keyword(s): hydraulic backfilling, stowing, surface water, surface structural damage, coal mining, modeling, empirical model, influence function
Location(s): Poland

Kochmanski, T. Comparison of the Accuracy of Three Methods of Calculation According to the Theories of K. Kochmanski, S. G. Avershyn, W. Budryk, and S. Knothe. National Science Association, U.S. Bureau of Mines Special Foreign Currency Scientific Information Program Translation, 1974, 54 p.
This report details the differences between subsidence measured by means of geodetic surveys and subsidence calculated using the Avershyn, Budryk-Knothe, and Kochmanski theories of prediction.
Keyword(s): vertical displacement, prediction, prediction theories, empirical model, profile function, influence function

Koehler, J. R., S. D. Jones, M. J. DeMarco. An Applications Approach to Barrier Pillar Design for Improved Resource Recovery. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural

Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 403-410.

Available barrier pillar design methods do not adequately account for overburden caving characteristics, the timing and magnitude of associated load transfers, the occurrence of unusual geologic features, or the effects of multiple-panel/multiple-seam mining. To address this problem, a barrier pillar study was conducted in a multiple-seam mine setting. Insufficient barrier width resulted in an excessive load transfer to an adjacent/underlying section. Consequent entry and pillar deterioration resulted in the section being prematurely abandoned. This paper proposes an approach based on in situ measurements, which includes mine-specific loading conditions in the barrier design process.

Keyword(s): mine design, overburden, geologic features, multiple-seam extraction, coal mining, longwall, pillar strength, instrumentation

Location(s): Utah, Rocky Mountain Coal Region, United States

Koerner, R. M. Acoustic Emission Monitoring of Land Subsidence. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., IAHS Publication No. 151, 1986, p. 225-234.

Acoustic emissions are sounds generated internally in a soil or rock mass as it deforms. These sounds produce stress waves that stimulate transducers implanted at strategic points in, or on, the material being monitored. This paper presents four case histories on relatively local subsidence which utilize the technique. For situations where larger land masses are involved, i.e., areal subsidence, the sensors must be left in place over long time periods and periodically visited. In such cases remote sensing is a definite possibility. Six schemes are presented, based on either continuous or periodic transmission, which include direct coupling, telephone, and airborne concepts.

Keyword(s): remote sensing, fluid extraction, coal mining, monitoring methods, soils, lab testing, abandoned mines, surface structural damage

Location(s): Pennsylvania, Appalachian Coal Region, United States

Kohli, K., T. M. Crandall, R. C. Dollence. Investigation of Subsidence Event Over Multiple Seam Mining Area. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 267.

An investigation was performed to determine the sequence of events causing the 1986 surface subsidence and related structural damage to several homes in Walker County, Alabama.

Keyword(s): multiple-seam extraction, coal mining, surface structural damage, abandoned mines, pillar strength

Location(s): Alabama, United States

Kohli, K. K., S. S. Peng, R. E. Thill. Surface Subsidence Due to Underground Longwall Mining in the Northern Appalachian Coal Field. Preprint No. 80-53, SME-AIME Annual Meeting, Las Vegas, NV, February 24-28, 1980, 8 p.

Keyword(s): longwall, coal mining

Location(s): Appalachian Coal Region, United States

Kohli, K. K., S. S. Peng, R. E. Thill. Surface Subsidence Due to Underground Longwall Mining In the Northern Appalachian Coal Fields. IN: Longwall-Shortwall Mining, State of the Art, R.V. Ramani, ed., SME-AIME, New York, 1981, p. 99-105.

An effort was initiated to contact each individual coal company in the Northern Appalachian Coalfield for any surface subsidence survey data that they might have. These data could then be assembled to aid subsidence engineering design. Data collected included 17 longwall panels and 2 room-and-pillar sections. Information covers survey raw data, underground layout maps, surface topography maps, geological logs showing stratigraphic sequences and thickness of the overburden and, if available, locations and types of surface structures. On-site visits followed collection of data, to study surface terrains and structures.

Keyword(s): coal mining, survey data processing, survey design, longwall, room-and-pillar, surface structural damage, mine design, vertical displacement, horizontal displacement, time factor

Location(s): West Virginia, Appalachian Coal Region, United States

Kohli, K. K., S. S. Peng, R. E. Thill. Subsidence Experiences in the Room-and-Pillar Mines of the Northern Appalachian Coalfield. IN: Proceedings, Conference on Ground Control in Room-and-Pillar Mining, Southern Illinois University, Carbondale, August 6-8, 1980, Y.P. Chugh, ed., SME-AIME, New York, 1982, p. 133-138.

The results of unpublished investigations into surface subsidence from coal mining in the Northern Appalachian Coalfield are summarized. These invesitigations were carried out by various coal companies and the state of Pennsylvania in the 1960s and 1970s. Subsidence data were collected and analyzed from 10 room-and-pillar panels in 5 mines in the Pittsburgh coal seam.

Keyword(s): room-and-pillar, ground control, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Kohli, K. K., T. Z. Jones. A Simplified Computerized Method to Predict Maximum Subsidence and the Subsidence Profile for the Appalachian Coal Basin. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 31-37.

This paper presents a simplified computerized method for the prediction of maximum subsidence and the subsidence profile for the Appalachian Coal Basin using the Hyperbolic Function Profile Method. Several case histories are cited to demonstrate the appropriateness of the predictive method. In addition, sample runs and a detailed listing of the computer program is provided. Other popular subsidence prediction methods are discussed and compared with the Hyperbolic Function Profile Method.

Keyword(s): computer, prediction, modeling, profile function, coal mining, longwall

Location(s): West Virginia, Appalachian Coal Region, United States

Kolesar, J. E., E. C. Palmer, V. A. Scovazzo. Subsidence Monitoring Plan of Longwall Panels--A Case Study, Kitt Mine No. 1. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 225-229.

This paper details a proposed rock-mass-response instrument plan for a longwall mining operation, including descriptions of instrumentation construction plans and practices.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, instrumentation, longwall

Location(s): West Virginia, Appalachian Coal Region, United States

Kosterin, M. A. Vliyanie Ugla Podeniya I Razmerov Vyrabotki Na Kharakter Mul'dy Sdvizheniya (Influence of the Dip Angle and of the Size of Excavation on the Nature of the Subsidence Trough). Izvestiya Vysshikh Uchebnykh Zavedenij Gornyj Zhurnal, no. 3, 1974, p. 43-49.

Keyword(s): geologic features, mine design

Kot, A., P. Trzcionka, J. Bryla. Praktyczna Metoda Wyznacznia Parametrow Teorii Ruchow Gorotworu (Practical Method for Determining the Parameters of the Ground-Displacements Theory). Przeglad Gorniczy, v. 28, no. 12, 1972, p. 582-587.

Keyword(s): prediction, modeling

Kotze, T. J. The Nature and Magnitude of Surface Subsidence Resulting from Mining at Relatively Shallow Depths on Platinum Mines. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 47-51.

With the advent of total extraction methods on coal mines, the attention has so intensely been focused on what happens when the overburden is relatively soft that there may be a tendency for mining engineers to forget that similar problems can occur even when the overlying measures are strong and competent.

Keyword(s): metal mining, overburden, coal mining, roof support, surface structural damage, survey methods

Location(s): South Africa

Kowalczyk, Z. Effect of Mining Exploitation on the Ground Surface and Structures in Heavily Industrialized and Populated Areas. Canadian Institute Mining & Metallurgy Transactions, Mining Society, Nova Scotia, v. 69, 1966, p. 387-393.

The author describes a proposed subsidence prediction theory that would permit the determination of surface deformations for planned underground exploitation.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, mine design, prediction theories, engineering, construction, land-use planning

Kraj, W. Proba Uzyskania W Gorotworze Jako Osrodku Sprezysto-Lepkim Niecki St. Knothego (Attempt to Determine if a Rock Mass is Considered as a Viscoelastic Medium in St. Knothe's Subsidence Trough). Archiwum Gornictwa, v. 18, no. 2, 1973, p. 111-121.

Keyword(s): prediction theories, empirical model, profile function

Krantz, G. W., J. C. LaScola. Longwall Mine Subsidence Surveying--An Engineering Technology Comparison. IN: Mine Subsidence Control, Proceedings Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, September 19, 1985, U.S. Bureau of Mines IC 9042, p. 2-12.

A typical longwall mine subsidence survey monitoring grid was installed at the USBM. Conventional and high-technology surveying systems were developed over the grid during a 1-month period. This investigation evaluated and compared five surveying methodologies available for use in surface longwall subsidence monitoring.

Keyword(s): survey design, monitoring methods, longwall, monitoring design, photography, survey methods

Location(s): Pennsylvania, Appalachian Coal Region, United States

Kratzsch, H. Reduced Subsidence by Planned Extraction. Bergbau-Archiv, Essen, v. 25, no. 5, December 1964, p. 15-21.

This paper examines the influence of the location and sequence of mine workings on the stresses affecting a building.

Keyword(s): mine design, surface structural damage

Kratzsch, H. Der Zeitfaktor in Der Bodenbewegungskunde (Time Factor in Theory of Surface Subsidence). Glueckauf-Forschungshefte, v. 29, no. 6, December 1968, p. 323-330.

Keyword(s): time factor, prediction theories

Kratzsch, H. Bergschadenkunde (Mining Subsidence Engineering). Springer-Verlag, Berlin-Heidelberg-New York, 1974, 582 p.

Keyword(s): vertical displacement, horizontal displacement

Kratzsch, H. Mining Subsidence Engineering. Springer-Verlag, Berlin-Heidelberg-New York, 1983, 535 p.

This book deals with the current state of international knowledge on strata and ground movement over mine workings, including detailed descriptions of the damaging effects to mine shafts and the ground surface.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, law

Location(s): Germany

Krauland, N., P.-E. Soder. Determining Pillar Strength from Pillar Failure Observation. Engineering & Mining Journal, v. 188, no. 88, August, 1987, p. 34-40.

On the basis of field observations, the process of pillar failure has been divided into six stages, each stage having visually well discernible characteristics. By combining these failure stage observations with pillar load calculations in an advanced stage of mining, mine planning engineers can determine large scale pillar strength for mine design purposes. This method has been applied in room-and-pillar mines of Boliden Mineral AB for pillar dimensioning. Details of the application to the Black Angel Mine of Greenex A/S in Marmorilik, Greenland, are described. The observed large scatter of pillar strength is handled by dividing the ore body into pillar areas with similar conditions with regard to geology, orebody, and pillar geometry, and dip. Stress measurements were conducted in eight pillars having different degrees of fracturing to confirm the calculated load levels for the pillar classes.

Keyword(s): pillar strength, room-and-pillar, coal mining, metal mining, mine design

Location(s): Greenland

Krausse, H-F., H. H. Damberger, W. J. Nelson, S. R. Hunt, C. T. Ledvina, C. G. Treworgy, W. A. White. Engineering Study of Structural Geologic Features of the Herrin (No. 6) Coal and Associated Rock in Illinois. Final Report, Contract No. H0242017, U.S. Bureau of Mines, 1979, 205 p.

Keyword(s): engineering, geologic features, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Kreitler, C. W. Lineation and Active Faulting in the Houston-Galveston Area of Subsidence. Geological Society of America, Abstracts with Programs, v. 7, 1975, p. 180.

Keyword(s): fluid extraction, geologic features

Location(s): Texas, United States

Kreitler, C. W., C. R. Lewis, D. McKalips. Geologic Control of Land Subsidence, Houston-Galveston, Texas. Geological Society America, Abstracts with Programs, v. 7, 1975, p. 1154.

Keyword(s): fluid extraction
Location(s): Texas, United States

Kreitler, C. W. Faulting and Land Subsidence from Ground-Water and Hydrocarbon Production, Houston-Galveston, Texas. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, December 13-17, 1976, International Association of Hydrological Sciences Publication No. 127, Washington D.C., 1977, p. 435-446.
Keyword(s): hydrology, subsurface water, oil extraction, fluid extraction
Location(s): Texas, United States

Kreitler, C. W. Fault Control of Subsidence, Houston, Texas. Ground Water, 15, 1977, p. 203-214.
Keyword(s): geologic features, hydrology
Location(s): Texas, United States

Krey, T. C. In-Seam Seismic Exploration Techniques. IN: Coal Exploration, Proceedings 1st International Symposium, Miller Freeman, San Francisco, CA, 1976, p. 227-235.
Keyword(s): roof stability, seismic, coal mining

Kripakov, N. P. Numerical Modeling Applied to Simulating Cutter Roof Failure in Underground Coal Mines. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 143-154.
This paper presents an overview of the application by the USBM of three unique numerical modeling techniques to analyze cutter roof problems in underground coal mines. Cutter roof failures are common in coal mines where the immediate roof is often composed of thin shale laminae exposed to high regional tectonic stress fields.
Keyword(s): roof stability, coal mining, modeling, roof support, finite element, roof bolting, geologic features, boundary element
Location(s): Pennsylvania, West Virginia, Illinois Coal Basin, Appalachian Coal Region, Rocky Mountain Coal Region, United States

Krishna, R., B. N. Whittaker. Floor Lift in Mine Roadways--Recent Investigations and Modern Methods of Control. Colliery Guardian, November, 1973, p. 396-402.
Keyword(s): mine operation, floor stability

Krishna, R. Progress in Ground Control Instrumentation. IN: Proceedings, International Symposium on Underground Engineering, New Delhi, India, B. Singh, ed., April 14-17, 1988, Balkema, Rotterdam, p. 83-89.
The author studied the mechanics of subsurface deformation caused by caving of the extracted area in a mine in the Ranigunj Coalfield. The earlier research findings indicate that the surface subsidence takes place as a result of deformation in underground and intervening strata. The paper describes some of the instruments being used in this project for study of the above phenomena, along with a few of the latest ones that are currently being developed to provide basic data for designing safe and economical underground structures.
Keyword(s): coal mining, monitoring design, monitoring equipment, overburden, instrumentation, remote sensing, seismic
Location(s): India

Kulhawy, F. H. Geomechanical Model for Rock Foundation Settlement. IN: Proceedings, ASCE, Journal of the Geotechnical Engineering Division, v. 104, GT2, February 1978, p. 211-227.
Keyword(s): foundations, geotechnical, engineering, modeling
Location(s): United States

Kumar, R., N. C. Saxena, B. Singh. Measurement of Horizontal and Vertical Movements on the Surface Caused by Mining Excavations. Journal of Engineering Geology, v. 7, no. 1, 1975, p. 429-436.
Keyword(s): monitoring equipment, modeling, horizontal displacement, vertical displacement, monitoring methods

Kumar, R., N. C. Saxena, B. Singh. A New Hypothesis for Subsidence Prediction. Journal of Mines, Metals and Fuels, 1983, p. 459.
Keyword(s): prediction

Kumar, S. R., B. Singh. Investigations on Surface Subsidence in Mine No. 1. Central Mining Research Station, Dhanbad, Bihar, India, Research Paper 34, May, 1967, 17 p.
Keyword(s): coal mining
Location(s): India

Kumar, S. R. Mine Subsidence Investigations Over a Longwall Working and the Prediction of Subsidence Parameters for Indian Mines. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 10, 1973, p. 151-172.

Results of subsidence investigations over the workings of a longwall panel, above which two old workings were present are described in this paper. These results provide a typical example of subsidence behavior in Indian mines. The comparison of observed and calculated subsidence parameters and their conformity with the authors' equations are discussed for this particular case in detail. Three other case histories are also briefly described to demonstrate the suitability of the authors' approach for the prediction of subsidence effects in Indian mines.

Keyword(s): active mines, abandoned mines, longwall, prediction, multiple-seam extraction

Location(s): India

Kumar, S. R., B. Singh, K. N. Sinha. Subsidence Investigations in Indian Mines. IN: Proceedings, 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute Mining & Metallurgy, Illawarra Branch, Paper 6, p. 6-1 - 6-8.

The subsidence behavior in Indian coal mines indicates smaller values of the angle of draw, small values of maximum subsidence and the distribution of subsidence over smaller surface area over the worked out area. The reasons for these special effects may be the hard nature of overlying strata and small areas of working in individual panels. Mines were worked on the bord-and-pillar system, the longwall system, the French method of working thick seams, the knife edge system of extraction pillars on a longwall basis (Russian method) and by a partial extraction system. Some workings were stowed with sand and some were caved.

Keyword(s): coal mining, stowing, room-and-pillar, longwall, pillar extraction, angle of draw, overburden, geologic features, vertical displacement, horizontal displacement

Location(s): India

Kusznir, N. J., D. Ashwin, A. Bradley. Mining Induced Seismicity in the North Staffordshire Coalfield, England. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 17, no. 1, February, 1980, p. 45-55.

Mining induced seismicity associated with longwall coal extraction in North Staffordshire, England, was investigated in order to establish the cause and mechanism of the seismicity. The study shows that seismicity is directly caused by active mining with earth tremor hypocentres moving in unison and in advance of the face. The seismicity does not appear to be directly associated with any of the major faults bounding the mined area.

Keyword(s): seismic, coal mining, rock mechanics, longwall, geologic features, monitoring methods

Location(s): England

Kusznir, N. J., K. R. Whitworth. Use of Synthetic Fracture Logs Derived from Borehole Geophysics to Assess Mine Roof and Floor Quality. International Journal Mining Engineering, October, 1983, p. 253-260.

Keyword(s): roof stability, floor stability, geophysical

Kusznir, N. J., K. R. Whitworth, K. Atkinson, R. Brassington. Experience in the Application of RocTec, a New Method of Obtaining Rock Quality Data from Borehole Geophysical Logs. IN: Extractive Industry Geology Conference, Warwick, England, March 1983, Institution of Geologists, London, p. 69-95.

This paper describes a method to aid prospecting for and evaluation of non-metallic rocks and minerals.

Keyword(s): overburden, geophysical, rock mechanics, geotechnical, non-metal mining

Location(s): England

Kuti, J. Mining Engineering Aspects of Longwall System Parameters in North America. Coal Mining Institute of America, December 11, 1969.

The development of longwall systems designs in the U.S. is compared to the European experience.

Keyword(s): coal mining, longwall, mine design

Location(s): United States, Europe

Kuti, J. Engineering Approaches to Rock Mechanics Problems in Longwall Mining. AIME Preprint No. 71-F-340, 1971.

Problems with longwall mining in the United States are discussed, including the effects of shallow workings and roof control.

Keyword(s): coal mining, roof stability, roof support, longwall, mine design, geologic features

Location(s): United States

Kuti, J. Longwall vs. Shortwall Systems. American Mining Congress Journal, August 1975, p. 24-33.

Keyword(s): longwall, shortwall, mine design, ground control, roof support, coal mining

Kuti, J. Longwall Mining in America. Society of Mining Engineers Preprint 78AU336, September, 1978.

Keyword(s): longwall

Location(s): United States

Kuti, J. Longwall Mining in America. Mining Engineering, November 1979, p. 1593-1602.

This article covers the historical background of longwall mining, general statistics for the United States and other countries, state of the art, development trends, and forecasts longwall systems of the future. The author states that immediate development will be determined by the need to comply with health and safety regulations without sacrificing production.

Keyword(s): longwall, coal mining, mine operation

Location(s): United States

Laage, L. W. The Development of Guidelines for Closing Eastern Underground Coal Mines. M.S. Mining Engineering thesis, Michigan Technological University, Houghton, 1982, 132 p.

Coal production from underground mines has been important to the development of the industrial economy of the United States. Environmental problems including subsidence have developed from some abandoned operations. The undesirable present-day situations could have been avoided or at least minimized by varying certain mining practices or mine closure procedures.

Keyword(s): coal mining, abandoned mines, active mines, mine waste, mine fires, mine operation, law, government, surface structural damage, surface water, reclamation

Location(s): Ohio, Illinois, United States

Lacey, R. M. Damage Resulting from Coal Mine Subsidence. Citizen Participation and Attitudes as a Guide to Governmental Action. M.S. Thesis, Southern Illinois University at Edwardsville, February, 1978.

The purpose of this paper is to provide some information and guidance for those decision-makers and the public who may at some point in the future be faced with subsidence problems. An incident is recounted where subsidence was occurring and adjustments to the problem were sought.

Keyword(s): surface structural damage, coal mining, abandoned mines, literature search, government, historical, foundations, construction, land-use planning, law, insurance, hydraulic backfilling

Location(s): Illinois, Illinois Coal Basin, United States

Lacey, W. D., H. T. Swain. Design for Mining Subsidence. Architecture Journal, October 10, 1957, v. 126, no. 3287, p. 557-570.

Keyword(s): architecture, coal mining, construction, engineering, foundations

Location(s): England

Lacey, W. D., H. T. Swain. The Development of the Notts System of Construction. Architecture Journal, October 24, 1957, v. 126, no. 3288, p. 631-636.

Keyword(s): construction, architecture, engineering, foundations

Location(s): England

Lacey, W. D., H. T. Swain. Three Nottinghamshire Schools. Architecture Journal, v. 129, no. 3348, 1960, p. 651-668.

Keyword(s): architecture, coal mining, foundations

Lackington, D. W., B. Robinson. Articulated Service Reservoirs in Mining Subsidence Areas. Journal of the Institution of Water Engineers, v. 27, 1973, p. 197-215.

Keyword(s): surface water

Laird, R. B., A. L. Amundson, G. J. Colaizzi, L. M. Bithell. Geologic Conditions Affecting Coal Mine Ground Control in the Western United States. U.S. Bureau of Mines OFR 63-86, Goodson and Associates, Inc., Denver, CO, December, 1985, 200 p. (NTIS PB86-217171/WNR)

An investigation was conducted into geologic features affecting coal mine ground control in western underground coal mines. The study involved a literature search. Data on mining operations were collected by interviewing mining and research personnel. Selected mines were toured within 10 coalfields in Utah and Colorado.

Keyword(s): literature search, ground control, roof stability, geologic features, coal mining

Location(s): Utah, Colorado, Rocky Mountain Coal Region, United States

Lama, R. D., P. Moxon, D. M. Shu. Prediction of Subsidence Due to Longwall Mining at West Cliff Colliery. IN: Proceedings, Symposium on Ground Movement and Control Related to Coal Mining, Illawarra, Australia, August, 1986, N.I. Aziz, ed., Australasian Institute of Mining and Metallurgy, p. 311-323.

Subsidence profiles at West Cliff colliery, in the Illawarra coal measures, Australia, have been predicted by three methods, the NCB empirical method, Salustowicz's profile functions, and the method of superposition of critical subsidence profiles. A method of predicting maximum subsidence using local data is also presented. Results are also compared with field measurements for the first four longwall panels. Strata movements above the extracted longwalls are also discussed.

Keyword(s): coal mining, longwall, prediction, prediction theories, National Coal Board, empirical model, profile function, survey data processing, overburden, active mines

Location(s): Australia

LaMoreaux, P. E., J. G. Newton. Catastrophic Subsidence: An Environmental Hazard, Shelby County, Alabama. Environmental Geology Water Science 8, 1986, p. 25-40.

Keyword(s): geologic features, hydrology
Location(s): Alabama, United States

LaMoreux, P. E. Catastrophic Subsidence, Shelby County, Alabama. IN: Sinkholes: Their Geology, Engineering and Environmental Impact, Proceedings 1st Multidisciplinary Conference on Sinkholes, Orlando, October 15-17, B.F. Beck, ed., 1984, Balkema, Rotterdam, p. 131-136.

Recent subsidence and collapse of the land surface in at least three areas underlain by carbonate rocks in Alabama have dramatically demonstrated the need for greater understanding of the causative mechanisms involved. Buildings, highways, utility lines, oil and gas pipelines, and constructions of all types are threatened by these collapses. This paper describes some of the remote sensing methods used to investigate this problem.

Keyword(s): geologic features, remote sensing, photography, hydrology
Location(s): Alabama, United States

Land, L. F., C. A. Armstrong. A Preliminary Assessment of Land-Surface Subsidence in the El Paso Area, Texas. Water-Resources Investigations Report No. WRI 85-4155, 1985, U.S. Geological Survey, Denver, CO, 96 p.

Keyword(s): surface subsidence damage, fluid extraction
Location(s): Texas, United States

Landes, K. K., T. B. Piper. Effect Upon Environment of Brine Cavity Subsidence at Grosse Isle, Michigan. Solution Mining Research Institute Report SMRI 72-0003, 1971, 55 p.

Keyword(s): non-metal mining, environment
Location(s): Michigan, United States

Landes, K. K. Recent Subsidence Hamilton County, Kansas. Association Petroleum Geologists Bulletin, v. 15, no. 6, 1978, p. 708.

Keyword(s): Kansas, United States

Landsberg, H. Recording of Roof Subsidence. Transactions, AIME, v. 119, 1936, p. 139-149.

Keyword(s): instrumentation, roof stability

Lane, W. T., J. H. Roberts. The Principles of Subsidence and the Law of Support. Alfred A. Knopf, Ltd., London, 1929, 311 p.

This book gives the English mining officials' and technicians' viewpoints at the time (1929) of legal questions regarding subsidence.

Keyword(s): ground control, descriptive theories, law
Location(s): England

Lang, T. A. Rock Mechanics Considerations in Design and Construction. IN: Proceedings 6th Symposium on Rock Mechanics, University of Missouri-Rolla, October, 1964, E.M. Spokes and C.R. Christiansen, eds., p. 561-605.

This paper emphasizes general considerations and fundamental principles rather than detailed procedures. In most cases, the latter must be developed to meet the needs and requirements of each job and site.

Keyword(s): rock mechanics, mine design, geologic features, lab testing, in situ testing, geotechnical

Langland, R., D. Fletcher. Predicting Subsidence Over Coal Gasification Sites. UCID-17326, Lawrence Livermore Laboratory, 1976, Livermore, CA.

Keyword(s): prediction, coal gasification

Lansdown, R. F. The Development of Pneumatic Stowing in the South Wales Coalfield. Transactions, Institute of Mining Engineers, v. 108, 1948, p.512.

Keyword(s): pneumatic backfilling, coal mining
Location(s): Wales

Larson, M. K., T. L. Pewe. Origin of Land Subsidence and Earth Fissuring, Northeast Phoenix, Arizona. Bulletin Association of Engineering Geologists, 23, 1986, p. 139-165.

Keyword(s): geologic features, engineering
Location(s): Arizona, United States

LaScola, J. Aerial Measurement of Mining Subsidence. MinTech '90: The Annual Review of International Mining Technology and Development, 1990, T.L. Carr, ed., Sterling, p. 67-70.

Keyword(s): remote sensing, surface subsidence damage, monitoring methods
Location(s): United States

LaScola, J. C. Comparison of Aerial and Ground Surveying of Subsidence Over an Active Longwall. U.S. Bureau of Mines RI 9214, 1988, 12 p.

The USBM repeatedly surveyed a grid of monuments over an active longwall mine panel in southwestern Pennsylvania during a 1-year period. Both conventional ground surveying techniques and photogrammetry were used. The objective of this investigation was to compare elevation measurements of subsidence obtained from aerial and ground survey methods under dynamic ground conditions. The results of a statistical analysis of the survey data show that the mean of the differences between 372 matched pairs of elevation measurements was 0.20 foot (61 mm) with a 95% confidence interval of 0.05 foot (15 mm). The mean of the absolute values of the differences was 0.38 foot (116 mm) with a 95% confidence interval of 0.04 foot (12mm). Ninety-five percent of the absolute values of the differences were less than 1.11 feet (338 mm).

Keyword(s): monitoring methods, monitoring equipment, monitoring installation, survey methods, survey equipment, survey design, remote sensing, horizontal displacement, vertical displacement, photography, longwall, active mines, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Laubscher, D. H., H. W. Taylor. The Importance of Geomechanics Classification of Jointed Rock Masses in Mining Operations. IN: Proceedings Symposium on Exploration for Rock Engineering, Johannesburg, November, 1976.

Keyword(s): rock mechanics, geologic features

Location(s): South Africa

Lautsch, H. Principles of the Theoretical Prediction of Ground Movements--Comparison with Practical Results and the Task of the Mining Surveyor in the Application of These Predictions. IN: Proceedings 1st Canadian Symposium on Mining Surveying and Rock Deformation Measurements, 1969, University of New Brunswick, Fredericton, p. 293-324.

Keyword(s): prediction, survey methods

Lautsch, H. Die Erweiterte Trogtheorie Zur Deutung Bergbaulich Bedingter Bodenbewegungen (Interpretation of the Ground Subsidence, Caused by the Mining Exploitation, by Means of the Expanded Trough Theory). Glueckauf-Forschungshefte, v. 35, no. 5, October 1974, p. 167-173.

Keyword(s): prediction theories

Lawson, J., A. Winstanley. The Working of Seams in Proximity. Transactions, Institution of Mining Engineers, v. 83, 1931-32, p. 176-190; discussion, v. 84, 1932-33, p. 43-49 and 324-325.

Keyword(s): multiple-seam extraction, longwall, coal mining

Leavitt, B. R., J. F. Gibbens. Effects of Longwall Coal Mining on Rural Water Supplies and Stress Relief Fracture Flow Systems. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 228-236.

The response of 174 domestic water supplies to longwall mining of the Pittsburgh coal seam was compared to various physical parameters. Sixty-four percent of domestic water supplies returned to service without the need for intervention, while 36% required intervention to reestablish a suitable water supply. Domestic well response is strongly correlated with the topographic setting. Valley wells showed the least effect while hilltop wells showed the greatest effect.

Keyword(s): hydrology, subsurface water, longwall, coal mining, modeling

Location(s): Pennsylvania, Ohio, West Virginia, Appalachian Coal Region, United States

Ledvina, C. T., C. W. Shabica, R. V. Sachs, K. Webb. Mining Geology of Secondary Paleo-channels Affecting the Herrin (No. 6) and Springfield (No. 5) Coals of Illinois. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 9-18.

The deposition of the Herrin and Springfield Coals and overlying strata was closely tied to primary (major), easily mappable paleo-channel systems such as the Walshville Channel and fill, herein named the Walshville Sandstone, and the Galatia Channel and fill, herein named the Galatia Sandstone. Because of this genetic relationship, primary channels have profound effects on the geology of coal, roof, and floor. Primary paleo-channel systems have been extensively mapped, and mines can be planned and operated to avoid them. Less obvious and predictable, however, are secondary paleo-channels. Secondary channels may be related to primary systems as tributaries or distributaries and occur frequently where mines operate or are contemplated. These channels almost always adversely affect mining by disrupting the continuity of coal, roof, or floor.

Keyword(s): coal mining, geologic features, mine design, ground control

Location(s): Illinois, Illinois Coal Basin, United States

Lee, A. J. The Effect of Faulting on Mining Subsidence. The Mining Engineer, v. 125, no. 71, August, 1966, p. 735-745.

This paper is a record of a preliminary investigation of the effects of faulting on mine subsidence. A summary is given of the results obtained from a detailed survey of a selected area. These results indicate that faults are more important than generally thought. An analysis of the results is made and tentative rules are advanced for the prediction of movement in simplified cases.

Keyword(s): overburden, geologic features, prediction, survey methods

Lee, F. T., J. F. Abel, Jr. Subsidence from Underground Mining: Environmental Analysis and Planning Considerations. U.S. Geological Survey Circular 876, 1983, 28 p.

Subsidence is potentially severe in damage to surface utilities and structures, changes in water conditions, and effects on vegetation and animals. To develop prediction methods and models for the United States, more information is needed on magnitude and timing of ground movements and geologic properties.

Keyword(s): environment, land-use planning, hydrology, time factor, prediction, modeling, utilities, surface water, subsurface water, geologic features, wildlife

Location(s): New Mexico, Wyoming, Rocky Mountain Coal Region, Pennsylvania, West Virginia, Appalachian Coal Region, United States

Lee, K. L., M. E. Strauss. Prediction of Horizontal Movements Due to Subsidence Over Mined Areas. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 89, v. 2, 1969, p. 512-522.

This paper reviews qualitative and quantitative interrelations among vertical subsidence, geological conditions, and resulting horizontal movements. It includes a case history of horizontal movements occurring over a sulfur mining area.

Keyword(s): vertical displacement, horizontal displacement, prediction, finite element, non-metal mining, geologic features

Lee, K. L., C. K. Shen. Horizontal Movements Related to Subsidence. ASCE Journal Soil Mechanics & Foundations Division, v. 69, no. SM1, 1969, p. 139-166; v. 96, no. SM4, 1970, p. 1464-1466.

This paper reviews cases involving compressible foundations to illustrate the extent of subsidence. Analytical methods and experimental studies are used to investigate mechanisms of horizontal movement. An earth dam constructed on a compressible foundation is used as an example of predicted horizontal movements.

Keyword(s): horizontal displacement, soil mechanics, prediction, foundations

Lee, P. A., W. F. Kane, E. C. Drumm, R. M. Bennett. Investigation and Modeling of Soil-Structure Interface Parameters. IN: Proceedings Congress on Foundation Engineering, Evanston, IL, June 25-29, 1989, F.H. Kulhawy, ed., ASCE, p. 580-587.

Keyword(s): foundations, soils, modeling, engineering

Location(s): United States

Lee, P. H. Interface Parameters for Earth-Structure Interaction During Mining-Induced Subsidence. M.S. Thesis, University of Tennessee, Knoxville, December, 1989, 111 p.

This investigation examines the technique of placing various materials under foundations to reduce friction. A hyperbolic model, in order to allow future numerical analyses, is presented to characterize this type of interface behavior. A series of direct shear tests were performed on various interface combinations of soil and construction materials. The interfaces were tested over a range of normal stresses, which includes the typical stresses to which a residential or light commercial facility foundation might be subjected. For each interface combination, shear strength, shear stiffness, and hyperbolic model parameters were determined.

Keyword(s): surface structural damage, structural mitigation, foundations, modeling, soils, coal mining, active mines, lab testing

Location(s): Illinois, Illinois Coal Basin, United States

Lee, R. D. Testing Mine Floors. Colliery Engineering, v. 38, no. 448, 1961.

Keyword(s): floor stability, in situ testing

Leeman, E. R. The Measurement of Stresses in Rock. (a) Part I: The Principle of Rock Stress Measurements; (b) Part II: Borehole Rock Stress Measuring Instruments; (c) Part III: The Results of Some Rock Stress Investigations. Journal South African Institute Mining & Metallurgy (a) September 1964, p. 45-81; (b) September 1964, p. 82-114; (c) November 1964, p. 254-284.

Keyword(s): ground control, instrumentation, rock mechanics, in situ testing

Location(s): South Africa

Leeman, E. R., W. L. Van Heerden. Stress Measurements in Coal Pillars. Colliery Engineering, pt. 1, December 1963; pt. 2, January 1964.
These articles present data obtained from borehole stress measurements in coal pillars.
Keyword(s): coal mining, instrumentation, monitoring methods, pillar strength, in situ testing

Legget, R. F. Duisberg Harbor Lowered by Controlled Coal Mining. Canadian Geotechnical Journal, v. 9, no. 4, 1972, p. 374-383.
Mining operations led to the successful lowering of the Duisberg Harbor and associated industrial facilities. Subsurface geological conditions, planning, and mining operations are outlined, and results described in detail.
Keyword(s): hydrology, surface water, subsurface water, coal mining

Lehr, J. What's All the Fuss About Longwall Mining? Water Well Journal, February 1989, p. 4-5.
Found on the Editor's Page, this article describes the longwall mining process and its effects on surface and subsurface hydrology. According to the author, in most cases, the net hydrogeological result of longwall mining is increased permeability, transmissibility, and specific capacities of wells as a result of the increases in secondary fracturing. Surface hydrology is less commonly affected, though local springs may experience moderate decreases or increases in flow. With few exceptions, what amounts to massive hydrofracturing of the shallow formations yields an improved groundwater system. For the most part, negative impacts are easy to remedy.
Keyword(s): surface water, subsurface water, hydrology, coal mining, longwall, overburden, geologic features, mine safety, surface structural damage
Location(s): United States

Leighton, M. W. Coal Research at the Illinois State Geological Survey. IN: Proceedings Illinois Mining Institute, 1986, p. 20-45.
This paper discusses coal research program at the ISGS in terms of present and future needs.
Keyword(s): coal mining, environment, geologic features
Location(s): Illinois, Illinois Coal Basin, United States

Lenge, A. Inspection and Correction of Damage to Railways Caused by Mining in the Saar. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 106-114.
This paper describes the subsidence damage to railroads in the Saar mining region; repair methods used are also detailed.
Keyword(s): surface structural damage, railroads
Location(s): Europe

Leonhardt, J. Bessere Standfestigkeit Von Grubenbauen Durch Markscheiderische Messungen (Improved Stability of Workings by Measurements by Mine Surveyors). Glueckauf-Forschungshefte, v. 110, no. 24, December 1974, p. 1027-1029.
Keyword(s): survey methods

Lepper, C. M., F. Ruskey. High Resolution Seismic Reflection Techniques for Mapping Coal Seams from the Surface. U.S. Bureau of Mines, Coal Mine Health and Safety Program, TPR 101, 1976, 17 p.
Keyword(s): roof stability, ground control, seismic, coal mining, geologic features, mine safety
Location(s): United States

Leshendok, T. V. Geologic Factors Related to Surface Subsidence Due to Underground Coal Mining. IN: Proceedings, 41st Annual Meeting American Society of Photogrammetry, Boulder, CO, March 6-8, 1975, p. 21-22.
Keyword(s): geologic features, coal mining, surface subsidence damage
Location(s): United States

Leshendok, T. V., R. V. Amato, O. R. Russell. Remote Sensing Applied to Mine Subsidence: Experience in Pennsylvania and the Midwest. IN: Proceedings 41st Annual Meeting of American Society of Photogrammetry, Boulder, CO, March 6-8, 1975, p. 298-307.
Keyword(s): remote sensing, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Leting, H. The Law Governing Dynamic Subsidence, Tilts and Curvatures Over a Working Face During Mining. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 209-222.
This paper discusses the laws governing dynamic subsidence, tilt, and curvature during mining, as opposed to the final, fully developed subsidence trough. A series of problems such as

the distribution of ground movements and their derivatives, their maximum values, and the laws covering the locations of these maxima, still await resolution. Based on data from stations set up for ground movement observations at Zijuang mine, a preliminary analysis and discussion are presented of the laws governing the subsidence, tilts, and curvatures of a half subsidence trough directly over the face, before it is subjected to the dynamic effect brought about by a critical or a supercritical area of extraction.

Keyword(s): horizontal displacement, vertical displacement, survey data processing

Location(s): China

Leung, A., J. W. Mahar, S. S. Huang, M. D. Boscardin. Mine Subsidence at the Northland Drive - Southland Court Area, Belleville, Illinois; Progress Report, June 30 to 1981 to May 31, 1982. Illinois Abandoned Mined Lands Reclamation Council, 1983, 41 p.

Keyword(s): surface structural damage, coal mining, abandoned mines

Location(s): Illinois, Illinois Coal Basin, United States

Levy, E. Rock Filling at Rio Tinto. Engineering and Mining Journal, v. 89, 1910, p. 363.

This article describes hand stowing in a Spanish copper mine for roof control, due to the limited availability of timber.

Keyword(s): stowing, historical, metal mining, roof support

Location(s): Spain

Lewis, B. C. Longwall Mining: Future Concerns That Must Be Addressed. Mining Engineering, October, 1990, p. 1170-1171.

This article lists present trends in the coal mining industry. Also, responses to an industry questionnaire regarding technological needs are given, with the number one category being subsidence-groundwater issues.

Keyword(s): longwall, hydrology, mine operation, coal mining, law

Location(s): Illinois, Illinois Coal Basin, United States

Lewis, R., A. Clark. Elements of Coal Mining. 3rd Edition, McGraw-Hill, New York, 1966.

This text is designed to acquaint mining students with the entire spectrum of mine-related activities, both coal and metal. Several chapters deal with the support of mining excavations, coal mining methods, and rock mechanics.

Keyword(s): coal mining, metal mining, rock mechanics, mine design, mine operation

Liebenburg, A. C. Building on Undermined Ground. South African Mining Engineering Journal, v. 81, no. 4038, June 26, 1970, p. 179, 181-183.

Keyword(s): construction, engineering, land-use planning

Location(s): South Africa

Lin, P. M., S. M. Hsiung, S. S. Peng. Investigation of Subsidence of AML: A Case Study. IN: Proceedings 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., West Virginia University, Morgantown, p. 249-257.

This paper describes the approach employed for the determination of abandoned mine subsidence. A site investigation was made first. According to the information obtained from the site investigation, a hypothesis was set up. Then instrumentation was used to prove the hypothesis. By going through the procedures for several cases, a guideline which can be used by the inspectors to inspect abandoned mine subsidence will be established.

Keyword(s): abandoned mines, coal mining, roof stability, floor stability, surface structural damage, bituminous, instrumentation

Location(s): Pennsylvania, Appalachian Coal Region, United States

Lin, P. M., S. S. Peng. Surface Damage Due to Longwall Mining--A Case Study. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 519-526.

A subsidence monitoring program over a longwall panel was established to explore the impacts of dynamic subsidence on the ground surface and structures and to correlate the movements between the structures and their corresponding points on the ground. The program consisted of a transverse line survey and a series of survey points around the structures on the ground surface and their corresponding survey points on the exterior walls of the structures.

Keyword(s): longwall, monitoring methods, surface structural damage, survey methods, vertical displacement, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Lin, P. M., S. S. Peng, P. Tsang. Abatement Optimization of Abandoned Mine Land Subsidence. SME Preprint No. 90-165, for presentation at the SME Annual Meeting, Las Vegas, NV, February 26-March 1, 1990, 5 p.

This paper presents an overall stabilization method to eliminate the potential of reoccurrence of subsidence over abandoned mine lands. The method considers column grouting at the specific locations inside the subsidence influence areas including the destressed and stress concentration zones instead of grouting around and beneath the damaged structures. The conditions of stress distribution in the strata before and after grouting can be calculated using the finite element method.

Keyword(s): abandoned mines, grouting, finite element, land-use planning, surface structural damage

Location(s): Pennsylvania, Appalachian Coal Region, United States

Lin, P. M., S. S. Peng, P. Tsang. Dealing with Subsidence on Abandoned Mine Lands. Mining Engineering, November 1990, p. 1245.

Column grouting is a common method being applied to remedy a small-scale abandoned mine subsidence. The advantages are that it is a simple operation and only a small amount of grouting material is used. However, this method may not be able to solve the long-term stability problem due to stress concentration. Subsidence will develop continuously if remedial measures are not provided. However, subsidence still may reoccur if the remedial measures do not take into account the stress concentration.

Keyword(s): grouting, abandoned mines, coal mining, surface structural damage, surface subsidence damage

Location(s): United States

Lin, P. N., S. M. Hsiung, S. S. Peng. Prediction of Abandoned Mines Trough Subsidence. IN: Proceedings Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 17-35.

The objectives of this study were to develop techniques to locate the surface subsidence area and the underground failure zone, and to reconstruct the subsidence profile. These techniques will help to improve the effectiveness of the remedial program. The probability (influence) function method has been used to predict the subsidence profile and ground movements caused by longwall mining. The results show a fairly good agreement with the field data, especially for flat terrain. In this paper the method is extended to predict abandoned mine trough subsidence only. Sinkhole subsidence is not discussed.

Keyword(s): prediction, abandoned mines, structural mitigation, backfilling, influence function, modeling, surface structural damage, horizontal displacement, coal mining, room-and-pillar, longwall

Location(s): Illinois, Illinois Coal Basin, Pennsylvania, Appalachian Coal Region, United States

Lin, S., B. N. Whittaker, D. J. Reddish. Application of Asymmetrical Influence Functions for Subsidence Prediction of Gently Inclined Seam Extractions. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 29, no. 5, 1992, p. 479-490.

The principle of the asymmetrical influence function method using variable functional parameters is detailed for predicting subsidence induced by the extraction of gently inclined seams. Also dealt with are the fundamental parameters necessary for accurate subsidence prediction and their relations with the seam dip. Carefully calibrated with respect to the Subsidence Engineers' Handbook, the model is applied for subsidence analysis of some cases of coal fields from the United Kingdom in comparison with the measured data.

Keyword(s): influence function, prediction, coal mining, modeling, longwall, active mines, geologic features, National Coal Board

Location(s): United Kingdom

Lindstrom, P. Longwall Mining Results at the Radon Mine. Transactions SME-AIME, December, 1964, p. 397-400.

This article is in reference to longwall mining in a uranium mine in Utah. Surface surveys indicate an increase in surface elevation outside the margins of the extraction area. The author theorizes that a thick (135 to 220 feet) sandstone layer cantilevers.

Keyword(s): metal mining, longwall, survey data processing, survey methods, overburden

Location(s): Utah, United States

Listak, J. M., J. L. Hill III, J. C. Zelanko. Direct Measurement of Longwall Strata Behavior: A Case Study. U.S. Bureau of Mines RI 9040, 1986, 19 p.

This report describes a rock mechanics study conducted to monitor deformation of near-seam strata above a longwall panel in the Pittsburgh coalbed. The primary goal was to determine the height of caving immediately behind advancing longwall face supports.

Keyword(s): rock mechanics, longwall, overburden, monitoring methods, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Listak, J. M., J. L. Hill III, J. C. Zelanko. Characterization and Measurement of Longwall Rock Mass Movement. IN: U.S. Bureau of Mines IC 9137, Eastern Coal Mine Geomechanics, Proceedings Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, November 19, 1986, p. 12-26.

The USBM conducted a rock mechanics study to monitor deformation of near-seam strata above a longwall panel in the Pittsburgh Coalbed. The primary goal of this research was to determine the height of caving immediately behind advancing longwall face supports. This study, although site specific, provides information on the caving mechanism associated with longwall extractions so that strata behavior and its interaction with longwall face supports can be better understood.

Keyword(s): longwall, rock mechanics, overburden, roof support, coal mining, geologic features, geotechnical, lab testing, instrumentation, monitoring equipment, monitoring methods

Location(s): Pennsylvania, Appalachian Coal Region, United States

Listak, J. M., J. C. Zelanko. An Assessment of the Effects of Longwall Chain Pillar Configuration on Gate Road Stability. IN: Rock Mechanics, Proceedings of the 28th U.S. Symposium, June 29-July 1, 1987, I.W. Farmer, et al., eds., Tucson, AZ. Balkema, Rotterdam, p. 1083-1093.

The USBM conducted a study to assess the redistribution of mining induced stress associated with longwall panel extraction. The objective of this study was to assess the performance of various chain pillar configurations on gate road entry stability. To achieve this objective, field measurements were collected and analyzed to develop profiles of the stress redistribution occurring in the gate road chain pillars during longwall panel retreat mining.

Keyword(s): longwall, coal mining, ground control, instrumentation, pillar strength, yielding supports

Location(s): Pennsylvania, Appalachian Coal Region, United States

Littlejohn, G. S. Soil-Structure Interaction in Mining Areas with Particular Relevance to Horizontal Subgrade Restraint. Ph.D. Thesis, Department of Civil Engineering, University of Newcastle-upon-Tyne, 1966.

Keyword(s): surface structural damage, foundations, longwall

Littlejohn, G. S. Monitoring Foundation Movements in Relation to Adjacent Ground. Ground Engineering, v. 6, no. 4, 1973, p. 17-22.

Location(s): foundations, monitoring methods

Littlejohn, G. S. Observations of Brick Walls Subjected to Mining Subsidence. IN: Proceedings Conference on Settlement of Structures, Cambridge, April, 1974, John Wiley & Sons, New York, p. 384-393.

This paper describes a field experiment carried out at Peterlee New Town, County Durham. Brick walls with footings and footings without walls were built and monitored in order to make a detailed investigation of their behavior when subjected to mining subsidence.

Keyword(s): surface structural damage, construction, foundations, horizontal displacement, monitoring methods

Location(s): United Kingdom

Littlejohn, G. S. Old Coal Workings--A Cover-Up Job. Ground Engineering, v. 8, no. 1, January, 1975.

Keyword(s): abandoned mines, coal mining

Littlejohn, G. S. Consolidation of Old Coal Workings. Ground Engineering, v. 12, no. 4, May, 1979, p. 15-18, 20-21.

Bearing in mind the variety of coal mining methods and extraction patterns developed in Britain over the centuries, together with the present-day situation of these same workings in various states of deterioration or collapse, no one method of treatment can be recommended to satisfy all conditions.

Keyword(s): abandoned mines, coal mining, grouting, backfilling, National Coal Board, geologic features

Location(s): United Kingdom

Littlejohn G. S. Surface Stability in Areas Underlain by Old Coal Workings. Ground Engineering, v. 12, no. 2, 1979, p. 22-48.

Keyword(s): abandoned mines, coal mining, ground control

Littlejohn, G. S., J. M. Head. Specification for the Consolidation of Old Shallow Mine Workings. IN: Mineworkings 84: Proceedings, International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1984, M.C. Forde, B.H.V. Topping, and H.W. Whittington, eds., Engineering Technics Press, p. 131-140.
Keyword(s): abandoned mines, coal mining, engineering

Litwiniszyn, J. The Differential Equation of Displacements of Rock Masses. Bulletin De L'Academie Polonaise Des Sciences, v. I, 1953, p. 38-40.
Keyword(s): modeling

Litwiniszyn, J. Applications of the Equations of Stochastic Processes to Mechanics of Loose Bodies. Archivum Mechanikik Stosowanej, v. 8, 1956, p. 393-411.
Keyword(s): modeling, empirical model, stochastic model

Litwiniszyn, J. The Theories and Model Research of Movement of Ground Masses. IN: Proceedings European Congress on Ground Movement, University of Leeds, England, April, 1957, p. 202-209.
This paper presents a series of differential equations to describe subsidence phenomena using the stochastic media approach. Mathematical and laboratory subsidence models are described and summarized.
Keyword(s): prediction, modeling, empirical model, stochastic model, mathematical model

Litwiniszyn, J. Fundamental Principles of the Mechanics of Stochastic Media. IN: Proceedings 3rd Congress on Theoretical and Applied Mechanics, Bangalore, 1957, p. 93-110.
Keyword(s): modeling, empirical model, stochastic model

Litwiniszyn, J. Time-Space Processes in Stochastic Media II. Bulletin de L'Academie Polonaise des Sciences, v. 7, 1959, p. 319-326.
Keyword(s): modeling, empirical model, stochastic model

Litwiniszyn, J. On a Certain Problem of Stochastic Bodies with Discontinuously Non-Homogeneous Properties. Bulletin de L'Academie Polonaise des Sciences, v. 7, 1959, p. 673-678.
Keyword(s): modeling, empirical model, stochastic model

Litwiniszyn, J., A. Z. Smolarski. On a Certain Solution of the Equation and its Application to the Problems of Mechanics of Loose Media. Bulletin de L'Academie Polonaise des Sciences, v. 10, 1962, p. 115-121.
Keyword(s): modeling, empirical model, stochastic model

Litwiniszyn, J. On Certain Linear and Non-Linear Strata Theoretical Models. IN: Proceedings 4th International Conference on Strata Control and Rock Mechanics, May 4-8, 1964, Henry Krumb School of Mines, Columbia University, New York, 1965.
The author reviews theoretical and experimental investigations conducted in the field of discontinuous media and their application to rock mechanics.
Keyword(s): modeling, rock mechanics, empirical model, stochastic model

Litwiniszyn, J. Remark Concerning the So Called "Point of the Attraction Centre" and its Connection with the Formation of the Subsidence Trough. Archiwum Gornictwa, v. 19, no. 3, 1974, p. 231-236.
Keyword(s): modeling, empirical model

Litwinowicz, L., K. Kazimierz. Effect of Mining Subsidence on Near Surface Underground Structures. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 220-222.
The effect on communication tunnels of horizontal tensile deformations perpendicular to the tunnel axis was examined, and a generalized hypothesis for vertical and horizontal pressures was developed.
Keyword(s): surface structural damage, vertical displacement, horizontal displacement, subsurface structural damage, utilities
Location(s): Poland

Litwinowicz, L. The Influence of Horizontal Expansion on Soil Strength in Mining Areas. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 397-403.

Extensional soil deformations are developed in the outer zone of mining depressions. When a mining face advances, soil near the surface first expands and then passes into a compression strain zone, adversely affecting foundation conditions and causing building damage in mining areas. One less recognized aspect of the problem is the extent of change in soil strength occuring in the outer zone.

Keyword(s): soils, soil mechanics, foundations, surface structural damage, active mines

Liv, B. S. Motion of Rock Masses Due to Advancing Exploitation But in Light of Theory of Stochastic Media. Bulletin, Academie Polonaise des Sciences, Serie des Sciences Techniques, v. 10, no. 4, 1962, p. 243-252.

Keyword(s): modeling, empirical model, stochastic model

Lizak, J. B., J. E. Semborski. Horizontal Stresses and Their Impact on Roof Stability at the Nelms No. 2 Mine. IN: Proceedings 4th Conference on Ground Control in Mining, West Virginia University, Morgantown, July 22-24, 1985, 7 p.

Keyword(s): roof stability, ground control, horizontal displacement

Lloyd, W. D. The Effect of Coal Mining On the Overlying Rocks and On the Surface. Transactions Institute of Mining Engineers, London, v. 57, 1918-19, p. 74-100.

Keyword(s): coal mining, subsurface subsidence damage, overburden, surface subsidence damage

Location(s): England

Lofgren, B. E. Near-Surface Land Subsidence in Western San Joaquin Valley, California. Journal Geophysical Research, v. 65, 1960, p. 1053-1062.

Keyword(s): fluid extraction

Location(s): California, United States

Lofgren, B. E. Measurement of Compaction of Aquifer Systems in Areas of Land Subsidence. U.S. Geological Survey Professional Paper 424-B, 1961, p. B49-B52.

Keyword(s): hydrology, subsurface water, fluid extraction

Location(s): United States

Lofgren, B. E. Land Subsidence in the Arvin-Maricopa Area, San Joaquin Valley, California. Geological Survey Research 1963, Professional Paper 475-B, U.S. Department of the Interior, p. B171-B175.

Keyword(s): fluid extraction

Location(s): California, United States

Lofgren, B. E. Land Subsidence Due to Artesian-Head Decline in the San Joaquin Valley, California. IN: Guidebook for Field Conference I, Northern Great Basin and California--International Association of Quaternary Research, 7th Congress, U.S.A., Nebraska Academy of Science, Lincoln, 1965, p. 140-142.

Keyword(s): fluid extraction, subsurface water

Location(s): California, United States

Lofgren, B. E. Subsidence Related to Ground Water Withdrawal. IN: Proceedings, 2nd Geologic Conference on Landslides and Subsidence, Los Angeles, CA, California Resources Agency, Sacramento, 1966, p. 97-104.

Keyword(s): fluid extraction

Location(s): California, United States

Lofgren, B. E. Analysis of Stresses Causing Land Subsidence. U.S. Geological Survey Professional Paper 600-B, 1968, p. B219-B225.

Keyword(s): fluid extraction, surface subsidence damage

Location(s): United States

Lofgren, B. E. Parameters Relating Subsidence to Water-Level Decline. Geological Society of America, Special Paper 101, (abstract), 1968, p. 125-126.

Keyword(s): fluid extraction

Location(s): United States

Lofgren, B. E., R. L. Klausing. Land Subsidence Due to Ground-Water Withdrawal, Tulare-Wasco Area, California. U.S. Department of the Interior, Geological Survey, Professional Paper 437-B, 1969, p. B1-B103.

Keyword(s): fluid extraction, subsurface water

Location(s): California, United States

Lofgren, B. E. Land Subsidence Caused by Water-Level Decline in Intermontane Basins. IN: Geological Society of America, Abstracts with Programs, pt. 5, 1969, p. 45-46.

Keyword(s): fluid extraction

Location(s): United States

Lofgren, B. E. Parameters for Estimating Future Subsidence. Geological Society of America, Special Paper 121, (abstract), 1969, p. 178-179.

Keyword(s): fluid extraction, prediction

Lofgren, B. E. Monitoring Ground Movement in Geothermal Areas. IN: Proceedings American Society Civil Engineers, Hydraulics Division Annual Special Conference, no. 21, 1973, p. 437-447.
Keyword(s): fluid extraction, monitoring methods

Lofgren, B. E. Land Subsidence and Fissuring Caused by Pumping Ground Water, Raft River Valley, Idaho. IN: Association Engineering Geologists, Annual Meeting, Program Abstracts, 1975, no. 18, p. 34.
Keyword(s): fluid extraction, subsurface water, hydrology
Location(s): Idaho, United States

Lofgren, B. E. Land Subsidence Due to Ground-Water Withdrawal, Arvin-Maricopa Area, California. U.S. Department of the Interior, Geological Survey Professional Paper 437-D, 1975, 55 p.
Keyword(s): fluid extraction, subsurface water
Location(s): California, United States

Lofgren, B. E. Land Subsidence and Aquifer-System Compaction in San Jacinto Valley, Riverside County, California; a Progress Report. U.S. Department Interior, Geological Survey Journal of Research, v. 4, 1976, p. 9-18.
Keyword(s): fluid extraction, hydrology
Location(s): California, United States

Lofgren, B. E. Hydrogeologic Effects of Subsidence, San Joaquin Valley, California. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 113-123.
Keyword(s): hydrology
Location(s): California, United States

Logan, W. E. On the Character of the Beds of Clay Immediately Below the Coal Seams of South Wales; and On the Occurrence of Coal Boulders in the Pennant Grit of that District. IN: Proceedings Geological Society of London, v. 3, 1842, p. 275-277; also Transactions Geological Society London, v. 6, p. 491-498.
Keyword(s): floor stability
Location(s): United Kingdom

Lojas, J., A. Kidybinski, Z. Hladyysz. Working the Lower Lift of a Thick Seam Under the Caved Debris Reconsolidated with Waters from Drainage of Overburden Strata. IN: 6th International Strata Control Conference, Banff, Canada, September, 1977, p. 1-10.
Keyword(s): hydrology, subsurface water, overburden, ground control

Londong, D. Principles for the Planning and Design of Drainage Pumping Stations in Areas of Mining Subsidence. IN: Proceedings International Symposium on Fossil Fuel Production and Water Resources, 1976, 20 p.
Keyword(s): engineering, hydrology

Lonergan, M. J., R. P. Terry. Local and State Regulatory Powers Dealing with Land Use and Construction in Subsidence Prone Areas for the Commonwealth of Pennsylvania. Appalachian Regional Commission Report ARC-73-163-2557, 1975, 159 p. (NTIS PB 272 513)
Keyword(s): government, law, land-use planning
Location(s): Pennsylvania, United States, Appalachian Coal Region

Long, A. E., L. Obert. Block Caving in Limestone at the Crestmore Mine, Riverside Cement Company, Riverside, California. U.S. Bureau of Mines IC 7838, 1958, 21 p.
Keyword(s): non-metal mining
Location(s): California, United States

Longwall Forum. Industry Prevails in Recent Flannery Decision on Recharge Capacity. American Mining Congress Subsidence Network, v. 2, no. 2, October 1990.
A decision by Judge Thomas Flannery in the first round of litigation over regulations issued by OSM to implement the permanent regulatory program produced largely favorable results for the coal industry.
Keyword(s): law, government, active mines, subsurface water, longwall
Location(s): United States

Longwall Forum. Industry Blasts ELI Study on Subsidence. American Mining Congress Subsidence Network, v. 2, no. 2, October 1990.
This article reviews a study published in April 1990 by the Environmental Law Institute (ELI) called, "Environmental Regulation of Coal Mining--SMCRA's Second Decade."
Keyword(s): law, coal mining, active mines, longwall
Location(s): United States

Longwall Forum. Industry Succeeds in Limiting Accommodation Act. American Mining Congress Subsidence Network, v. 2, no. 2, October 1990.

As originally drafted, the Accomodation Act threatened to disrupt existing and future mining operations by requiring mineral developers to alter their operations to accommodate surface uses, regardless of cost.

Keyword(s): law, coal mining, active mines, longwall

Location(s): United States

Longwall Forum. Southern Ohio Coal Company--Winner of Reclamation Award. American Mining Congress Subsidence Network, v. 2, no. 2, 1990.

The Southern Ohio Coal Company earned an excellence in Surface Coal Mining and Reclamation Award for 1989 from OSM.

Keyword(s): coal mining, active mines, structural mitigation, reclamation, longwall

Location(s): Appalachian Coal Region, United States

Longwall Forum. Industry Panel Testifies at Hearings on Subsidence. American Mining Congress Subsidence Network, v. 2, no. 2, 1990.

The Mining and Natural Resources Subcommittee of the House Interior and Insular Affairs Committee held an oversight hearing on active mine subsidence June 28, 1990. From all indications, it appears that subsidence will be among the most significant issues of the 1990s.

Keyword(s): law, government, coal mining, active mines, longwall

Location(s): United States

Longwall Forum. Valid Existing Rights Rule on Separate Track. American Mining Congress Subsidence Network, v. 2, no. 2, 1990.

While the OSM apparently has shifted its focus on the subsidence rulemaking, a companion proposal to define the "valid existing rights" (VER) exception to the SMCRA Section 522(e) prohibitions appears to be proceeding on a separate, but parallel track.

Keyword(s): law, government, active mines, coal mining, longwall

Location(s): United States

Longwall Forum. OSM Shelves 522(e) Proposal; Commences Outreach on Subsidence. American Mining Congress Subsidence Network, v. 2, no. 2, 1990.

In the face of strong opposition from coal industry leaders and members of Congress, the OSM has shelved a proposal to apply the prohibitions in Section 522(e) of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) to subsidence.

Keyword(s): law, government, subsurface water, surface structural damage, structural mitigation

Location(s): United States

Loos, W. The Occurrence of the Subsidence Trough in the Saar Coalfield. Mitteilungen aus dem Markscheidewesen, no. 5, v. 67, 1960, p. 264-265 (in German).

Keyword(s): coal mining

Lorig, L. J., R. D. Hart, M. P. Board, G. Swan. Influence of Discontinuity Orientations and Strength on Cavability in a Confined Environment. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., 1989, Balkema, Rotterdam, p. 167-174.

This paper presents the results of two- and three-dimensional distinct element analyses that show different conclusions than those reported from finite element studies. The distinct element method is selected for analysis of cavability because this method treats the rock mass as an assemblage of rock blocks that may interact individually. The results of the analyses are compared to a documented case history.

Keyword(s): rock mechanics, finite element, modeling, metal mining

Location(s): Canada

Louis, H. Compensation for Subsidence. Transactions Institute Mining Engineering, London, v. 59, 1920, p. 292-310; v. 60, 1920, p. 240-241.

Keyword(s): mine operation, surface subsidence damage

Louis, H. A Contribution to the Theory of Subsidences. Transactions Institute of Mining Engineers, London, v. 64, 1922, p. 257-273.

The article details the derivation of a subsidence prediction theory based upon Coulomb's theory of earth pressure.

Keyword(s): vertical displacement, prediction theories

Louis, H. The Theory of Subsidences. Colliery Guardian, January 5, 1923, p. 1215-1216.

The author says it is remarkable that subsidence, a subject of great importance to the mining industry, should have received such scanty attention in the literature. He propounds a general theory of subsidence, in hopes of helping mining companies deal with subsidence damage claims against them.

Keyword(s): coal mining, surface structural damage, surface subsidence damage, prediction, angle of draw

Location(s): United Kingdom

Louis, H. Subsidence From Mining. Mining and Metallurgy, v. 10, 1929, p. 130-131.

Louis, H. The Royal Commission on Mining Subsidence. Transactions AIME, v. 88, 1929, p. 135-143.

Keyword(s): government

Location(s): England

Lu, P. H. In-Situ Determination of Rock Properties and Strata Pressures. IN: Ground Control Aspects of Coal Mine Design, Proceedings, Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 28-34.

This paper presents several practical ways of determining geomechanical properties of coal measure strata and of determining strata pressures from in situ measurements. Emphasis is given to the basic concepts of measurement techniques and to the impact of measured results on safer and rational mine design and ground control.

Keyword(s): coal mining, overburden, mine design, ground control, in situ testing, active mines

Location(s): United States

Lu, P. H. Rock Mechanics Instrumentation and Monitoring for Ground Control Around Longwall Panels. IN: State-of-the-Art of Ground Control in Longwall and Mining Subsidence, September, 1982, Y.P. Chugh and M. Karmis, eds., SME-AIME, p. 159-166.

This report presents several practical and inexpensive types of rock mechanics instrumentation for ground control around longwall panels. Application of these critical parameters, determined by this instrumentation, to the design and modification of rational longwall-mining systems is also discussed.

Keyword(s): coal mining, rock mechanics, monitoring methods, ground control, longwall, instrumentation, mine design, monitoring equipment

Location(s): Utah, New Mexico, Rocky Mountain Coal Region, West Virginia, Appalachian Coal Region, Oklahoma, United States

Lu, P. H. Stability Evaluation of Retreating Longwall Chain Pillars with Regressive Integrity Factors. IN: Rock Mechanics for Resource Development, Mining and Civil Engineering, Proceedings 5th Congress International Society for Rock Mechanics, Melbourne, Australia, 1983, Balkema, Rotterdam, p. E 37-E 40.

Profiles of mining-induced loading and residual strength across a pillar vary with the position of the longwall face. The residual pillar-strength profile can be constructed on the basis of laboratory-determined triaxial compressive strength, in which the in situ measured horizontal pressure is considered as the constraint. The vertical-loading profile can be established with the measured vertical pressures. Vertical and horizontal pillar pressures can be measured with hydraulic borehole pressure cells. Defined as the ratio of the integrated total strength to the integrated total load under the profiles, the integrity factor is proposed here as a rational parameter for evaluating chain-pillar stability.

Keyword(s): longwall, coal mining, pillar strength, rock mechanics, geotechnical, lab testing, in situ testing, mine design, monitoring methods, monitoring equipment

Lubina, T. Praktyczny Sposob Wyznaczania Parametrow Teorii T. Kochmanskiego (Simplified Method for Determining the Parameters of the T. Kochmanski Theory). Przeglad Gorniczy, v. 29, no. 5, 1973, p. 196-200.

Keyword(s): prediction theories, modeling, empirical model, influence function

Lucas, J. R. Design Optimization in Underground Coal Systems. Interim Report, July-September 1977. Report on U.S. DOE Contract/Grant EX-76-C-01-1231, Virginia Polytechnic Institute and State University, Blacksburg, VA, December, 1977, 53 p. (NTIS FE-1231-10)

Continued work on the dependence of measured mechanical properties on sample size and shape and loading rate was described. Computer programs to simulate longwall mining, support loads, ground subsidence, etc., and to aid in longwall planning and equipment selection were developed. Body-loaded plastic longwall models were examined by photoelastic methods to validate computer programs. Roof truss supports were

evaluated by a literature search, model studies, and the behavior of instrumented roof trusses installed in an Alabama coal mine.

Keyword(s): coal mining, active mines, longwall, computer, modeling, roof support, rock mechanics

Location(s): Alabama, United States

Lucas, J. R. Design Optimization in Underground Coal Systems. Interim Report, April--June 1978. Report on DOE Contract/Grant EX-76-C-01-1231, September, 1978, by Virginia Polytechnic Institute and State University, Blacksburg, 58 p. (NTIS FE-1231-13)

The mechanical properties of coal are reviewed with respect to sampling, size, and shape of samples, loading rate, etc. Longwall mining was investigated with respect to panel width, economic analysis, and ground subsidence. Roof truss supports were investigated by literature search and photoelastic models. All of these efforts included the development of extensive computer programs and field studies.

Keyword(s): coal mining, active mines, longwall, rock mechanics, economics, roof support, literature search, computer, modeling, backfilling, mathematical model, elastic model, roof bolting

Location(s): United States

Lucero, R. F. Use of Foaming Mud Cement to Terminate Underground Coal Fires and to Control Subsidence of Burn Cavities. Final Report to Office of Surface Mining, September 29, 1988, Colloidal Concrete Corporation, Golden, CO, 149 p. (NTIS PB89-223853)

Foaming mud cement (FMC) was developed at the Colorado School of Mines Research Institute for the purpose of addressing abandoned mine land problems. During a program sponsored by the OSM, the following significant developments were made: (1) the ability to effectively isolate buring coal from the available air by penetrating burning coal rubble with heat resistive FMC; and (2) the ability to encapsulate and isolate a wide range of coal particle sizes, resulting in permanent coal fire termination by air exclusion. The materials developed were specifically designed to terminate underground coal fires and prevent further subsidence.

Keyword(s): mine fires, abandoned mines, coal mining, reclamation, soils

Location(s): Wyoming, Colorado, Rocky Mountain Coal Region, Arizona, United States

Luckie, P. T., T. S. Spicer. Methods Employed for Underground Stowing (A Resume of a Literature Survey). Pennsylvania State University, College of Earth and Mineral Science Experiment Station, Coal Research Section, Special Report SR-55, February 28, 1966, 55 p.

Principles of backfilling as applied to underground mines are covered. This report discusses hand, mechanical, and pneumatic backfilling, and includes compressibility data for materials.

Keyword(s): pneumatic backfilling, stowing, literature search, lab testing

Location(s): Pennsylvania, Appalachian Coal Region, United States, Europe, England

Lundin, T. K., G. G. Marino, E. G. Wildanger, J. W. Mahar, A. L. Leung. Procedures for Responding to Hazardous Subsidence Induced Structural Damage Events. Subsidence Response Team Final Report, July 1980-June 1981, Illinois Abandoned Mined Lands Reclamation Council, Springfield, 128 p.

Keyword(s): surface structural damage, abandoned mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Luo, Y., S. S. Peng. CISPM--A Subsidence Prediction Model. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 853-860.

A PC-based computer model was developed by the authors for predicting surface subsidence due to underground coal mining. Its reliability, comprehensiveness and user friendliness demonstrate that it is a good tool for the mine operators, government agencies and scientific researchers alike.

Keyword(s): prediction, modeling, coal mining, geologic features, mathematical model, influence function, longwall, active mines, survey data processing

Luo, Y., S. S. Peng. A Mathematical Model for Predicting Subsidence Over Chain Pillars Between Mined-Out Longwall Panels. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 247-257.

A model was developed for predicting subsidence over the chain pillars between two adjacent longwall panels. The development and application of the model are presented in this paper.

Keyword(s): prediction, longwall, modeling, pillar strength, overburden, mathematical model, coal mining

Location(s): Appalachian Coal Region, United States

Luo, Y., S. S. Peng. Mathematical Model for Predicting Final Subsidence Basin in Hilly Regions. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 223-231.

In this paper, a mathematical model is proposed for predicting surface movement and deformation induced by underground longwall mining in hilly regions. The development of this model is based on the principles of the influence function method.

Keyword(s): coal mining, longwall, mathematical model, influence function, horizontal displacement, vertical displacement

Luo, Y., S. S. Peng. Protecting a Subsidence Affected House: a Case Study. IN: Proceedings VIII Congress International Society for Mine Surveying, September 22-27, 1991, University of Kentucky, Lexington, UKY BU154, p. 297-300.

In this paper, a case of applying the CISPM code (a subsidence prediction model developed by the authors) in design and implementation of some mitigation techniques for protecting an old residence over a shallow longwall panel is illustrated.

Keyword(s): surface structural damage, structural mitigation, active mines, longwall, coal mining, modeling, prediction, foundations, horizontal displacement, vertical displacement

Location(s): United States

Luo, Y., S. S. Peng. Some New Findings from Surface Subsidence Monitoring Over Longwall Panels. Mining Engineering, October 1991, v. 43, no. 10, p. 1261-1264; also SME Annual Meeting preprint 91-150. Discussion by E. Arioglu, Mining Engineering v. 44, no. 8, August 1992, p. 1042-1044.

Several issues deserve further attention to improve subsidence prediction accuracy. These include subsidence initiation and development over a setup area; subsidence development after face stop; and subsidence over chain pillars. An intensive subsidence monitoring program has been carried out over several longwall panels. A large amount of subsidence data has been collected and analyzed, and solution techniques have been developed. In this paper, some of the measured data, data analysis techniques and the developed prediction models are presented.

Keyword(s): longwall, coal mining, modeling, mathematical model, prediction, survey data processing

Location(s): Appalachian Coal Region, Illinois, Illinois Coal Basin, Alabama

Luo, Y., S. S. Peng, D. Dutta. Some Mitigative Measures for Protection of Surface Structures Affected by Ground Subsidence. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 129-138.

Theoretical and analytical analyses of three mitigative measures (the plane fitting method, trenching, and tension cable) led to the development of a total protection plan to eliminate or reduce damages to residential structures subjected to surface movements caused by underground longwall mining. The protection plan was successfully applied to 12 residential houses and 2 external garages. This paper describes the methods employed for protection and results of those case studies.

Keyword(s): structural mitigation, surface structural damage, coal mining, longwall, active mines

Location(s): United States

Luxbacher, G. W. Subsidence Planning and Risk Assessment. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 100-105.

The inclusion of a new term "planned subsidence" in the Surface Mining and Reclamation Act of 1977 has led the coal mining industry into a new aspect of engineering: subsidence planning. Subsidence planning has necessitated the integration of geotechnical, civil, and mining engineering. This paper discusses the application of subsidence planning in several brief case studies (a high voltage transmission tower, a sewage treatment plant, and a slurry impoundment), emphasizing the risk assessment aspects necessary to account for some of the uncertainties that may exist.

Keyword(s): law, engineering, mine design, coal mining, utilities, prediction, surface structural damage, structural mitigation, longwall, active mines

Location(s): Virginia, West Virginia, Appalachian Coal Region, United States

Luza, K. V. Stability Problems Associated with Abandoned Underground Mines in the Picher Field, Northeastern Oklahoma. Oklahoma Geological Survey Circular 88, University of Oklahoma, Norman, 1986, 114 p.

Approximately 2,540 acres are underlain by underground lead-zinc mines in northeastern Oklahoma. Subsidence problems associated with these mines either existed during mining or have developed since cessation of mining in the Picher Field.

Keyword(s): abandoned mines, metal mining, structural mitigation, land mitigation, historical, surface subsidence damage

Location(s): Oklahoma, Kansas, Missouri, United States

Ma, W. M., W. Y. Zhu. Effect of Multi-Seam Mining on Subsidence. International Journal of Mining Engineering, v. 2, no. 2, 1984, p. 171-173.

Model studies and case histories show that vertical settlement and surface subsidence above multiple seam coal mining, where the upper seam is worked first, is greater than would be expected from the sum of equivalent single seam mining operations. This can be attributed to three factors: (1) strata disturbed by the mining of the upper seam has reduced bending resistance and bed separation does not occur, (2) where the seams are closely spaced, dilation during caving is reduced, and (3) pressure over the goaf or caved area increases with depth leading to increased compaction of the caved area, and reduced ribside abutment pressures.

Keyword(s): multiple-seam extraction, coal mining, overburden, vertical displacement

Location(s): China

Mabry, R. E. An Evaluation of Mine Subsidence Potential. IN: New Horizons in Rock Mechanics: Underground Design and Instrumentation, Proceedings, 14th Symposium on Rock Mechanics, SME/AIME, New York, 1973, p. 263-297.

Keyword(s): prediction, mine design, rock mechanics, instrumentation

Mac Court, L., B. J. Madden, E.H.R. Schumann. Case Studies of Surface Subsidence Over Collapsed Bord and Pillar Workings in South Africa. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 25-32.

Ground elevations above collapsed bord-and-pillar workings have been measured at 17 sites. A review of bord-and-pillar design is followed by a general geological characterization of the superincumbent strata.

Keyword(s): room-and-pillar, coal mining, longwall, surface structural damage, pillar extraction, survey methods, vertical displacement, overburden

Location(s): South Africa

MacLennan, F. W. Subsidence from Block Caving at Miami Mine, Arizona. Transactions, AIME, v. 85, 1929, 1929 Yearbook, p. 167-178.

Keyword(s): metal mining, surface subsidence damage

Location(s): Arizona, United States

Madden, B. J., D. R. Hardman. Long Term Stability of Bord and Pillar Workings. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 37-51.

This paper examines the factors to be considered when structures are placed over old bord-and-pillar areas or mining is done beneath existing surface structures. The probability of pillar collapse is discussed as well as the possible surface effects and remedial measures that may be undertaken to reduce the effects on the surface.

Keyword(s): pillar strength, land-use planning, room-and-pillar, coal mining, mine safety, surface structural damage, backfilling, mine fires

Location(s): South Africa

Madhav, M. R., P. Basak. Ground Subsidence Due to Nonlinear Flow Through Deformable Porous Media. Journal of Hydrology, v. 34, 1977, p. 211-213.

Keyword(s): fluid extraction, hydrology

Magers, J. A. Surface Subsidence Over a Room-and-Pillar Mine in the Western United States. U.S. Bureau of Mines IC 9347, 1993, 15 p.

This report summarizes the results of subsidence research conducted at the Roadside Mine, Powderhorn Coal Company, Palisade, Colorado. This research was conducted from February 1981 to August 1985; additional data were obtained during July 1991 to evaluate residual subsidence. Subsidence was studied at three distinct room-and-pillar sections at separate locations over the mine, and the maximum subsidence values and surface subsidence profiles for each section were determined. Maximum subsidence of 3.0 feet occurred over the room-and-pillar sections, with overburden depths ranging from 50 to 600 feet. Surface tension cracks occurred and were still evident during the residual subsidence survey.

Keyword(s): room-and-pillar, vertical displacement, coal mining, geologic features, overburden, surface water, monitoring methods, survey methods, survey design, monitoring equipment, survey data processing

Location(s): Colorado, Rocky Mountain Coal Region, United States

Magnuson, M. O., W. T. Malenka. Utilization of Fly Ash for Remote Filling of Mine Voids. IN: Ash Utilization, Proceedings 2nd Ash Utilization Symposium, March 10-11, 1970, Pittsburgh, PA, U.S. Bureau of Mines IC 8488, p. 83-96.

Dry fly ash injection and fly ash-water injection are economical, yet effective methods for remote filling of mine voids to prevent mine subsidence. These methods also control or extinguish abandoned mine fires.

Keyword(s): pneumatic backfilling, hydraulic backfilling, abandoned mines, mine fires, mine waste, coal mining

Location(s): United States

Magnuson, M. O., R. Cox. Environmental Protection of Surface Areas Near Underground Mining Sites. Coal Age, v. 80, no. 7, 1975, p. 135-138.

Keyword(s): environment, land-use planning, coal mining

Mahar, J. W., E. J. Cording, S. R. Hunt, G. G. Marino. Phase I Subsidence Study, O'Fallon, Illinois. Illinois Abandoned Mined Land Reclamation Council, Springfield, 1979, 42 p.

Subsidence was located over an abandoned mine, from which coal was excavated using the room-and-pillar method. The cause of the ground movement was probably related to the collapse of the mine pillars with possible floor heave. In the weeks preceding the main subsidence, water lines broke and pavement bumps were noted. Most of the subsidence occurred over a 36-hour period. The area that resulted is a slightly elliptical, bowl-shaped depression approximately 400 feet in diameter. The initial movement resulted in a maximum surface settlement of 2.9 feet.

Keyword(s): abandoned mines, coal mining, surface structural damage, room-and-pillar, utilities, monitoring methods, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Mahar, J. W., E. G. Wildanger, R. D. Gibson. Subsidence Rapid Response Team Quarterly Progress Report, July 1--September 30, 1980. Illinois Abandoned Mined Lands Reclamation Council, Springfield, October, 1980, 34 p.

The Subsidence Rapid Resonse Team investigated 16 subsidence reports during the quarter. Thirteen cases did not involve mine subsidence Of the three that did, only one required federal emergency funds.

Keyword(s): abandoned mines, coal mining, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Mahar, J. W., E. G. Wildanger, R. D. Gibson. Mine Subsidence at the District 11 State Police Headquarters in Maryville, Illinois. Illinois Abandoned Mined Lands Reclamation Council, Springfield, Progress Report: September 10, 1980 to March 31, 1981, 45 p.

Subsidence beneath the police headquarters building was first noticed on May 12, 1980, and appeared to have been caused by collapse of abandoned coal mine workings located about 230 feet below the ground surface.

Keyword(s): surface structural damage, abandoned mines, coal mining, vertical displacement, horizontal displacement, utilities, monitoring methods, subsurface water, hydrology, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Mahar, J. W., E. G. Wildanger, R. D. Gibson. Subsidence Rapid Response Team Quarterly Progress Report, October 1 through December 31, 1980. Illinois Abandoned Mined Lands Reclamation Council, Springfield, January, 1981.

During this time period, there were 10 requests for investigations of possible subsidence. Only three were found to be subsidence related, none constituting emergency conditions.

Keyword(s): abandoned mines, coal mining, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Mahar, J. W., E. G. Wildanger, R. A. Bauer, R. D. Gibson. Mine Subsidence, Powell Residence, Danville, Illinois. Illinois Abandoned Mined Lands Reclamation Council, July 1981, Springfield, 14 p.

This report describes the pit-type subsidence that developed in a residential area and the remedial measures used to abate the problem.

Keyword(s): abandoned mines, coal mining, land mitigation, reclamation

Location(s): Illinois, Illinois Coal Basin, United States

Mahar, J. W., G. G. Marino. Building Response and Mitigation Measures for Building Damages in Illinois. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 238-252.

This paper summarizes observations made on building response to mine subsidence and discusses techniques for mitigating building damage. It describes typical Illinois geologic and mining conditions.
Keyword(s): surface structural damage, engineering, construction, structural mitigation, geologic features, coal mining, abandoned mines
Location(s): Illinois, Illinois Coal Basin, United States

Mahtab, M. A. Influence of Natural Jointing on Coal Mine Stability and on the Preferred Direction of Mine Layout. IN: Ground Control Aspects of Coal Mine Design, Proceedings Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 70-78.
In a preliminary study on this topic, the USBM found that 3 out of 18 mines showed distinct roof jointing patterns as well as trends of roof failure. These observations highlight the importance of the effect of jointing in determining mine stability and preferred direction of mine layout. Before assessing the effect of jointing on coal mine stability, the geometric as well as the mechanical characteristics of joints must be measured.
Keyword(s): coal mining, geologic features, roof stability, modeling
Location(s): United States

Mainil, P. Contribution to the Study of Ground Movement Under the Influence of Mining Operations. International Journal of Rock Mechanics and Mining Science & Geomechanics Abstracts, v. 2, no. 2, 1965, p. 225-243.
Coal measures strata become displaced under the influence of mining operations and exert forces on the roof support, the waste, the coal pillars, and the coal faces. These forces deform, crack, or break them, since they cannot completely resist the rock movements. The influence of coal extraction reaches as far as the surface and brings about vertical subsidence and horizontal displacement of the ground in that locality.
Keyword(s): mine design, surface subsidence damage, subsurface subsidence damage, mine operation, vertical displacement, horizontal displacement, overburden, roof support, coal mining
Location(s): United Kingdom

Maize, E. R., H. P. Greenwald. Studies of Roof Movement in Coal Mines, 2. Crucible Mine of the Crucible Fuel Company. U.S. Bureau of Mines RI 3452, 1939, 19 p.
Subsidence data and roof and timber studies were taken from a mine in Pennsylvania.
Keyword(s): coal mining, roof stability, floor stability
Location(s): Pennsylvania, Appalachian Coal Region, United States

Maize, E. R., E. Thomas, H. P. Greenwald. Studies of Roof Movement in Coal Mines, 3. Gibson Mine of the Hillman Coal and Coke Company. U.S. Bureau of Mines RI 3506, 1940, 9 p.
Keyword(s): coal mining, roof stability, room-and-pillar, utilities, surface subsidence damage, overburden, floor stability
Location(s): Pennsylvania, Appalachian Coal Region, United States

Maize, E. R., E. Thomas, H. P. Greenwald. Studies of Roof Movement in Coal Mines. 4. Study of Subsidence of a Highway Caused by Mining Beneath. U.S. Bureau of Mines RI 3562, 1941, 11 p.
This paper summarizes data obtained along a Pennsylvania highway as it passed over two active mines. Mining was conducted in two stages with ultimate pillar removal. The roadbed was extensively cracked and suffered a small change in grade. The authors note that the value of the coal that would have been required for protection of the road was far in excess of the cost of repairing the road. The authors recommend total, rather than partial, extraction whenever surface displacements can be tolerated or the resulting damage is minimal.
Keyword(s): roads, roof stability, coal mining, pillar extraction, surface subsidence damage, partial extraction, longwall
Location(s): Pennsylvania, Appalachian Coal Region, United States

Maleki, H. Ground Response to Longwall Mining: A Case Study of Two-entry Yield Pillar Evolution in Weak Rock. Colorado School of Mines Quarterly, v. 83, no. 3, Fall, 1988, 52 p.
This material was prepared in response to a need of coal mine engineers and the scientific community for better understanding of practical aspects of ground control during longwall mining. Ground control experience and geotechnical investigations during and after mining a seven-panel longwall block are integrated to develop snapshots-in-time models for cave progress and load transfer to the gate pillars. A new criterion for coal mine stability evaluation is proposed based on rates of ground movement.

Keyword(s): coal mining, longwall, yielding supports, ground control, geotechnical, pillar strength, geologic features, roof stability, instrumentation, mine design, modeling

Location(s): Utah, Rocky Mountain Coal Region, United States

Maleki, H. N., M. P. Hardy, R. D. Tifft III. Geotechnical Mine Design of the Foidel Creek Mine. IN: Proceedings, 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 137-148.

The results of 5 years of geotechnical investigations are presented to develop productive and stable longwall layouts for the Foidel Creek Mine. The program was initiated during the pre-mining stage, and has continuously provided the data required for mine design. From several stress determinations at the mine, the relationship between geologic structure and the stress field/depth was established. The results were used for orienting the entries for improved stability. Cave conditions and load transfer to panel boundaries were evaluated from closely monitored full extraction mining and computer analysis. Back-analyses of ground movements, as compared with the actual measurements, indicated that cave conditions were favorable in spite of the presence of competent, thick-bedded sandstones in the main roof. Gate pillar design using a yield-rigid concept was developed through computer analyses and underground instrumentation.

Keyword(s): geotechnical, mine design, instrumentation, geologic features, computer, roof stability, pillar strength, longwall, geophysical, lab testing, in situ testing, coal mining, survey methods, monitoring methods, monitoring equipment, monitoring installation, pillar extraction, finite element, modeling, yielding supports

Location(s): Colorado, Rocky Mountain Coal Region, United States

Maleki, H. N., J. F. T. Agapito, M. Moon. In-Situ Pillar Strength Determination for Two-Entry Longwall Gates. IN: Proceedings, 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 10-19.

Extensive measurements and underground observations in three coal mines in the western United States are integrated in this paper to determine in situ pillar load-deformation characteristics for narrow pillars on two-entry gate road systems. The pillar peak strength, post-failure behavior, and failure mechanism were shown to be significantly different despite similarities in the regional geology, coal pillar laboratory mechanical properties, and gate pillar geometries. Pillar peak strength was shown to be dependent on depth at one site, approaching burst-prone stress levels of 4,000 psi. At another site, the pillar peak stress was lower because of lower confinement; this was related to the higher frequency of cleats and the lower frictional properties of the roof/floor and coal contact. Two failure mechanisms were identified: one in the pillar and the other in the mine floor. The roof stability was good at all three sites because of the thick-bedded nature of the roof strata and limited total gate span in a two-entry system. Existing pillar design techniques were shown to be inadequate for design, requiring adjustments for depth of cover, cleat frequency, and roof/floor frictional properties.

Keyword(s): pillar strength, yielding supports, coal mining, floor stability, longwall, instrumentation, geologic features, lab testing, monitoring methods, rock mechanics

Location(s): Utah, Rocky Mountain Coal Region, United States

Maleki, H. N. Detecting Stability Problems by Monitoring Rate of Roof Movement. Coal, December, 1988, p. 34-38.

Roof falls have long been a factor in coal mine safety and productivity. Five different investigators have successfully demonstrated that monitoring the rate of roof movement can detect impending roof falls in a copper mine and two coal mines in the western United States.

Keyword(s): roof stability, roof support, coal mining, metal mining, monitoring methods

Location(s): Utah, Rocky Mountain Coal Region, United States

Maleki, H. N., R. Colombo, J. F. T. Agapito. Geotechnical Evaluation of Caving Mining Systems. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 249-256.

Geotechnical advantages of short-wall mining systems have been identified for shallow Illinois mines. These include (1) a reduction of surface tensile strains and improvements in hydrologic control, (2) an improvement in underclay stability, and (3) a reduction of face support capacity requirements.

Keyword(s): geotechnical, shortwall, floor stability, room-and-pillar, coal mining, active mines, longwall, overburden, hydrology, subsurface water, geologic features, in situ testing, high-extraction retreat

Location(s): Illinois, Illinois Coal Basin, United States

Maleki, H. N. Development of Modeling Procedures for Coal Mine Stability Evaluation. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Golden, CO, Balkema, Rotterdam, p. 85-92.

Procedures were developed for coal mine stability evaluation using long-term instrumentation, extensive numerical modeling, and underground observations. In view of the lack of a coherent design methodology for jointed coal measure strata, such procedures should enhance coal mine design efforts toward increasing mine stability and productivity. In this paper, an integrated approach for coal mine stability evaluation is developed, using both planned geotechnical monitoring and numerical modeling. General monitoring and modeling procedures are developed by analyzing a comprehensive case study at a coal mine in the western United States.

Keyword(s): coal mining, modeling, instrumentation, monitoring methods, geologic features

Location(s): Utah, Rocky Mountain Coal Region, United States

Malgot, J., F. Baliak, T. Mahr. Prediction of the Influence of Underground Coal Mining on Slope Stability in the Vtacnik Mountains. Bulletin of the International Association of Engineering Geology, Paris, no. 33, April, 1986, p. 57-65.

Coal mining in the Handlova deposit in middle Slovakia takes place under complicated engineering geological conditions at the foot of the volcanic Vtacnik mountains, which have slopes affected by deep gravitational deformations. A prediction, based on a detailed engineering geological investigation after undermining, was made of the influence of coal mining on the surface of the mountains. Results will serve to protect four villages.

Keyword(s): prediction, active mines, surface structural damage, engineering, coal mining, geologic features

Location(s): Czechoslovakia

Malkin, A. B., J. C. Wood. Subsidence Problems in Route Design and Construction. Quarterly Journal of Engineering Geology, Great Britain, v. 5, 1972, p. 179-194.

Keyword(s): surface structural damage, engineering, roads

Location(s): England

Maneval, D. R., H. B. Charmbury, R. A. Lambert. Underground Stowing of Anthracite Refuse for Surface Support. AIME Preprint No. 66F61, 1966.

This paper describes mine flushing using coal mine refuse. A description and cost of one project is included.

Keyword(s): hydraulic backfilling, economics, mine waste, anthracite, coal mining

Location(s): United States

Mansur, C. I., M. C. Skouby. Mine Grouting to Control Building Settlement. ASCE Journal Soil Mechanics and Foundations Division, v. 96, no. SM2, 1970, p. 511-522.

Further subsidence of a partially constructed building above an abandoned coal mine is prevented by filling the mine with portland cement grout.

Keyword(s): grouting, surface structural damage, abandoned mines, coal mining

Location(s): United States

Manula, C. B., B. Mozumdar, D. K. Jeng. A Master Environmental Control and Mine System Design Simulator for Underground Coal Mining. Volume V. Subsidence Subsystems, Grant GO111808, Pennsylvania State University, U.S. Bureau of Mines OFR 84(5)-76, 1974, 199 p. (NTIS PB 255 425)

Keyword(s): coal mining, mine design, modeling

Location(s): United States

Manula, C. B., R. A. Rivell, R. V. Ramani. A Master Environmental Control and Mine System Design Simulator for Underground Coal Mining. Volume XI. Total Systems Application, Grant GO111808, Pennsylvania State University, U.S. Bureau of Mines OFR 84(11)-76, 1975, 620 p. (NTIS PB 255 431)

Keyword(s): coal mining, mine design, modeling

Location(s): United States

Manula, C. B., A. S. C. Owili-Eger. A Master Environmental Control and Mine System Design Simulator for Underground Coal Mining, v. IX: Water Generator. U.S. Bureau of Mines Open File Report 84(9)-76, 1975.

Keyword(s): subsurface water, coal mining

Marino, G. G., J. W. Mahar, E. J. Cording, J. E. Shively, T. K. Lundin. Mine Subsidence and Related Damages in O'Fallon, Illinois, Phase 2 Report. Illinois Abandoned Mined Lands Reclamation Council, Springfield, 1980, 100 p.

This document presents the detailed findings of the Phase II mine subsidence study at O'Fallon, Illinois. The document is the product of 2 years of research and monitoring that followed the mine subsidence episode in August 1978. Two homes were severely damaged by the mine subsidence, as were several utilities.

Keyword(s): surface subsidence damage, surface structural damage, utilities, abandoned mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., J. W. Mahar, T. K. Lundin. Mine Subsidence and Related Structural Damage, Hegeler, Illinois. Phase I Report to the U.S. Bureau of Mines, 1981, 62 p.

Keyword(s): surface structural damage, abandoned mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., J. W. Mahar, D. J. Dobbels, D. R. Kiesling. Mine Subsidence and Related Structural Damage, Hegeler, Illinois. Report to U. S. Bureau of Mines, Twin Cities Research Center, Minneapolis, MN, June, 1982, 120 p.

The purpose of this study was to augment the characterization and understanding of mine subsidence and related damage occurring over abandoned room-and-pillar mines. The project objective was to summarize and evaluate three adjacent subsidence cases in Hegeler, Illinois. Phase I of the research primarily considered the surface effects and related damage to surface structures. Phase II concentrated on the mechanisms of mine collapse. This report summarizes both phases.

Keyword(s): abandoned mines, surface structural damage, subsurface structural damage, coal mining, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., J. W. Mahar. Response of Homes to Sag Subsidence Over Illinois Abandoned Coal Mines. Presented at Society of Mining Engineers of AIME Annual Meeting, Los Angeles, CA, February 26-March 1, 1984, SME-AIME preprint 84-181, 18 p.

This paper summarizes and evaluates data on mine subsidence ground movements and associated damages for houses in Illinois. The response of these homes is expressed in terms of repair costs.

Keyword(s): abandoned mines, surface structural damage, economics, coal mining, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., J. W. Mahar. Subsidence Damaged Homes over Room and Pillar Mines in Illinois. Illinois Abandoned Mined Lands Reclamation Council Report, Springfield, 1984, 450 p.

Keyword(s): surface structural damage, abandoned mines, room-and-pillar, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., J. W. Mahar. House Damage Criteria for Sag-Subsidence Over Illinois Room and Pillar Coal Mines. Transactions, SME-AIME, December, 1984, v. 278, p. 1818-1825.

This paper provides an understanding of the behavior and potential damage of homes resulting from sag-type mine subsidence. Extensive and numerous case histories in Illinois were collected. The house response to subsidence-induced ground displacements is summarized and evaluated.

Keyword(s): surface structural damage, foundations, room-and-pillar, abandoned mines, coal mining

Location(s): Illinois, United States

Marino, G. G., E. J. Cording. Geotechnical Aspects of Subsidence Over Room and Pillar Mines in Illinois. IN: Proceedings, 4th Conference on Ground Control in Underground Mining, July 22-24, 1985, Morgantown, WV, 9 p.

Site conditions at several shallow room-and-pillar mines in Illinois are described and compared with the characteristics of the subsidence profiles at the ground surface. The shape and magnitude of the subsidence profiles were found to be closely related to the thickness of the soil and rock over-burden, the percent extraction of the coal, and the shape of the mine pillars. The room-and-pillar mines were located at a shallow depth beneath flat to gently rolling terrain. Thickness of the coal seams ranged from 6 to 9 feet and was underlain by underclays at all sites. This information was developed to improve techniques for evaluating the subsidence potential at sites within the Illinois Coal Basin.

Keyword(s): geotechnical, room-and-pillar, ground control, pillar strength, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G. Subsidence Damaged Houses over Illinois Room and Pillar Mines. Ph.D. Thesis, University of Illinois at Urbana-Champaign, Urbana, IL, 1985, 435 p.

A relationship is established between residential damage and ground movements over Illinois room-and-pillar mines. House damage can be estimated using this ground movement damage criterion and knowing the expected level of ground displacement. Subsidence characteristics observed at the ground surface are presented for estimating ground movement for damage prediction.

Keyword(s): surface structural damage, room-and-pillar, coal mining, abandoned mines, structural mitigation, vertical displacement, foundations

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., A. G. Devine. Mine Subsidence and Related Structural Damage, Hegeler, Illinois from July 1981 to February 1985. Report to U.S. Bureau of Mines-Twin Cities Research Center, May, 1985, Civil Engineering Department, University of Illinois at Urbana-Champaign, 45 p.

The objectives of this research program were to (1) monitor mine subsidence effects on the surface, the near-surface groundwater, and the surface structures; and (2) assess subsurface conditions and evaluate mechanisms of long-term mine collapse or yield. This work was conducted over an area of abandoned workings in Hegeler, Illinois, where subsidence has resulted and is expected to continue.

Keyword(s): surface structural damage, coal mining, abandoned mines, subsurface water, monitoring methods, time factor, vertical displacement, horizontal displacement

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., J. W. Mahar, L. R. Powell, R. E. Thill. Ground Subsidence and Structural Damage Over an Abandoned Room-and-Pillar Coal Mine at Hegeler, IL. U.S. Bureau of Mines IC 9072, 1986, 24 p.

The USBM and the University of Illinois investigated surface characteristics and damage to structures from mine subsidence over a room-and-pillar coal mine in Hegeler, Illinois. Data on three adjacent subsidence sags and associated structural damage were collected, summarized, and evaluated. The subsidence sags developed over a 10-year period and took place above a modified room-and-pillar operation mining the Herrin coal at a depth of 130 to 135 feet. Surface vertical displacements of 3.0 to 3.5 feet resulted from extracting 6.1 to 6.4 feet of coal.

Keyword(s): room-and-pillar, abandoned mines, surface structural damage, coal mining, utilities

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G. Interactions Between Building and Subsidence Movements. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University Department of Mining Engineering, p. 163-180.

The main subsidence-ground-structure interactions are presented, with an overview of the response of surface structures to subsidence ground movements. Data presented generally apply to structures up to two or three stories high and no more than several hundred feet in length.

Keyword(s): surface structural damage, construction, foundations, coal mining

Marino, G. G. Long-Term Stability of Overburden Above Room and Pillar Mines. IN: Mine Subsidence, M.M. Singh, ed., Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, SME, Littleton, CO, p. 73-82.

Vast improvement in methods of design and analysis of the long-term stability of overburden above room-and-pillar mines is needed. Improved methods are vital for planning and land development and for prediction above existing, presently stable, room-and-pillar mines.

Keyword(s): overburden, room-and-pillar, roof stability, floor stability, pillar strength, mine design, agriculture, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., M. R. Funkhouser. Mine Subsidence of the District 11 State Police Headquarters, Maryville, Illinois. Final report for Illinois Abandoned Mined Lands Reclamation Council, Springfield, 1986, 81 p.

Keyword(s): surface structural damage, abandoned mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., W. L. Gamble. Mine Subsidence Damage from Room and Pillar Mining in Illinois. International Journal of Mining and Geological Engineering, v. 4, 1986, p. 129-150.

This paper presents case histories of subsidence damage occurring over abandoned room-and-pillar mines in Illinois. Major modes of behavior and damage in houses from sag-subsidence are summarized. The houses rested on concrete and masonry foundations. The prevalent mode of failure of bearing walls was inward bending. Failure is analyzed. Conventional design procedures are used to evaluate foundation failure.

Keyword(s): foundations, surface structural damage, room-and-pillar, coal mining, abandoned mines

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G. Analysis of the Initial Collapse of the Overburden Over Longwall Panels Using Subsidence Data. IN: Proceedings, 7th International Conference on Ground Control in Mining, Morgantown, WV, August, 1988.

Documented case histories of surface ground movements from mine subsidence were used to help determine when the initial collapse of the overburden occurred above longwall panels.

Keyword(s): longwall, coal mining, overburden, vertical displacement, engineering, geotechnical, roof stability, monitoring methods

Location(s): Illinois, Illinois Coal Basin, Appalachian Coal Region, Colorado, New Mexico, United States

Marino, G. G., J. W. Mahar, E. W. Murphy. Advanced Reconstruction for Subsidence-Damaged Homes. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, American Society of Civil Engineers, Nashville, TN, May 1988, p. 87-106.

Significant repair costs have resulted from homes damaged by subsidence from underground coal mining. A research and development project was undertaken in Illinois to address many of the residential damage and reconstruction problems from mine subsidence. Phase I of this project is complete and has resulted in a draft handbook of advanced abatement and reconstruction methods.

Keyword(s): insurance, surface structural damage, coal mining, foundations, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G. Progressive Failure of the V-Day Mine and a Comparison with Other Similar Features in Illinois. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 183-192.

The performance of the V-Day Mine near Danville, Illinois, has been evaluated from data extending about 20 years. The area included in this study involves more than 16 acres. This entire area has progressively subsided. Extensive data has been collected on the geologic and mining conditions, the subsidence movements, and on the response of the surface structures to the subsidence.

Keyword(s): abandoned mines, coal mining, surface structural damage, room-and-pillar, geologic features, floor stability

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G. Subsidence Damage and Remedies. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, C.D. Elifrits, ed., October 2-3, 1990, Pittsburgh, PA, p. 153-164.

This paper describes the development of advanced procedures on abatement and reconstruction of homes damaged by mine subsidence. The objectives of the project are for more economical and effective abatement measures, correct evaluation of damage, and education of contractors with abatement and reconstruction technology.

Keyword(s): insurance, room-and-pillar, abandoned mines, surface structural damage, engineering

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., W. L. Gamble. Repair and Strengthening of Subsidence Damaged Concrete Block Foundation Walls. IN: Proceedings, 5th North American Masonry Conference, June 3-6, 1990, Urbana, IL, 12 p.

This paper describes ongoing research and development of improved methods for repair of concrete block foundations.

Keyword(s): structural mitigation, surface structural damage, foundations, engineering, vertical displacement, horizontal displacement, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G. Innovative Repair of Subsidence Damage. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 139-145.

To improve handling of subsidence damages, the Illinois Mine Subsidence Insurance Fund supported the development of novel cost-effective methods of repair. The research in developing the repairs was directed towards the most common and costly damages observed. As a result, repair techniques were designed for structurally cracked foundations in the tension and compression zones, and for damaged or undamaged tilted foundations. All the postulated repair methods were laboratory and/or field tested.

Keyword(s): structural mitigation, surface structural damage, insurance, coal mining, foundations, engineering, construction, lab testing

Location(s): Illinois, Illinois Coal Basin, United States

Mark, C., Z. T. Bieniawski. A New Method for Sizing Longwall Pillars Based on Field Measurements. IN: Proceedings, 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., West Virginia University, Morgantown, p. 157-171.

A new method for the design of longwall pillars, called "Analysis of Longwall Pillar Stability" (ALPS) is described. The method is the final result of a research program that included two major field studies, extensive reanalysis of data from other in situ measurements, and detailed evaluations of available pillar design methods. The key problem addressed by ALPS is estimation of the abutment loads applied to longwall pillars.

Keyword(s): pillar strength, longwall, computer, mine design, prediction, coal mining

Location(s): West Virginia, Kentucky, Appalachian Coal Region, United States

Mark, C., T. Barton. Field Evaluation of Yield Pillar Systems at a Kentucky Longwall Headgate. IN: Proceedings, 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 1-9.

The USBM is conducting research to assess the effectiveness of different chain pillar designs in maintaining gate entry stability. The study described in this paper was performed in an experimental headgate section which was 1,200 feet long and contained three pillar designs: (1) a three-entry, yield-abutment pillar system, (2) a four-entry, yield-abutment pillar system, and (3) a five-entry, all-yield pillar system. Engineers monitored entry convergence, roof sag, and changes in roof quality. The results of the study indicate that the all-yield system performed at least as well as, and probably better than, the two abutment pillar systems.

Keyword(s): pillar strength, yielding supports, longwall, mine design, roof stability, roof support, geologic features

Location(s): Kentucky, United States

Mark, C., J. Listak, Z. T. Bieniawski. Yielding Coal Pillars--Field Measurements and Analysis of Design. IN: Key Questions in Rock Mechanics, Proceedings of the 29th U.S. Symposium, Minneapolis, MN, June 13-15, 1988, P.A. Cundall, R.L. Sterling, and A.M. Starfield, eds., Balkema, Rotterdam, p. 261-270.

Yielding pillars are gaining increasing acceptance as a technique for improving ground control in coal mines The field studies described in this paper provide insights into the failure mechanics of yielding pillars that may prove helpful in improving yielding pillar design. Analysis includes the derivation of expressions for the stress distribution within a yielding pillar implied by several well known empirical pillar design formulas.

Keyword(s): yielding supports, coal mining, longwall, instrumentation, modeling, empirical model

Mark, C. Longwall Pillar Design--Some Recent Developments. SME Preprint 98-103, for presentation at SME Annual Meeting, Las Vegas, NV, February 27-March 2, 1989, 9 p.

Effective ground control in gate entries, particularly in the tailgate travelways, is essential for safe longwall mining. Longwall pillars maintain gate entry stability and carry abutment loads. To answer the need for effective longwall pillar design, an empirical method called Analysis of Longwall Pillar Stability (ALPS) was proposed. The ALPS was originally developed from field studies in which multiple stressmeters were installed in longwall pillars and monitored during mining. Several new field studies have been used to verify formulas for predicting abutment strength and pillar loads, and to develop an expression for the distribution of the abutment load. Since its development, ALPS has been applied to nearly 100 mining case histories throughout the eastern United States.

Keyword(s): longwall, mine design, pillar strength, coal mining, ground control, yielding supports, computer
Location(s): Appalachian Coal Region, United States

Mark, C. Pillar Design Methods for Longwall Mining. U.S. Bureau of Mines IC 9247, 1990, 53 p.
Effective ground control in the gate entries is essential for safe and productive longwall mining. Longwall pillars protect the gate entries from the severe abutment loads that develop as the longwall retreats. This report focuses on the Analysis of Longwall Pillar Stability (ALPS) design method. With ALPS, mining engineers can estimate the strength of longwall pillar systems and the load that will be applied to them. Several other methods that can be directly used to size longwall pillars are also described, using a data bank of more than 100 case histories.
Keyword(s): pillar strength, mine design, longwall, coal mining, ground control, yielding supports, multiple-seam extraction, floor stability
Location(s): United States

Mark, C. Horizontal Stress and its Effects on Longwall Ground Control. Mining Engineering, November 1991, p. 1356-1360.
This paper discusses measurements of in situ horizontal stress fields in the eastern United States, experience with horizontal stress in longwall mines, and methods for predicting and controlling horizontal stresses. The data were collected through site investigations at 45 longwall mines in the United States and a review of international literature.
Keyword(s): longwall, coal mining, ground control, roof stability, mine design, literature search
Location(s): West Virginia, Pennsylvania, Appalachian Coal Region, Illinois, Illinois Coal Basin, Alabama, United States

Marr, J. E. Horizontal and Vertical Movements of the Surface in Longwall Mining. Transactions, Institute of Mining Engineers, London, 1950, p. 106-118.
Keyword(s): horizontal displacement, vertical displacement, longwall, surface subsidence damage
Location(s): England

Marr, J. E., J. F. Ward. Some Practical Aspects of Precise Subsidence Surveying. Transactions, Institute Mining Surveyors, 1952, 17 pp; available upon request from A.J. Fejes, U.S. Bureau of Mines, Denver, CO.
This paper evaluates survey techniques and details the design and construction of survey monuments used to monitor ground movements over longwall mining operations.
Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey data processing, longwall, instrumentation
Location(s): United States

Marr, J. E. A New Approach to the Estimation of Mining Subsidence. Transactions, Institute Mining Engineers, London, v. 118, 1958-59, p. 692-706.
From the study of the shapes of a number of subsidence profiles, a general mathematical equation to define various subsidence parameters has been deduced. The application of this equation to two examples is illustrated. The relationship between the angle of draw and the width/depth ratios for several strata are considered, plus the relationship between angle of draw and inclined strata. The effect of variations in local geological conditions and the quality of packing systems are discussed, along with the accuracy to which subsidence estimations can be carried out.
Keyword(s): vertical displacement, prediction, angle of draw, backfilling, geologic features

Marr, J. E. The Estimation of Mining Subsidence. Colliery Guardian, v. 198, no. 5116, March, 1959, p. 345-352.
This article discusses general aspects of subsidence prediction. Included are data later improved and summarized in the form of the National Coal Board's Subsidence Engineers' Handbook.
Keyword(s): prediction, longwall, surface structural damage, vertical displacement, horizontal displacement, National Coal Board, coal mining
Location(s): England, Europe

Marr, J. E. Subsidence Observations in the South Lancashire Coalfield. Sheffield University Mining Magazine, 1961, p. 24-35.
Keyword(s): surface subsidence damage, coal mining
Location(s): England

Marr, J. E. The Effects on Surface Property By a Modified Mining Method. Chartered Surveyor, v. 97, January, 1965.
Keyword(s): surface structural damage, mine design

Marr, J. E. The Application of the Zone Area System to the Prediction of Mining Subsidence. The Mining Engineer, London, v. 176, no. 135, October, 1975, p. 53-62.

This article outlines the introduction and initial development of the zone area system in Europe and the difficulties experienced in applying the system to British mining circumstances.

Keyword(s): zone area, vertical displacement, horizontal displacement, prediction

Location(s): England, Europe

Marsden, S. S., Jr., S. N. Davis. Geologic Subsidence. Scientific American, v. 216, 1967, p. 93-100.

Keyword(s): fluid extraction

Location(s): United States

Marshall, G. J. A Viscoelastic Treatment of the Deformation of the Ground Caused by Mining Operations. Journal Mechanics Physics Solids, v. 17, no. 3, 1969, p. 151-162.

Keyword(s): modeling, viscoelastic model, phenomenological model

Martin, A.W. & Associates, Inc. Relationship Between Underground Mine Water Pools and Subsidence in the Northeastern Pennsylvanian Anthracite Floods. Department of Environmental Resources, Commonwealth of PA, Harrisburg, 1975.

Keyword(s): subsurface water, hydrology, anthracite, coal mining, environment

Location(s): Pennsylvania, Appalachian Coal Region, United States

Martin, A. W. & Associates, Inc. Development of a Comprehensive Program of Insurance Protection Against Mining Subsidence and Associated Hazardous Location Risks. Appalachian Regional Commission Report ARC-73-163-2558, June 1975, 108 p. (NTIS PB 272 515)

Keyword(s): insurance

Location(s): Pennsylvania, Appalachian Coal Region, United States

Martin, C. H., A. J. Hargraves. Shortwall Mining with Power Supports in the Broken Hill Proprietary Co., Ltd. Mines in Australia. IN: Proceedings, 5th International Strata Control Conference, London, 1972, National Coal Board, p. 13.1-13.13.

Keyword(s): shortwall, National Coal Board, roof support, coal mining

Location(s): Australia

Martin, J. C., S. Serdengecti. Subsidence Over Oil and Gas Fields. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, The Geological Society of America, 1984, T.L. Holzer, ed., p. 23-34.

Most oil and gas reservoirs experience only small amounts of compaction and surface subsidence. Significant subsidence due to production of hydrocarbons has been observed over some oil and gas fields. This paper presents a review of the fundamentals of reservoir compaction and surface subsidence over oil and gas fields and explains why large-scale subsidence is rare. A new method of estimating maximum potential subsidence is presented and used to analyze the subsidence over oil and gas fields in Louisiana. Large-scale compaction and subsidence are evidently associated with inelastic behavior of the reservoir rock and in some cases of the surrounding rock. No reliable methods have been established for predicting either the transition from elastic to inelastic reservoir rock behavior or large-scale reservoir compaction and subsidence.

Keyword(s): oil extraction, fluid extraction, prediction, geologic features

Location(s): Louisiana, Texas, California, United States

Martos, F. Concerning An Approximate Equation of the Subsidence Trough and Its Time Factor. IN: Proceedings, International Strata Control Congress, Leipzig, October 14-16, 1958, p. 191-205 and LXXXIII-XC.

It is well known that above seams in horizontal or almost horizontal formation at the end of movements caused by underground excavations there is a trough which in its vertical section resembles the profile of a bell. In this paper a model shows the schematic stratification of the subsidence trough in the Oroszlany coal district, after having worked two seams. The author expresses the various subsidence troughs and profile curves as analytical functions.

Keyword(s): time factor, modeling, coal mining, multiple-seam extraction, vertical displacement

Location(s): Hungary

Martos, F. Protection of Buildings from Damage Caused by Rock Movement. Hungarian Mining Research Institute, no. 2, 1958, p. 11-22.

Keyword(s): architecture, surface structural damage, engineering

Marvin, M. H., G. S. Knoke, W. R. Archibald. Backfilling of Cavities Produced in Borehole Mining Operations. Contract JO285037, Flow Industries, Inc., U.S. Bureau of Mines OFR 4-81, 1979, 85 p. (NTIS PB 81-171308)
Keyword(s): backfilling
Location(s): United States

Mates, R. R., A. M. Richardson, N. R. Roberts, M. J. Superfesky. Rock Anchor Systems for Reducing Subsidence Damage. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 134-141.

This paper describes the use of post-tensioned rock anchors to reduce the risk of future damage to a residential structure as a result of coal mine subsidence.

Keyword(s): surface structural damage, coal mining, grouting, abandoned mines, instrumentation
Location(s): West Virginia, Appalachian Coal Region, United States

Matetic, R. J., G. J. Chekan, J. A. Galek. Design Considerations for Multiple-Seam Mining with Case Studies of Subsidence and Pillar Load Transfer. IN: Rock Mechanics: Proceedings of the 28th U.S. Symposium, University of Arizona, Tucson, June 29-July 1, 1987, I.W. Farmer, et al., eds., Balkema, Rotterdam, p. 1095-1106.

The USBM, as part of a program to improve mine planning and development, is currently investigating interactions associated with multiple-seam mining. Two common interactions that occur between adjacent coalbeds are subsidence and pillar load transfer. This study involves underground observations and measurements at two mines affected by these interactions.

Keyword(s): multiple-seam extraction, coal mining, pillar strength, instrumentation, roof support, roof bolting, mine design
Location(s): United States

Matetic, R. J., G. J. Chekan, J. A. Galek. Room-and-Pillar Mine Design in Multiple Seams. Coal Mining, December, 1987, p. 36-40.

There are two basic interactions that occur between seams: pillar load transfer and subsidence. Pillar load transfer is an interaction resulting from load transfer through pillars in overlying or underlying mining operations. This interaction occurs particularly when coalbeds are in close proximity, less than 110 feet apart. When an underlying bed is extracted first, strata interactions from subsidence will result. To further understand these interactions and their influence on mine ground stability, the USBM conducts geological and geotechnical investigations in the field. This knowledge will lead to improvements in mine design and conservation of resources that might otherwise be lost.

Keyword(s): room-and-pillar, mine design, multiple-seam extraction, pillar strength, coal mining, roof stability, roof support, roof bolting, geologic features, instrumentation, time factor
Location(s): Appalachian Coal Region, United States

Matetic, R. J., G. J. Chekan. Assessment of Pillar Load Transfer at Two Multiple-Seam Mine Sites. SME Preprint 89-94, for presentation at SME Annual Meeting, Las Vegas, NV, February 27-March 2, 1989, 13 p.

The USBM, as part of a program to improve mine planning and development, is currently investigating the effects of pillar load transfer, which can impact mining operations within a multiple-seam configuration. A comparative study was performed at two separate mine sites to determine the effects of this load transfer mechanism. The Bureau installed and monitored instrumentation at both sites to gather pertinent data on rock mechanics.

Keyword(s): mine design, pillar strength, multiple-seam extraction, instrumentation, rock mechanics, coal mining, overburden
Location(s): West Virginia, Appalachian Coal Region, Illinois, Illinois Coal Basin, United States

Matetic, R. J., M. A. Trevits. Longwall Mining Impact on Near-Surface Water. IN: Mine Subsidence - Prediction and Control, National Symposium 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 131-139.

A total of eight shallow observation wells were spaced across two longwall panels in Pennsylvania. Various hydrological parameters such as specific capacity, transmissivity and well yield were determined before and after mining, along with water level fluctuation data.

Keyword(s): active mines, hydrology, subsurface water, overburden, longwall, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Matetic, R. J., M. A. Trevits. Hydrologic Variations Due to Longwall Mining. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 204-213.

A field case study was conducted in Cambria County, Pennsylvania, where five observation water wells were drilled above two adjacent longwall panels. The study showed that the observed changes in chemistry did not affect the potability of the water, short-term major water level fluctuations occur at the approximate time of undermining, and water level recovery begins before the process of subsidence is complete.

Keyword(s): longwall, subsurface water, hydrology, monitoring methods, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Mather, J. D., D. A. Gray, D. G. Jenkins. The Use of Tracers to Investigate the Relationship Between Mining Subsidence and Ground Water Occurrence at Aberfan, South Wales. Journal of Hydrology, Amsterdam, v. 9, 1969, p. 136-154.

Keyword(s): hydrology, monitoring methods, subsurface water

Location(s): Wales, United Kingdom

Matheson, G. M., A. E. Clift. Characteristics of Chimney Subsidence Sinkhole Development from Abandoned Underground Coal Mines Along the Colorado Front Range. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 204-214.

The factors that control chimney subsidence sinkhole development in weak rock were assessed by analyzing the characteristics of approximately 3,000 chimney subsidence features along the Colorado Front Range. Data were collected for sinkholes occurring over both room-and-pillar and retreat mining areas in coal seams with a wide range of dips.

Keyword(s): abandoned mines, coal mining, geologic features

Location(s): Colorado, Rocky Mountain Coal Region, United States

Matheson, G. M., Z. F. Bliss. Observations on the Location of Chimney Subsidence Sinkhole Development Along the Colorado Front Range. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 169-189.

This paper reviews the mechanism of chimney subsidence sinkhole development in soft rocks and presents empirical data on the maximum height chimney subsidence may develop over horizontal and dipping coal seams. Generalizations are drawn that can be useful in the prediction of potential chimney subsidence sinkhole development throughout the Front Range.

Keyword(s): abandoned mines, surface subsidence damage, horizontal displacement, historical, soils, roof stability, floor stability, pillar strength, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, United States

Matheson, G. M. Subsidence Above Abandoned Underground Coal Mines-Weak Rock Overburden. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October 1987, p. 63-81.

The study of more than 85 mines of various ages, mined thicknesses, depths, and geohydrologic conditions in Colorado has shown that (1) there is a period in which active widespread subsidence occurs, and it begins with mining and ends some 20 to 30 years after mining; (2) subsidence after this period is at a much lower frequency and appears to occur from the collapse of relatively limited areas of mining; (3) a probabilistic relationship between depth to mining and chimney subsidence sinkhole development can be developed; and (4) over deeper mining areas, calibrated numerical modeling analyses indicate limits of potentially damaging surface strains for the collapse of typical sized mine openings.

Keyword(s): coal mining, abandoned mines, modeling, room-and-pillar, time factor, overburden, lab testing, multiple-seam extraction, land-use planning

Location(s): Colorado, Wyoming, Rocky Mountain Coal Region, United States

Matheson, G. M. A Probabilistic Function for Prediction of Chimney Subsidence Sinkhole Development. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 233-246.

The prediction of chimney subsidence sinkholes above abandoned underground mines has depended largely on rules of thumb and semiquantitative relations developed by assuming various caving geometries. A study of more than 2,000 chimney subsidence sinkhole features over abandoned coal mines in Colorado has resulted in the development of a probabilistic function that describes the potential for sinkholes to develop above collapsing mine openings.

Keyword(s): abandoned mines, modeling, coal mining, prediction, empirical model

Location(s): Colorado, Rocky Mountain Coal Region, United States

Mathur, S. K., M. R. Mikkilineni. Preliminary Predictive Model of Subsidence Process Over Room and Pillar Workings. Phase I. Definition of Factors. Open File Report January 81-April 82. U.S. Bureau of Mines OFR 68-83, MRM Engineers, Pittsburgh, PA, April 1982, 113 p. (NTIS PC A06/MF A01)

This report identifies all the possible activities, variables, and factors that contribute to surface subsidence over room-and-pillar workings. The subsidence failure mechanism is initiated by the failure of the mine floor bed and/or the failure of the pillars or the failure of the roof after second mining, which eventually brings down the roof. The individual responses of these components cannot be attributable to any single factor. Because of the lack of field data, no attempt was made to quantify the significance of each of these factors and relate it to the ground subsidence.

Keyword(s): prediction, room-and-pillar, modeling, floor stability, roof stability, pillar strength, pillar extraction

Location(s): United States

Maung, H. M., S. P. Banerjee. Investigation into Strata Behavior Around an Experimental Longwall Caving Face in Jharia Coalfield. Journal of Mines, Metals, and Fuels, v. 24, no. 9, September, 1976, p. 283-289.

Keyword(s): longwall

Location(s): India

Maury, V. Effondrements Spontanes (Spontaneous Subsidence). Industrie Minerale, St. Etienne, France, v. 61, no. 10, 1979, p. 511-522.

Keyword(s): surface subsidence damage

Location(s): France

Mautner, K. W. Structures in Areas Subjected to Mining Subsidence. IN: Proceedings, 2nd International Conference on Soil Mechanics and Foundation Engineering, Rotterdam, June 21-30, 1948, v. 2, p. 167-177.

This paper covers the mechanics of mining subsidence, the design of structures with regard to subsidence, and some examples of structures constructed and kept under observation for long periods.

Keyword(s): surface structural damage, engineering, foundations

Mautner, K. W. Structures in Areas Subjected to Mining Subsidence. Structural Engineering, v. 26, no. 1, 1948, p. 35-69.

Keyword(s): surface structural damage, engineering

Mavrolas, P., M. Schechtmann. Coal Mine Subsidence: Proceedings From a Citizen's Conference. The Illinois South Project, Inc., Herrin, IL, 1981, 45 p.

This report is based upon a citizen education conference on coal mine subsidence held in Illinois on October 13, 1979. The goal was to prepare a readable and useful report for people concerned about mine subsidence.

Keyword(s): active mines, abandoned mines, economics, surface structural damage, agriculture, structural mitigation, land mitigation, insurance, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Maxwell, B., G. Zink, F. D. Wang. Improving Coal Mine Roof Stability by Pillar Softening. U.S. Bureau of Mines OFR 7-78, 1977, 105 p. (NTIS PB 276-474)

Keyword(s): roof stability, room-and-pillar, roof support, pillar strength, yielding supports, coal mining

Location(s): United States

Maxwell, G. M. Some Observations on the Limitations of Geophysical Surveying in Locating Anomalies from Buried Cavities Associated with Mining in Scotland. The Mining Engineer, March, 1975, v. 134, no. 170, p. 277-285.

Keyword(s): abandoned mines, survey methods, geophysical

Location(s): Scotland

Mayer, L. W. The Advantage of Flushing in Coal Mining. Engineering and Mining Journal, v. 86, 1908, p. 1.

This article discusses advantages of hydraulic flushing over hand stowing, and gives a brief history and comparison of backfilling practices in the United States and Europe.
Keyword(s): hydraulic backfilling, coal mining, historical
Location(s): United States, Europe

Mayer, L. W. Sand Filling in the Iron Mines of Peine, Germany. Transactions, AIME, v. 39, 1908, p. 355.
Hydraulic backfilling is used in conjunction with room-and-pillar mining.
Keyword(s): hydraulic backfilling, room-and-pillar, metal mining, multiple-seam extraction
Location(s): Germany

Mayer, L. W. Subsidence with Hydraulic Filling Hardly Noticeable at Carmaux, France. Mining Methods in Europe, New York, 1909, p. 154.
This article covers the application of hydraulic backfilling to French mining methods.
Keyword(s): hydraulic backfilling
Location(s): Europe, France

Mayuga, M. N. How Subsidence Affects the City of Long Beach. IN: Proceedings, 2nd Geologic Conference on Landslides and Subsidence, Los Angeles, California Resources Agency, Sacramento, 1966, p. 122-129.
Keyword(s): fluid extraction
Location(s): California, United States

Mayuga, M. N., D. R. Allen. Long Beach Subsidence. Engineering Geology in Southern California, Association of Engineering Geologists, Los Angeles Section Special Publication, 1966, Glendale, CA, p. 280-285.
Keyword(s): oil extraction, fluid extraction
Location(s): California, United States

McCallum, T. Mineral Subsidence and Local Authority Services. Institute Municipal and County Engineers Journal, v. 70, no. 11, 1944, p. 441-422.
Keyword(s): government
Location(s): United Kingdom

McCallum, T. The Maintenance of Roads in a Mining Area. Journal of Inter Highway Engineers, v. 2, January, 1952, p. 369-376.
Keyword(s): roads

McCann, G. D., C. H. Wilts. Mathematical Analysis of the Subsidence in the Long Beach-San Pedro Area. California Institute Technical Report 117, November, 1951.
Keyword(s): modeling, mathematical model, fluid extraction
Location(s): California, United States

McCauley, C. A., R. L. Gum. Subsidence Damage in Southern Arizona. Hydrology and Water Resources in Arizona and the Southwest, v. 2, 1972, p. 87-94.
Keyword(s): fluid extraction
Location(s): Arizona, United States

McCauley, C. A. Management of Subsiding Lands: An Economic Evaluation. Ph.D. Thesis, University of Arizona, Tucson, 1973, 84 p. (NTIS 240 305)
Keyword(s): economics, land-use planning
Location(s): United States

McClain, W. C. Time-Dependent Behavior of Pillars in the Alsace Potash Mines. IN: Proceedings 6th Symposium on Rock Mechanics, University of Missouri at Rolla, 1964, E.M. Spokes and C.R. Christiansen, eds., p. 489-500.
This paper describes part of a rock mechanics investigation carried out in the potash mines of the Alsace district, France. One of the basic objectives was the understanding and description of the behavior of long pillars of potash with respect to time and the manner in which they perform their task of supporting the overlying strata.
Keyword(s): pillar strength, non-metal mining, time factor, rock mechanics
Location(s): France

McClain, W. C. Surface Subsidence Associated with Longwall Mining. Transactions, AIME, v. 235, 1966, p. 231-235.
This paper examines characteristics of subsidence due to longwall mining and resulting damages to surface structures. A general review of subsidence mechanics and protective measures used to minimize damage to surface structures is included.
Keyword(s): vertical displacement, horizontal displacement, surface structural damage, longwall
Location(s): United States

McColloch, J. S., R. F. Fonner, C. P. Messina. BOM Mine Subsidence Study, Fairmont, West Virginia, Core Drilling Report. West Virginia Geological and Economic Survey Open File Report OF8012, September, 1980, for U.S. Bureau of Mines, 54 p.

The evaluation of information obtained from core drilling was undertaken by the West Virginia Geological and Economic Survey to assist the USBM in their study of mine subsidence. The drilling program was initiated to determine the effect of deep mining on the integrity of the overburden above the extensively mined Pittsburgh coal seam.

Keyword(s): overburden, coal mining, rock mechanics, geologic features, pillar strength, floor stability

Location(s): West Virginia, Appalachian Coal Region, United States

McCoy, A. E. R. Longwall Mining at Appin Colliery. IN: Annual Conference, Australasian Institute of Mining & Metallurgy, May, 1976, p. 195-207.

Keyword(s): longwall, coal mining

Location(s): Australia

McCreedy, J., W. J. Taylor. The Use of Hydraulic Fill Underground at the Mines of the International Nickle Company of Canada, Limited. Canadian Mining Journal, v. 81, no. 9, September, 1960, p. 95-103.

This detailed article discusses complete hydraulic filling operations in three mines.

Keyword(s): hydraulic backfilling, metal mining

Location(s): Canada

McCulloch, C. M., M. Deul. Geological Factors Causing Roof Instability and Methane Emission Problems. U.S. Bureau of Mines RI 7769, 1973, 25 p.

Keyword(s): roof stability, ground control, geologic features, coal mining

Location(s): United States

McCulloch, C. M., P. W. Jeran, C. D. Sullivan. Geological Investigations of Underground Coal Mining Problems. U.S. Bureau of Mines RI 8022, 1975, 30 p.

Keyword(s): roof stability, ground control, geologic features, coal mining

Location(s): United States

McCulloch, C. M., W. P. Diamond, B. M. Bench, M. Deul. Selected Geologic Factors Affecting Mining of the Pittsburgh Coalbed. U.S. Bureau of Mines RI 8116, 1976, 19 p.

Keyword(s): roof stability, ground control

Location(s): Pennsylvania, Appalachian Coal Region, United States

McDougall, J. J. Longwall Operations, Sydney Mines, N.S. Transactions of the Candian Institute of Mining and Metallurgy and the Mining Society of Nova Scotia, 1925, Montreal, Quebec.

The object of this paper is to point out the reason for the adoption of longwall methods in the mines discussed and to give a true account of results that attended the efforts of those concerned.

Keyword(s): longwall, coal mining

Location(s): Canada

McKim, M. J., A. Shakoor. An Investigation of Mine Subsidence Incidents in Selected Areas of Madisonville, Kentucky. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 271-286.

During the past several decades, numerous houses and commercial buildings in and around Madisonville, Kentucky, have experienced extensive structural damage due to mine subsidence. Surface and subsurface investigations were conducted at four selected sites to evaluate possible subsidence mechanisms.

Keyword(s): surface structural damage, coal mining, overburden, rock mechanics, geologic features, abandoned mines, pillar strength, roof stability, geotechnical, lab testing, engineering

Location(s): Kentucky, Illinois Coal Basin, United States

McLellan, A. G. The Lining with Rubber of a Large Service Reservoir Damaged by Mining Subsidence. Journal Institute Water Engineers, v. 9, no. 1, 1955, p. 19-50.

Keyword(s): surface structural damage, surface water, structural mitigation

Location(s): United Kingdom

McMahan, T. J., W. G. Pariseau. A Comparison Between Two- and Three-Dimensional Numerical Models of a Coeur d'Alene District Mine. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium,1989, A.W. Khair, ed., Balkema, Rotterdam, p. 963-970.

This USBM study describes the development of a large-scale, three-dimensional, finite-element model of a deep-vein Coeur d'Alene District Mine. The three-dimensional model was prepared from combined digitized mine maps and generated levels that may also be analyzed as independent two-dimensional models. A comparison of the stress changes and displacements was made following a simulated vein excavation in both the three-dimensional and two-dimensional models. A one-cut excavation was simulated with the two-dimensional model and a multiple-cut excavation was simulated with the three-dimensional model. The results from the two analyses are dicussed in terms of the inherent differences between the models.

Keyword(s): modeling, finite element, metal mining

Location(s): Idaho, United States

McMillan, A. A., M. A. E. Browne. The Use or Abuse of Thematic Mining Information Maps. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 237-245.

Thematic and environmental geology mapping has been applied in recent years by the British Geological Survey. Experience in Scotland indicates that the separate portrayal of particular aspects of the drift and solid geology, former underground mining, and geotechnical properties are of greatest benefit to planners and civil engineers concerned with land use and ground stability.

Keyword(s): coal mining, abandoned mines, land-use planning, engineering, geologic features

Location(s): Scotland, United Kingdom

McNabb, K. E. Three-Dimensional Numerical Modelling of Surface Subsidence Induced by Underground Mining. Commonwealth Scientific and Industrial Research Organization, Australia, Technical Report No. 146, July 1987, 20 p.

This report presents three-dimensional numerical analyses of the surface subsidence induced by the total extraction of a longwall panel. The finite element and displacement continuity stress analysis methods were used to obtain linear elastic solutions for an idealized subsidence problem. Subsidence profiles are presented for a number of panel length to width ratios and for a range of anisotropic material values. Model predictions show that for the geometry modeled, a 5:1 (length to width) aspect ratio produces results equivalent to a two-dimensional idealization. The aspect ratio comparison was made using a linear elastic isotropic material model. The results also show that anisotropic are better than isotropic material models in producing a closer fit to observed subsidence profiles.

Keyword(s): modeling, longwall, finite element, geologic features, mine design, computer, subsurface water, hydrology, coal mining, overburden

Location(s): Australia

McTrusty, J. W. Control of Mining Subsidence. Colliery Engineering, v. 36, no. 421, March, 1959, p. 122-125.

Keyword(s): ground control

McVey, J. R. Mechanical and Ultrasonic Closure-Rate Measurements. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 91-97.

The USBM constructed two intrinsically safe closure rate measurement instruments that provide an aid for predicting an imminent local roof caving during pillar robbing. This improves operator and machine safety and reduces the incidence of getting equipment caught in the caved area. One instrument system consists of two rugged retrievable extensometers connected by long electrical cables to a digital readout unit for reading closure and closure rate. The Bureau is also evaluating a small ultrasonic unit to make these measurements. The new instrument provides an unobstructing technique to obtain measurements up to 35 feet. The ultrasonic transducer can be attached to a roof bolt, tossed into an unsupported area, or handheld.

Keyword(s): roof stability, high-extraction retreat, room-and-pillar, pillar extraction, mine safety, ground control

Location(s): Utah, United States

Meade, R. H. Compaction of Sediments Underlying Areas of Land Subsidence in Central California. U.S. Department of the Interior, Geological Survey, Professional Paper 497-D, 1968, 39 p.

Keyword(s): fluid extraction, geologic features

Location(s): California, United States

Meador, S. Regulation of Surface Subsidence in West Virginia. IN: Proceedings, 2nd Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University Department of Mining Engineering, p. 6-8.

West Virginia's coal mining regulatory programs are not unique when compared to federally approved programs implemented by other coal producing states. In fact, the language in the West Virginia Energy Act governing subsidence mirrors that written in the Federal Surface Mining Control and Reclamation Act and other state statutes. Certain legal and administrative issues, however, combine to make West Virginia's regulation of surface subsidence a singular approach.

Keyword(s): coal mining, law, government, multiple-seam extraction, active mines, longwall, room-and-pillar

Location(s): West Virginia, Appalachian Coal Region, United States

Mehnert, B. B., D. J. Van Roosendaal, R. A. Bauer, D. F. Brutcher. Effects of Longwall Coal Mine Subsidence on Overburden Fracturing and Hydrology in Illinois. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 105-110.

Sites over two longwall panels in southern Illinois were instrumented and characterized before and after subsidence to study the effects of coal-mine subsidence on the overburden. Geotechnical instrumentation included survey monuments, piezometers, time domain reflectometry cables, and a pump test well.

Keyword(s): longwall, coal mining, active mines, overburden, geologic features, geotechnical, instrumentation, monitoring methods, monitoring equipment, survey methods, survey data processing, subsurface water, hydrology, geophysical, rock mechanics

Location(s): Illinois, Illinois Coal Basin, United States

Mehnert, B. B., D. J. Van Roosendaal, R. A. Bauer. Long-term Subsidence Monitoring Over a Longwall Coal Mine in Southern Illinois. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 311-316.

Long-term monitoring is necessary to successfully develop predictive subsidence models. Thus, the Illinois Mine Subsidence Research Program has documented subsidence over a longwall mine in south-central Illinois throughout a 3-year period. No monitoring results of this duration have been previously published for longwall mining in Illinois.

Keyword(s): monitoring methods, longwall, coal mining, active mines, overburden, vertical displacement, survey methods, prediction, instrumentation

Location(s): Illinois, Illinois Coal Basin, United States

Mehnert, B. B., D. J. Van Roosendaal, R. A. Bauer, D. Barkley, E. Gefell. Final Report of Subsidence Investigations Over a High-Extraction Retreat Mine in Williamson County. Final Report to U.S. Bureau of Mines-Twin Cities Research Center on Contract CO267001, by Illinois State Geological Survey, Champaign, IL, January 1993, 91 p.

To investigate the effects of high-extraction retreat (HER) mining on the overburden, two instrument clusters were placed over an HER panel in Williamson County, Illinois. The effects investigated included the amount, extent, and location of fracturing in the bedrock. The effects on the local hydrogeology were also evaluated. The instruments included surface monuments, piezometers, extensometers, and two time-domain reflectometry cables. The panel was monitored before, during and after subsidence by the ISGS. This was the first time such information was collected over an HER operation in Illinois. This is one of three sites investigated under the Illinois Mine Subsidence Research Program to study the effects of mining on the overburden.

Keyword(s): high-extraction retreat, active mines, instrumentation, monitoring methods, overburden, subsurface water, monitoring equipment, geotechnical, lab testing

Location(s): Illinois, Illinois Coal Basin, United States

Meier, D. G. The Galatia Paleochannel and Ground Stability at the Wabash Mine. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 19-27.

Mining near the ancient Galatia paleochannel at the Wabash Mine has exposed a variety of mining conditions. In this paper, the physical characteristics of the accompanying features and their influence on ground stability are described. The procedures that have been successful in alleviating the mining problems are discussed.

Keyword(s): coal mining, geologic features, mine design, roof support, roof bolting, ground control

Location(s): Illinois, Illinois Coal Basin, United States

Meikle, P. G., C. T. Holland. The Effect of Friction on the Strength of Model Coal Pillars. Transactions, SME-AIME, December, 1965, p. 322-327.

Laboratory experiments were performed on model coal pillars in which the pillars were lubricated at the plate-specimen interface prior to compression tests. The purpose of lubrication was to determine the effect on the ultimate unit compressive strength of coal pillars in relation to frictional forces.

Keyword(s): lab testing, coal mining, pillar strength

Location(s): United States

Merrill, R. H., T. A. Morgan. Method of Determining the Strength of a Mine Roof. U.S. Bureau of Mines RI 5406, 1958.

The strength of a mine roof was tested by injecting air between the roof rock and the overlying layers, and measuring the strain and deflection of the roof until failure.

Keyword(s): roof support, roof stability, in situ testing

Location(s): United States

Michael Baker, Jr., Inc. Architectural Measures to Minimize Subsidence Damage. Appalachian Regional Commission Report ARC-73-111-2551, December, 1974, 130 p. (NTIS PB 242 466)

The purpose of this publication is to provide guidelines, principles, and criteria to enable the architectural and engineering professions to design and construct buildings, structures, and underground utilities to minimize subsidence damage.

Keyword(s): architecture, engineering, surface structural damage, coal mining, pipelines, literature search, utilities, foundations

Location(s): Pennsylvania, Appalachian Coal Region, United States

Michael Baker Jr., Inc. A Comprehensive Program for Dealing with Mine Subsidence. Appalachian Regional Commission Report ARC-73-163-2559, 1976.

Keyword(s): surface structural damage, land-use planning, coal mining

Location(s): Appalachian Coal Region, United States

Michael Baker, Jr., Inc. Subsidence and Mining Related Problems, Summary of Research Program. Appalachian Regional Commission Report ARC-73163-2259-S, April 1977, 46 p. (NTIS PB 272 724)

Keyword(s): subsidence research, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Michael, P. R. Subsidence Over Abandoned Bituminous Coal Mines in the Appalachian Coal Basin; An Analysis of Subsidence Parameters and Three Case Studies. M.S. Thesis, State University of New York, Binghamton, 1984.

Keyword(s): abandoned mines, coal mining, bituminous

Location(s): Appalachian Coal Region

Michael, P. R., A. S. Lees, T. M. Crandall, J. L. Craft. Controlled Grout Columns: A Point-Support Technique for Subsidence Abatement. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October 1987, p. 111-125.

Mixtures of fly ash, sand, gravel, and cement are commonly used to fill abandoned room-and-pillar coal mines to prevent or abate surface subsidence due to mine void closure. However, the large volume of material required to provide support to the mine pillars, overlying strata, and surface facilities is extremely costly. Controlled placement of the material and sufficient roof contact are often difficult to achieve. To maximize control of the implaced material and improve roof contact, a method for the remote construction of cylindrical columns within the mine void has been developed.

Keyword(s): grouting, reclamation, abandoned mines, room-and-pillar, coal mining

Location(s): Ohio, United States

Michalski, S. R., L. J. Winschel, R. E. Gray. Fires in Abandoned Coal Mines. Bulletin of the Association of Engineering Geologists, November 1990, p. 479-495.

Case histories of mine fire projects in Pennsylvania's anthracite and bituminous coal fields demonstrate successful extinguishment by utilizing a combination of mitigation technologies.

Keyword(s): mine fires, abandoned mines, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Mickle, D. G., H. L. Hartman. Permeability and Compressibility Tests Aid in Selecting Suitable Hydraulic Fill Materials. Mining Engineering, v. 13, no. 11, November, 1961, p. 1246.

This article describes the procedure for determining the particle size distribution and composition necessary for maximum support of rock strata overlying mined-out areas.

Keyword(s): hydraulic backfilling, geotechnical, lab testing
Location(s): Pennsylvania, Appalachian Coal Region, United States

Mickle, D. G., Jr. The Permeability of Hydraulic Fill Materials. M.S. Thesis, Department of Mining, The Pennsylvania State University, 1961.
Keyword(s): hydraulic backfilling
Location(s): United States

Mieville, A. Ground Engineering and the Support of Unstable Ground. Civil Engineering and Public Works Review, v. 66, no. 782, September, 1971, p. 953, 956-957.
Keyword(s): engineering, ground control

Mikula, P. A., G. E. Holt. Prediction of Mine Subsidence in Eastern Australia by Mathematical Modeling. IN: Proceedings, 5th International Congress on Rock Mechanics, Melbourne, Australia, 1983, p. E119-E125.
Finite element modeling of subsidence due to coal extraction in Eastern Australia is described under certain limiting conditions. A systematic means of data acquisition and handling was developed to provide realistic input for the geotechnical model. The constant strain finite element program requires large, carefully designed meshes and empirical reduction of laboratory strength properties. Anisotropy needs to be considered for coal measures strata. The inclusion of joint elements improves subsidence simulation but is not essential for generalized prediction. Examples of successful modeling at shallow depths are discussed.
Keyword(s): prediction, mathematical model, rock mechanics, finite element, coal mining, modeling, geotechnical, computer, lab testing
Location(s): Australia

Milford, K. S. Survey Techniques for the Analysis of Movement. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 7-11.
The requirements for survey networks relating to monitoring projects are outlined. A review is given of some methods currently applied internationally. The problems of invariant quantities and biased estimates are detailed for free net adjustments and the selection of stable points from the geometric stability of the networks as characterized by angles and length ratios is discussed.
Keyword(s): survey design, survey methods, survey data processing, monitoring methods, instrumentation, modeling, empirical model, mathematical model, stochastic model, geotechnical, computer
Location(s): South Africa

Miller, C. H. Geophysical Studies to Detect the Acme Underground Coal Mine, Wyoming. U.S. Geological Survey Bulletin 1677, 1988, 27 p.
Adequate location maps are not available for some of the older underground coal mines in the Powder River Basin, Wyoming, nor for mines in other parts of the United States. These mines may subside and cause damage at the ground surface, or they may spontaneously ignite and consume coal deposits, polluting air and water. Consequently, techniques are needed for locating those potentially hazardous coal mines.
Keyword(s): geophysical, coal mining, abandoned mines, mine fires, seismic, land-use planning, subsurface water, historical, geologic features
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Miller, E. H., F. L. Pierson. Underground Movement and Subsidence over United States Potash Company Mine. SME-AIME Preprint 5819P9, 1958, 3 p.
Keyword(s): non-metal mining, subsurface subsidence damage, surface subsidence damage
Location(s): United States

Miller, H. D. S., M. A. Stoakes. Subsidence Associated with Louisiana Salt Domes. IN: Proceedings, Canada Institute of Mining Conference on Subsidence in Soft Rock Mining, Saskatoon, Saskatchewan, 1985, 20 p.
Keyword(s): non-metal mining
Location(s): Louisiana, United States

Miller, M. J., R. E. Panton, J. R. Steiding. A Comprehensive Program for Dealing with Mine Subsidence Emphasizing Local Government Options. Appalachian Regional Commission Report ARC-73-163-2559, 1976, 156 p.
This report defines and evaluates potential subsidence risk and mitigation measures within the four anthracite coalfields of northeastern Pennsylvania with an emphasis on an evaluation of surface (e.g., land use) and subsurface (subsidence potential) conditions.

Keyword(s): insurance, surface structural damage, mine design, land-use planning, law, structural mitigation, land mitigation, anthracite, coal mining, government
Location(s): Pennsylvania, Appalachian Coal Region, United States

Miller, R. E. Compaction of An Aquifer System Computed from Consolidation Tests and Decline in Artesian Head. U.S. Department Interior, Geological Survey Professional Paper 424-B, Geological Survey Research 1961, p. B54-B58.
Keyword(s): fluid extraction, hydrology
Location(s): United States

Miller, R. E. Land Subsidence in Southern California. Engineering Geology in Southern California, Association Engineering Geologists, Los Angeles Section Special Publication, Glendale, CA, 1966, p. 272-279.
Keyword(s): fluid extraction
Location(s): California, United States

Miller, R. E., J. H. Green, G. H. Davis. Geology of the Compacting Deposits in the Los Banos-Kettleman City Subsidence Area, California. U.S. Department Interior, Geological Survey Professional Paper 497-E, 1971, 46 p.
Keyword(s): fluid extraction, geologic features
Location(s): California, United States

Milliken, B. E. Coal Mine Subsidence Surveys, Illawarra Encampment, New South Wales Australia. IN: Proceedings 3rd Canadian Symposium on Mining Surveying and Rock Deformation Measurements, Sudbury, Ontario, October 10-12, 1979, Canadian Institute Surveyors, p. 87-124.
This paper details the survey work performed for a subsidence monitoring project.
Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, survey data processing, computer, coal mining
Location(s): Australia

Mills, C. E. Ground Movement and Subsidence at the United Verde Mine. Transactions, AIME, v. 109, 1934, p. 153-172; also AIME Technical Publication No. 551, 1934, 21 p.
Keyword(s): surface subsidence damage
Location(s): United States

Mindling, A. L. A Summary of Data Relating to Land Subsidence in Las Vegas Valley. University of Nevada, Desert Research Institute, Center Water Resources Research, Reno, 1971, 55 p.
Keyword(s): fluid extraction
Location(s): Nevada, United States

Mines and Minerals. Method of Supporting Mine Roofs. v. 32, 1912, p. 279-281, 402-403.
This is a discussion of the patent of William Griffith covering the method of making waste to fill in the gob by blasting down the roof and/or blasting up the floor.
Keyword(s): roof support

Mines and Minerals. Flushing or Silting of Mine Workings. v. 32, 1912, p. 321-385.
This article discusses hydraulic injection of culm in 1886 to prevent subsidence of anthracite workings under the city of Shenandoah, Pennsylvania.
Keyword(s): hydraulic backfilling, anthracite, coal mining, mine waste
Location(s): Pennsylvania, Appalachian Coal Region, United States

Ming-Gao, C. A Study of the Behaviour of Overlying Strata in Longwall Mining and its Application to Strata Control. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 13-17.
The objective of this investigation was to describe the behavior of strata above a longwall face through a study of the movement of inter-strata plugs in a longwall working area. The investigations were conducted in the Dai-Tun coal mine, Province Jiangsu, China. By analyzing the subsidence curves of the overlying strata, a structural model was constructed to examine the behavior of the strata. Some of the phenomena of ground subsidence and roof pressure in the longwall mining can be explained using this model.
Keyword(s): longwall, overburden, modeling, roof stability, multiple-seam extraction, floor stability, vertical displacement, horizontal displacement
Location(s): China

Mining Magazine. Slope Filling on Rand. v. 10, May, 1914, p. 376.
This article describes hydraulic backfilling of a gold mine in South Africa to allow pillar removal.
Keyword(s): hydraulic backfilling, metal mining, pillar extraction
Location(s): South Africa

Mishra, G., R. L. Grayson. An Engineering Analysis of "Squeeze" Failure of Pillars in the Pittsburgh Coal Bed. IN: Proceedings 1st Annual Conference on Ground Control in Mining, July 27-29, 1981, S.S. Peng, ed., West Virginia University, Morgantown, p. 144-153.

In mid-1979, J&L Steel Corporation experienced rapid failure of pillars after only 2 weeks of operation with a combination of full retreat and partial mining. This paper describes the development of the squeeze, presenting the results of analyses of the condition and illustrating its progression over time through the use of maps. A general discussion of future mining plans near the squeeze area are also analyzed.

Keyword(s): coal mining, engineering, pillar strength, ground control, mine design, partial extraction, high-extraction retreat

Location(s): Pennsylvania, Appalachian Coal Region, United States

Misich, I., A. Evans, O. Jones. Groundwater Control and Strata Investigations to Allow Total Extraction of Coal by Underground Methods in the Collie Basin (Western Australia). IN: Proceedings 4th International Mineral Water Association Congress, Ljubljana (Slovenia)-Portschach (Austria), September 1991, p. 131-147.

A research program has been undertaken to evaluate the effect of total extraction of coal by underground methods on superimposed aquifer systems in the Collie Basin sediments, Western Australia. The research program has incorporated comprehensive field monitoring of surface and subsurface subsidence and groundwater levels along with empirical modeling techniques. Results have identified that ground curvature can be used to predict--ahead of mining--the likely impact on the Permian sediments and potential water inflow into the mine. Research is continuing on development of this approach using more sophisticated modeling techniques, including displacement discontinuity boundary element mathematical models and centrifuge modeling. Early results indicate both methods have good application to the subsidence processes noted in the Collie Basin.

Keyword(s): subsurface water, hydrology, coal mining, modeling, monitoring methods, boundary element, empirical model, mathematical model, physical model, inflow

Location(s): Australia

Missavage, R. J., Y. P. Chugh, T. Roscetti. Subsidence Prediction in Shallow Room-and-Pillar Mines. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 146-150.

A mathematical model was developed using the relative flexural strength of the strata overlying a coal seam to predict the vulnerability of shallow room-and-pillar mined areas to subsidence. The model assumes the failure of the immediate roof as the precursor of a subsidence event in shallow room-and-pillar mines. After the roof fails, either a sink hole subsidence event develops if the unconsolidated material is thin and dry; or a subsidence trough forms if the unconsolidated material is thick and wet.

Keyword(s): coal mining, prediction, room-and-pillar, mathematical model, modeling, land-use planning, abandoned mines, active mines, mine design, overburden, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Missavage, R. J., Y. P. Chugh, T. Roscetti. Subsidence Prediction in Shallow Room and Pillar Mines. International Journal of Mining and Geological Engineering, v. 4, 1986, p. 39-46.

A mathematical model uses the relative flexural strength of the strata overlying a coal seam to predict the vulnerability of shallow room-and-pillar mined areas to subsidence. The model assumes the failure of the immediate roof as the precursor of a subsidence event. The developed and validated model was subjected to a blind test in a mine in the Illinois Coal Basin; the model predicted 10 out of 12 subsidence events in the blind half of the study area and two of three additional subsidence events in the known half of the study area.

Keyword(s): coal mining, room-and-pillar, prediction, modeling, mathematical model, roof stability, abandoned mines

Location(s): Illinois, Illinois Coal Basin, United States

Mitchell, S. J., J. F. T. Agapito, L. A. Weakly. Reinforcement of Large Pillars by Bolting. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 523-532.

An analysis of bolting reinforcement of several large pillars was performed. The many overcoring stress profiles in pillars at the mine were used to produce generalized stress distributions at various stages in pre- and post-failure. A complete stress-deformation curve was estimated from this data. The effect of pillar bolting on the load-deformation behavior was extrapolated from the observed unbolted behavior. Bolting can increase pillar strength by up to 10%.

Keyword(s): pillar strength, modeling, computer

Location(s): Colorado, Rocky Mountain Coal Region, United States

Mitre Corporation. Environmental Action Programs for Northeastern Pennsylvania: Refuse Bank Removal--Subsidence Monitoring. U.S. Bureau of Mines Open File Report OFR 3-73, 1972.

Refuse removal and subsidence monitoring are the two topics of discussion.

Keyword(s): instrumentation, economics, mine waste, monitoring equipment, monitoring design, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Mock, R. G., L. F. Marrs. Hazard Reduction Techniques Used for Pit Subsidence Near Hanna, Wyoming. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 223-233.

Three different backfill techniques were used to reduce immediate hazards associated with pit subsidence over shallow abandoned coal mines near Hanna, Wyoming. The three techniques included the following: granular soil backfilling, a grouted boulder wedge, and open boulder backfilling.

Keyword(s): local backfilling, grouting, abandoned mines, reclamation, historical, land mitigation, coal mining

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Mock, R. G., L. F. Marrs. Hazard Reduction Techniques Used for Pit Subsidence Near Hanna, Wyoming. IN: Proceedings 8th Annual National Abandoned Mine Lands Conference, August 10-15, 1986, Billings, MT, p. 151-160.

Three different backfill techniques were used to reduce immediate hazards associated with pit subsidence over shallow abandoned coal mines near Hanna, Wyoming.

Keyword(s): backfilling, abandoned mines, coal mining, local backfilling

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Moebs, N. N. Geologic Guidelines in Coal Mine Design. IN: Ground Control Aspects of Coal Mine Design, Proceedings, Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 63-69.

Geologic techniques have been developed by which coal mine roof competency can be evaluated in advance of mining. The data for evaluation are derived from exploratory core drilling. Isopach maps of selected beds in the immediate roof are constructed from detailed logs of the core and standard physical properties of roof rock obtained from testing core samples.

Keyword(s): mine design, coal mining, geologic features, roof stability

Location(s): United States

Moebs, N. N., E. A. Curth. Geologic and Ground-Control Aspects of an Experimental Shortwall Operation in the Upper Ohio Valley. U.S. Bureau of Mines RI 8112, 1976, 30 p.

Keyword(s): roof stability, ground control, shortwall, coal mining, geologic features

Location(s): Ohio, United States

Moebs, N. N. Roof Rock Structures and Related Roof Support Problems in the Pittsburgh Coalbed of Southwestern Pennsylvania. U.S. Bureau of Mines RI 8230, 1977, 30 p.

Keyword(s): roof support, roof stability, coal mining, geologic features

Location(s): Pennsylvania, Appalachian Coal Region, United States

Moebs, N. N. Subsidence Over Four Room-and-Pillar Sections in Southwestern Pennsylvania. U.S. Bureau of Mines RI 8645, 1982, 23 p.

Keyword(s): room-and-pillar, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Moebs, N. N. Subsidence Over Four Room and Pillar Sections in Southwestern Pennsylvania. U.S. Bureau of Mines, Pittsburgh Mining Technology Center, 1984.

Keyword(s): room-and-pillar, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Moebs, N. N., R. M. Stateham. Geologic Factors in Coal Mine Roof Stability--A Progress Report. U.S. Bureau of Mines IC 8976, 1984, 27 p.
Keyword(s): roof stability, geologic features, coal mining
Location(s): United States

Moebs, N. N., T. M. Barton. Short-Term Effects of Longwall Mining on Shallow Water Sources. IN: Mine Subsidence Control, Proceedings Bureau of Mines Technology Transfer Seminar, Pittsburgh, September 19, 1985, U.S. Bureau of Mines IC 9042, p. 13-24.
The USBM monitored surface subsidence, water table levels, and stream flow above a longwall panel in southwestern Pennsylvania for about 6 months prior to mining and 12 months afterward. Only water levels within the boundary of the longwall showed a precipitous decline as a result of mining.
Keyword(s): longwall, hydrology, subsurface water, room-and-pillar, environment, surface water, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Moebs, N. N., R. M. Stateham. The Diagnosis and Reduction of Mine Roof Failure. Coal Mining, v. 22, 1985, pt. 1, no. 2, 1985, p. 52-55; pt. 2, no. 3, 1985, p. 42-48.
Keyword(s): roof stability, coal mining

Moebs, N. N., R. M. Stateham. Coal Mine Roof Instability: Categories and Causes. U.S. Bureau of Mines IC 9076, 1986, 15 p.
Coal mine roof failure is categorized according to character, trend, or pattern of occurrence. Two principal categories of failure are proposed: geology related and stress related. Each of several subcategories reflects the probable cause of failure and thereby provides a basis for the selection of appropriate techniques for reducing the incidence of failure.
Keyword(s): roof stability, mine safety, ground control, overburden, roof support, coal mining, geologic features
Location(s): United States

Moebs, N. N., G. P. Sames. Geotechnical Aspects of Roof and Pillar Stability in a Georgia Talc Mine. U.S. Bureau of Mines RI 9404, 1992, 29 p.
This report summarizes a study on the application of geotechnology to identify and minimize ground control hazards in talc mining operations in northwestern Georgia. The major ground control hazard is pillar sloughing attributed to the steeply dipping orientation of a pronounced foliation in the talc ore body. A boundary element model confirmed the advantages of using a uniform pillar design to avoid excessive loads on portions of irregular pillars.
Keyword(s): geotechnical, non-metal mining, ground control, pillar strength, boundary element, modeling, instrumentation, roof stability, mine safety, rock mechanics, in situ testing
Location(s): Georgia, United States

Mohr, F. Observations in Shafts on Rock Movements Due to Mining. IN: Proceedings, International Strata Control Congress, Leipzig, October 14-16, 1958, p. 112-123 and IL-LVIII.
Rock movements at the surface above a mining area are of great interest in connection with the costly alterations to buildings and the drainage in the upper formations caused by such rock movements. The behaviour of the rock in the direct vicinity of the mining cavity has been frequently the subject of recent rock mechanics research. It is true that the movements occurring between these two zones have often been observed in horizontal cavities, for example, roadways.
Keyword(s): overburden, surface subsidence damage, rock mechanics
Location(s): Germany

Mohr, H. F. Influence of Mining on Strata. Mine and Quarry Engineering, April, 1956, v. 22, no. 4, 1956, p. 140-152.
This paper discusses the effects of mining on the rock strata between the surface and the extraction zone. Particular reference is made to influences on vertical shafts.
Keyword(s): overburden, subsurface subsidence damage

Molinda, G. M., K. A. Heasley, D. C. Oyler, J. R. Jones. Effects of Horizontal Stress Related to Stream Valleys on the Stability of Coal Mine Openings. U.S. Bureau of Mines RI 9413, 1992, 26 p.
This investigation was conducted to determine the nature and frequency of coal mine roof failure beneath valleys. A mechanism for this failure and suggestions for controlling this problem are presented. Hazardous roof conditions identified in some mines were positively correlated with mining activities beneath stream valleys. Mine maps with overlays of unstable roof and locations of stream

valleys show that 52% of the instances of unstable roof in the surveyed mines occurred directly beneath the bottom-most part of the valley. The survey also showed that broad, flat-bottomed valleys were more likely to be sites of hazardous roof than narrow-bottomed valleys.

Keyword(s): roof stability, geologic features, coal mining, modeling

Location(s): Pennsylvania, West Virginia, Appalachian Coal Region, United States

Montz, H. W. Subsidence from Anthracite Mining. Transactions, AIME, v. 88, 1930, p. 98-134.

The author discusses three case studies involving pillar extraction.

Keyword(s): anthracite, coal mining, pillar extraction, surface structural damage

Location(s): United States

Monz, H. W. A Study of Surface Subsidence Accompanying Mining Operations in the Northern Anthracite Mining Fields of Pennsylvania. Thesis, The Pennsylvania State University, 1933.

Keyword(s): surface subsidence damage, anthracite, coal mining, active mines

Pennsylvania, Appalachian Coal Region, United States

Moore, R. C., M. A. Nawrocki. Effects of Subsidence from Thick Seam Coal Mining on Hydrology. Contract JO295012, Hittman Associates, Inc. U.S. Bureau of Mines OFR 93-80, 1980, 245 p. (NTIS PB 80-219280)

The USBM contracted a study to estimate what effects the underground mining of thick coal seams in the western United States would have on surrounding water resources. Potential coal fields where this type of mining might occur were identified. The international literature was searched for studies of effects on hydrology from thick seam underground coal mining. Estimates of the effects of this type of mining on the ground and surface water in the western states were made based on the limited information obtained from the foreign literature. No field work was performed.

Keyword(s): vertical displacement, horizontal displacement, surface water, subsurface water, hydrology, longwall, coal mining, literature search

Location(s): Montana, Wyoming, Colorado, New Mexico, Idaho, Utah, Arizona, Rocky Mountain Coal Region, United States

Morgan, R. C. Causes of Subsidences and the Best Safeguards for Their Protection. Colliery Guardian, v. 121, 1921, p. 795-797, 868, 869.

Keyword(s): backfilling, pillar strength

Location(s): Germany, England

Morgan, T. A. Coal Mine Roof Problems. IN: Ground Control Aspects of Coal Mine Design, Proceedings, Bureau of Mines Technology Transfer Seminar, Lexington, KY, March, 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 56-62.

The factors that contribute to coal mine roof problems are so numerous and work in so many combinations that the greatest difficulty in solving these problems lies in identifying the chief cause of the problem. The staffs of coal mining companies can often identify the cause without the help of ground control specialists by using practical and inexpensive monitoring devices in their mines. These measurements may lead directly to a solution or may show the problem to be similar to the problem in another mine for which a solution has already been found.

Keyword(s): roof stability, roof support, mine design, ground control, coal mining, geologic features

Location(s): United States

Morgan, T. A., J. C. Still. The Effect of Mining and Subsidence Rates on Transfer of Overburden Weight. IN: Ground Control Aspects of Coal Mine Design, Proceedings, Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 35-43.

This paper suggests a relationship between the rate of subsidence and the dynamic transfer of weight within low dip, bedded deposit mines. This information can be useful in the design of mine layouts and extraction sequences.

Keyword(s): mine design, overburden, ground control, active mines

Location(s): United States

Morgando, F. P. Engineering Geological Investigation of a Subsided Area, "D" Street--Connecticut Avenue, Rock Springs, Wyoming. Wyoming Highway Department Project ARS 1435, March 28, 1969, 7 p. (Available for consultation at the USBM Denver Research Center.)

Keyword(s): backfilling, surface structural damage

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Morgando, F. P. Rock Springs Backfill Project, Rock Springs, Wyoming. Wyoming Highway Department Project ARS 1523, January 21, 1971, 2 p. (Available for consultation at the USBM Denver Research Center.)
Keyword(s): backfilling, surface structural damage, abandoned mines
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Morgando, F. P. Surface Subsidence Due to Coal Mining, Rock Springs, Wyoming. IN: Proceedings, 9th Engineering Geology and Soils Engineering Symposium, Idaho Department of Highways, Boise, 1971, p. 189. (NTIS Accession No. 72-00498)
Keyword(s): coal mining, abandoned mines
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Morita, N., D. L. Whitfill, O. Nygaard, A. Bale. A Quick Method to Determine Subsidence, Reservoir Compaction, and In Situ Stress Induced by Reservoir Depletion. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 5-6.
This paper provides a quick method to determine subsidence, compaction, and in situ stress conditions resulting from pore pressure changes. The method is useful for formations showing large Young's modulus contrasts compared to the surrounding rocks.
Keyword(s): rock mechanics, fluid extraction, oil extraction

Morrison, C. S., D. V. Holmquist. Analysis of Subsidence Potential Using Complimentary Influence Functions. IN: Proceedings Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 299-305.
Complimentary influence functions analysis was used to predict potential subsidence and the effect of subsidence abatement procedures for undermined parts of Rock Springs, Wyoming. This analysis technique was chosen because it is easily applied to complex room-and-pillar mine geometries.
Keyword(s): influence function, prediction, room-and-pillar, computer, National Coal Board, backfilling, surface structural damage
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Morrison, W. C. Stabilization of a Deep, Submerged and Abandoned Mine. Presented at Annual Meeting, Association of Engineering Geologists, September 11, 1987, 24 p.
In 1980, a mine subsidence event, which affected homes, shopping centers, churches, and service stations, was reported in the CIty of Graysville, Alabama. Beneath the affected subsidence area are two abandoned coal mines. The USBM investigated the severity and extent of this event and made appropriate recommendations for stabilization.
Keyword(s): abandoned mines, coal mining, surface structural damage, utilities, foundations, roads, subsurface water, grouting, overburden
Location(s): Alabama, United States

Morrison, W. C. Grouting in Deep Flooded Mines. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October 1987, p. 127 (abstract only).
Grouting in the Mary Lee coalbed in Graysville, Alabama created difficulties regarding the development of massive grout columns in a flooded mine situated approximately 700 feet below the ground surface. Several difficulties had to be overcome to inject the grout into the mine.
Keyword(s): grouting, abandoned mines
Location(s): Alabama, United States

Morse, C. F. R. Some Mining Problems Encountered During the Construction of a Section of the M6 Motorway Adjacent to Walsall in Staffordshire. The Chartered Surveyor, 100, 1967, p. 236-243.
Keyword(s): roads
Location(s): United Kingdom

Mort, T., P. G. D. Pretorius. Extraction of No. 6 Shaft Pillar Area, Durban, Roodepoort Deep, Ltd. Association Mine Managers Transvaal, Papers and Discussions, 1946/47, p. 67-109.
Keyword(s): room-and-pillar, pillar extraction
Location(s): South Africa

Morton, D. M. Surface Deformation in Part of the San Jacinto Valley, Southern California. U.S. Department of the Interior, Geological Survey Journal of Research, v. 5, 1977, p. 117-124.
Keyword(s): fluid extraction
Location(s): California, United States

Moscnyi, E. Influence of Ground Subsidence Due to Mining on River Regime and Scale Model Experiments. IN: Proceedings, International Symposium of Fossil Fuel Production and Water Resources, Paper 18, 1976.

Keyword(s): surface water, surface subsidence damage, modeling

Mozumdar, B. K. A Mathematical Model of Ground Movement Due to Underground Mining. Ph.D. Thesis, The Pennsylvania State University, State College, 1974, 130 p.

Keyword(s): modeling, mathematical model

Mozumdar, B. K., C. B. Manula. Prediction of Ground Movement Due to An Advance Face. IN: Proceedings, 14th Symposium on Application of Computer Methods in the Mineral Industry, Pennsylvania State University, October 4-8, 1976, R.V. Ramani, ed., SME-AIME, New York, NY, 1977, p. 494-504.

Keyword(s): prediction, computer

Location(s): United States

Mraz, D. Z., D. Gendzwill. Evaluation of Subsidence Over a Deep Saskatchewan Potash Mine. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 91-103.

Subsidence profiles over Saskatchewan potash mines exhibit forms that cannot be explained by existing subsidence models. The subsidence is affected by bridging of competent rocks. A modification of the theory can explain the observed displacement of subsidence profiles due to bridging. An unusual shallow secondary subsidence trough has been observed extending 2 to 3 kilometers outside the primary subsidence. The secondary subsidence is explained as an elastic compression in response to a drop in pore water pressure in the vicinity of the caving zone. The concept of pore water pressure may lead to a safe extraction limit for Saskatchewan mines.

Keyword(s): non-metal mining, modeling, empirical model, profile function, influence function, prediction, rock mechanics, geologic features, overburden

Location(s): Canada

Mraz, D. Z., R. S. Jones. A Case History of Convergence and Subsidence Over a Deep Saskatchewan Potash Mine. IN: Mine Subsidence, Society of Mining Engineers Fall meeting, St. Louis, MO, September, 1986, M.M. Singh, ed. SME, Littleton, CO, p. 117-127.

Unlike in coal mines where caving methods are used, the subsidence over potash mines in Saskatchewan, Canada, is a function of gradual mining convergence. Because of the presence of high pressure water aquifers over the evaporite salt formations, the mines have to be designed as regionally stable and no caving is allowed. The extracted area converges gradually and the convergence is mainly a function of the extraction and mining method employed. Consequently, the subsidence rate is very slow and the bridging of the overlying strata is a considerably more important phenomenon than elsewhere. The paper evaluates a case history of convergence and subsidence in a deep potash mine in Saskatchewan.

Keyword(s): non-metal mining, subsurface water, overburden, geologic features, survey methods, survey data processing, angle of draw

Location(s): Canada

Mroz, Z., P. Nawrocki. Deformation and Stability of an Elasto-Plastic Softening Pillar. Rock Mechanics and Rock Engineering, v. 22, no. 2, April-June, 1989, p. 69-108.

A model of rock pillar or coal seam is considered assuming linear elastic behaviour before reaching the maximum strength and post-peak behaviour characterized by the residual strength. Deformation and stress across pillar height are assumed to be uniform. The interaction with overlying rock strata is treated assuming a beam model of the strata. The elasto-plastic stress distribution within the pillar and the onset of instability occurring for the critical opening span are determined. Comparison with a solution for a simplified "spring" model of a pillar is also presented.

Keyword(s): pillar strength, modeling, coal mining

Mrugala, M. J., R. M. Belesky. Pillar Sizing. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, A.W. Khair, ed., 1989, Balkema, Rotterdam, p. 395-402.

Coal strength, based on scaled uniaxial compressive strength from the laboratory and back-calculations from in-mine observations of pillar stability, indicates that material strength scaling rules are open to debate. Analyses presented indicate that the application of scaling factors lower than 0.5 provide a better correlation with field observations of pillar stability.

Keyword(s): coal mining, pillar strength, lab testing, rock mechanics, mine design, room-and-pillar, pillar extraction
Location(s): Pennsylvania, Appalachian Coal Region, United States

Mrugala, M. J., W. Bishop. Performance of a Two-Cavern Storage System Using Finite Element Method. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium,1989, A.W. Khair, ed., Balkema, Rotterdam, p. 689-696.
Finite element method was employed to assess the performance of a two-cavern system over a 20-year period of operation. Of primary importance was evaluation of the stability of the pillar separating the two caverns. Results of these analyses are discussed along with practical implications relevant to cavern operation.
Keyword(s): finite element, pillar strength, non-metal mining, modeling, computer
Location(s): United States

Mueller, W. Die Berechnung Der Bewegungen Und Spannungen Des Gebirges Vom Abbau Bis Zur Tagesoberflaeche Nach Der Methode Der Endlichen Elemente (Calculation of Displacements and Stress in Rock Strata Between the Mining Exploitation and the Surface by Means of Finite Element Method). Glueckauf-Forschungshefte, v. 34, no. 6, December 1973, p. 228-236.
Keyword(s): finite element, modeling, overburden

Muller, R. A., A. I. Juskin, J. I. Karavaev (eds.) Manual to Calculation of Buildings and Constructions Designed on Mining Areas. Publication of Construction Literature, Leningrad, U.S.S.R., 1968, 278 p. (in Russian).
Keyword(s): architecture, construction, surface structural damage

Munson, D. E., S. E. Benzley. Analytical Subsidence Model Using Void-Volume Distribution Functions. IN: Rock Mechanics: A State of the Art, Proceedings 21st U.S. Symposium on Rock Mechanics, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 299-307.
This paper presents an analytic theory of subsidence that acts as a framework describing both the time-dependent and time-independent aspects of the subsidence process. Also included is a description of the numerical tests performed on this proposed model using a finite element computer program.
Keyword(s): vertical displacement, horizontal displacement, computer, rock mechanics, time factor, finite element, modeling
Location(s): United States

Munson, D. E., W. F. Eichfeld. Evaluation of European Empirical Methods for Subsidence in U.S. Coal Fields. U.S. Department Energy contract SAND 80-0537, Sandia National Laboratory, 1980, 27 p. (NTIS SAND-79-2355 C)
This report analyzes the applicability of European subsidence prediction methods (including graphical methods, profile functions, and influence functions) for U.S. longwall mining conditions where the subsidence process has been documented.
Keyword(s): vertical displacement, horizontal displacement, prediction theories, longwall, profile function, influence function, coal mining, empirical model
Location(s): Europe, United States

Munson, D. E., W. F. Eichfeld. European Empirical Methods Applied to Subsidence in U.S. Coal Fields. SAND80-1920, Sandia National Laboratories, Albuquerque, NM, October, 1980, 20 p.
Keyword(s): prediction theories, coal mining, empirical model
Location(s): United States, Europe

Munson, D. E., H. J. Sutherland. Empirical and Analytic Approaches to Subsidence Prediction. IN: Proceedings, Conference on Ground Control in Room-and-Pillar Mining, Southern Illinois University, Carbondale, August 6-8, 1980, Y. P. Chugh, ed., SME-AIME, New York, 1982, p. 139-149.
Empirical methods for describing the shape of the subsidence trough over coal mines in Europe are tested against field measurements of subsidence over longwall panels in the United States. The graphical methods developed by the National Coal Board in the United Kingdom do not correlate well with measurements from the United States; however, the profile functions typically used on in Europe give quite acceptable fits to the data.
Keyword(s): prediction, modeling, ground control, empirical model, room-and-pillar, profile function, coal mining, National Coal Board
Location(s): Illinois, New Mexico, United States, Europe, United Kingdom

Munson, R. D. Subsidence Monitoring Using Seismic Activity. U.S. Bureau of Mines Denver Research Center, Mining Research Contract Final Report J5160064 to Office of Surface Mining, November, 1987, 69 p. (NTIS PB90-162496)

The occurrence of seismic events caused by developing zones of subsurface subsidence was monitored using a near-surface geophone array. The active subsidence site was located in a residential area of northeast Colorado Springs, Colorado. Although a considerable number of events were observed during the 10-month monitoring interval, the source of only a few could be located. Despite the problems inherent of subsidence sites, results indicate that this geophysical method has the potential to detect activity that is indicative of initial subsurface subsidence (i.e., failure of the abandoned mine roof).

Keyword(s): geophysical, abandoned mines, coal mining, roof stability, seismic, ground control

Location(s): Colorado, Rocky Mountain Coal Region, United States

Murphy, E. M., M. O. Magnuson, P. Sader Jr., J. Nagy. Use of Fly Ash for Remote Filling of Underground Cavities and Passageways. U.S. Bureau of Mines RI 7214, 1968, 27 p.

Extensive tests of materials, methods, and possible problems were made at the Bruceton Experimental Mine, an operating mine, and an abandoned mine.

Keyword(s): backfilling, abandoned mines, active mines

Location(s): United States

Murphy, E. W., R. E. Yarbrough, S. C. Bradford. A Review of Claims Data--Illinois Mine Subsidence Insurance Fund, October 1979 to October 1985. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 13-18.

This paper presents subsidence insurance claims and structural monitoring data; it describes changes that have occurred in the Illinois Insurance Code during the first 6 years the Illinois Mine Subsidence Insurance Fund has been in existence.

Keyword(s): surface structural damage, insurance, coal mining, historical, abandoned mines, monitoring methods, monitoring equipment

Location(s): Illinois, Illinois Coal Basin, United States

Murphy, E. W., R. E. Yarbrough. Reconstruction of Homes Damaged by Coal Mine Subsidence -- Progress Report. IN: Proceedings, 2nd International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1988, p. 185-190.

Keyword(s): coal mining, abandoned mines, foundations, structural mitigation, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Murray, M. J. Baillieston Interchange Bridges (with Particular Reference to the Design for Mining Subsidence). IN: Mineworkings 84: Proceedings International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1984, M.C. Forde, B.H.V. Topping, and H.W. Whittington, eds., Engineering Technics Press, p. 151-161.

Keyword(s): engineering, roads

Murria, J. Subsidence in Western Venezuela Oil Fields Monitoring and Prediction. IN: Proceedings VIII Congress International Society for Mine Surveying, September 22-27, 1991, University of Kentucky, Lexington, UKY BU154, p. 439-443.

The paper presents a brief historical summary of oil production and subsidence monitoring in western Venezuela, followed by a general review of the latest developments in subsidence monitoring, and a brief description of four subsidence models developed.

Keyword(s): oil extraction, monitoring methods, survey methods, modeling, prediction, geologic features, vertical displacement, empirical model, fluid extraction, finite element

Location(s): Venezuela

Musulin, M. Making a Case for Longwalls. Coal, August, 1989, p. 52-54.

The coal industry is at a critical juncture in regard to longwall mining. The public's acceptance and tolerance of longwall mining will determine the ultimate success or failure of this mining method. In order to be successful, the industry must educate the public prior to any longwall mining. The industry must make its case logically and with all the communication skills it can muster. At the same time, the industry must be sincere in what it says. The cardinal rule for success is communication.

Keyword(s): longwall, coal mining, land-use planning, active mines

Location(s): Kentucky, West Virginia, Ohio, United States

Myers, A. R., J. B. Hansen, R. A. Lindvall, J. B. Ivey, J. L. Hynes. Coal Mine Subsidence and Land Use in the Boulder-Weld Coalfield, Colorado. Grant GO244001, Colorado Geological Survey, U.S. Bureau of Mines OFR 64-77, 1975, 92 p.

Keyword(s): land-use planning, coal mining, abandoned mines

Location(s): Colorado, Rocky Mountain Coal Region, United States

Myers, K. L., C. C. Rehn. Multi-Phased Subsidence Study and Use of Progressive Failure Model for Subsidence Prediction Above Room and Pillar Mines. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 143-167.

This paper describes a study performed for a site in Colorado Springs, Colorado. The site is located above abandoned room-and-pillar coal mines last worked in the 1920s and 1940s. The three phases of the study involved a review of published data on the mines, a limited subsurface investigation, and a very detailed evaluation of the eastern portion of the site, resulting in a prediction of final subsidence profile and ground strains.

Keyword(s): abandoned mines, room-and-pillar, prediction, modeling, pillar strength, roof stability, floor stability, overburden, subsurface water, land-use planning, structural mitigation, hydraulic backfilling, grouting, utilities, literature search, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, United States

Nair, O. B. Roof and Floor Bearing Capacity Tests. IN: Proceedings, Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, Ground Control Aspects of Coal Mine Design, U.S. Bureau of Mines IC 8630, 1974, p. 114-120.

One of the factors causing problems in longwall operations is when the size of the supports is such that the bearing pressures exerted cause failure of the floor or roof. RI 7406 describes the development and test results of a simple, inexpensive, and effective method of testing the bearing capacity of mine roof and floor. The equipment and testing procedure is described and the results of tests in nine mines in the United States are discussed. The test may be used to determine the allowable bearing pressures that can be exerted on mine roof/floor by longwall support equipment.

Keyword(s): roof stability, floor stability, in situ testing, longwall, roof support, coal mining, active mines, bituminous

Location(s): United States

Najjar, Y., M. Zaman, J. Ahern. Prediction of Surface Subsidence Caused by Underground Mining Using a Nonlinear Finite Element Procedure. IN: Proceedings 3rd International Symposium on Numerical Models in Geomechanics, Niagara Falls, May 8-11, 1989, Elsevier, p. 557-565.

Subsidence and collapse due to underground mining are examined using nonlinear finite element analysis. An elastoplastic constitutive model represents the nonlinearity of the rock strata and an accurate algorithm simulates the extraction. The analysis is applied to the Blue Goose Lease in northern Oklahoma. Stress distribution before and after extraction is examined. The effect of dumping mine waste on the surface above the workings is also studied.

Keyword(s): finite element, modeling, elastic model, mine waste

Location(s): Oklahoma, United States

Narasimham, T. N., P. A. Witherspoon. Numerical Model for Land Subsidence in Shallow Groundwater Systems. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 133-143.

Keyword(s): modeling, subsurface water, hydrology

Narasimhan, T. N., K. P. Goyal. Subsidence Due to Geothermal Fluid Withdrawal. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, The Geological Society of America, T.L. Holzer, ed., 1984, p. 35-66.

Single-phase and two-phase geothermal reservoirs are currently being exploited for power production in Italy, Mexico, New Zealand, the United States, and elsewhere. Vertical ground displacements have been observed in California as well as in New Zealand (where horizontal displacements were also measured). No significant ground displacements attributable to large-scale fluid production have been observed in Italy or Mexico. Observations show that subsidence due to geothermal fluid production is characterized by an offset of the subsidence bowl from the main area of production, time-lag between production and subsidence, and nonlinear stress-strain relationships. Several plausible conceptual models have been proposed to explain the observed features.

Keyword(s): fluid extraction, vertical displacement, horizontal displacement, modeling

Location(s): Italy, Mexico, New Zealand, United States

National Academy of Sciences, National Research Council, Commission on Engineering and Technical Systems, Division of Natural Hazard Mitigation, Committee on Ground Failure Hazards Mitigation Research, Panel on Land Subsidence. Mitigating Losses from Land Subsidence in the United States. National Academy Press, 1991, Washington, D.C., 58 p.

More than 44,000 square kilometers of land in 45 states have been lowered by underground coal mining, groundwater withdrawal, and the drainage of organic soils. With annual costs exceeding $125 million because of the resultant structural damage and flooding, awareness and reduction of the subsidence hazard is an increasing concern in at-risk regions. This report reviews the land subsidence problem in the United States and assesses the effectiveness of current research, as well as the engineering, technical, and nonstructural solutions that have been utilized to reduce losses. Land use management, mandatory insurance, and construction codes are among the measures discussed.

Keyword(s): mitigation, coal mining, fluid extraction, land mitigation, oil extraction, soils, surface structural damage, structural mitigation, land-use planning, abandoned mines, active mines, longwall, partial extraction, economics, insurance, prediction

Location(s): United States

National Building Studies. Mining Subsidence Effects on Small Houses. Special Report No. 12, London, 1951, p. 24.
Keyword(s): surface structural damage, construction
Location(s): England

National Building Studies. Simplified Tables of External Loads on Buried Pipelines. Ministry of Works, no. 32, London, 1962.
Keyword(s): utilities, pipelines, subsurface structural damage
Location(s): England

National Coal Board. Investigation of Mining Subsidence Phenomena. Information Bulletin 52/78, 1952, 25 p.
The mechanics of surveying subsidence effects as observed at the ground surface are described.
Keyword(s): survey methods, National Coal Board, coal mining
Location(s): England

National Coal Board. Partial Extraction as a Means of Reducing Subsidence Damage. Information Bulletin 61/231, 1961, 16 p.
This bulletin is a factual record of experience in partial extraction and is intended to acquaint management with the technique and to serve as a reference for specialists. No attempt is made to discuss the theory of ground movement or to explain the phenomena recorded.
Keyword(s): partial extraction, ground control, National Coal Board, coal mining, active mines
Location(s): England

National Coal Board. Principles of Subsidence Engineering. Information Bulletin 63/240, 1963, 27 p.
Keyword(s): horizontal displacement, ground control, backfilling, descriptive theories, coal mining, National Coal Board
Location(s): England

National Coal Board. Design of Mine Layout, with Reference to Geological and Geometrical Factors. Mining Department of Working Party Report, 1972, 52 p.
Keyword(s): mine design, longwall, ground control, prediction, monitoring methods, geologic features, coal mining, National Coal Board
Location(s): England

National Coal Board. The Treatment of Disused Mine Shafts and Adits. National Coal Board, Mining Department, 1982.
Keyword(s): National Coal Board, abandoned mines, reclamation, coal mining
Location(s): England

National Coal Board, Divisional Strata Control Research Committee, Durham and Northern (N and C) Divisions. Memorandum on the Design of Mine Workings to Secure Effective Strata Control. Transactions Institution of Mining Engineers, v. 110, 1950-51, p. 252-271 and 273-278.
Keyword(s): ground control, mine design, coal mining, National Coal Board
Location(s): England

National Coal Board, Divisional Strata Control Research Committee, Durham and Northern (N and C) Divisions. Report on the Effects of Workings in Adjacent Seams Upon New Developments. Transactions Institution of Mining Engineers, v. 113, 1953-54, p. 389-403.
Keyword(s): multiple seam extraction, ground control, active mines, National Coal Board, coal mining
Location(s): England

National Coal Board, Mining Research Establishment. Strata Control on Longwall Faces. Bulletin 10, 1965, 11 p.
Keyword(s): coal mining, National Coal Board, active mines, longwall
Location(s): England

National Coal Board, Production Department. Subsidence Engineers' Handbook. 1966, 118 p.
This handbook presents a systematic discussion of subsidence and subsidence parameters derived from empirical data. It includes a scheme for using these parameters for subsidence prediction in Great Britain.
Keyword(s): engineering, prediction, time factor, survey methods, ground control, National Coal Board, coal mining
Location(s): England

National Coal Board, Production Department. Subsidence Engineers' Handbook. 1975, 111 p.
Various aspects of subsidence engineering are detailed, including prediction methods, subsidence mechanics, and structural precautions against subsidence damage.

Keyword(s): prediction, surface structural damage, horizontal displacement, structural mitigation, land mitigation, engineering, vertical displacement, subsurface structural damage, surface water, ground control, descriptive theories, angle of draw, longwall, time factor, National Coal Board, coal mining

Location(s): England

National Coal Board, Regional Subsidence Engineering Services. Subsidence Engineers' Report on Eastwood Hall. Nottingham, England, 1970.

Keyword(s): National Coal Board, coal mining, surface structural damage

Location(s): England

National Coal Board, Regional Subsidence Engineering Services. Subsidence Engineers' Report on Ransom Hospital. Nottingham, England, 1970.

Keyword(s): National Coal Board, coal mining, surface structural damage

Location(s): England

National Coal Board, Regional Subsidence Engineering Services. Subsidence Engineers' Report on the Vedonis Knitwear Factory at Watnall Road, Hucknall. Nottingham, England, 1972.

Keyword(s): surface structural damage, National Coal Board, coal mining

Location(s): England

National Research Council. Coal Mining and Ground-Water Resources in the United States. National Academy Press, Washington, D.C., 1981, 193 p.

This report examines the expansion and geographical redirection of coal mining now occurring in the United States, its effects on ground water, and the environmental and socioeconomic impacts of those effects. The term "effect" is used in reference to the changes in groundwater resources that result directly from a mining activity. The term "impact" refers to the ensuing environmental and socioeconomic consequences of the groundwater changes. Coal mining is examined as one of many competing uses for the nations's groundwater resources. The report addresses groundwater use, groundwater supplies and availability, principles that govern the functioning of hydrogeologic systems, and the institutional framework for groundwater allocation.

Keyword(s): coal mining, subsurface water, hydrology, environment, active mines, abandoned mines, inflow

Location(s): United States

Nawar, G. Quality Assurance for Buildings in Ground Movement Areas. IN: Proceedings, International Association of Bridge and Structural Engineers, Symposium on Safety and Quality Assurance of Civil Engineering Structures, Tokyo, 1986, p. 197-205.

Identification and quantification of the risk of damage to surface structures in areas liable to mining subsidence are studied. Risk is quantified with a probabilistic component, which is related to previous mining practice, and a deterministic component, which considers the relation between subsidence and consequent damage. Acceptable risk, risk management, and risk reduction to achieve an acceptable level of performance are considered.

Keyword(s): surface structural damage, coal mining, non-metal mining, multiple-seam extraction, foundations, construction

Location(s): Australia

Nawrot, J. R., R. J. Haynes, P. L. Pursell, J. R. D'Antuono, R. L. Sullivan, W. D. Klimstra. Illinois Lands Affected by Underground Mining for Coal. Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, 1977.

This report includes a county-by-county inventory of abandoned underground mine sites in Illinois and an assessment of environmental problems associated with each. Mine locations are shown in the appendices.

Keyword(s): abandoned mines, environment, reclamation, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Neate, C. J., B. N. Whittaker. Influence of Proximity of Longwall Mining on Strata Permeability and Ground Water. IN: Proceedings, 20th U.S. Symposium on Rock Mechanics, Austin, TX, June 4-6, 1979, University of Texas, p. 217-224.

Mining subsidence arising from longwall extractions produces appreciable ground strain in the overlying strata. The ground strains caused by mining produce changes in in situ permeability that are of special importance when working under aquifers and surface bodies of water. The paper describes the design and installation of test equipment to investigate changes in in situ permeability and groundwater conditions. Results are presented and discussed on the changes produced by the approach of a longwall coalface.

Keyword(s): longwall, subsurface water, surface water, hydrology, rock mechanics, coal mining, instrumentation, geologic features,

monitoring equipment, monitoring design, monitoring methods, inflow
Location(s): United Kingdom

Neighbors, R. J., R. E. Thompson. Subsidence in the Houston-Galveston Area of Texas. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication No. 151, 1986, p. 785-793.

The withdrawal of large quantities of groundwater in the Houston-Galveston area of Texas has resulted in declines in excess of 75 meters in the potentiometric surface in the Chicot aquifer and 100 meters in the Evangeline aquifer from 1943 to 1977. These declines have caused subsidence in excess of 3.0 meters to occur in the area.

Keyword(s): fluid extraction, hydrology
Location(s): Texas, United States

Nelson, A. Mining Subsidence and Surface Damage. Iron and Coal Trades Review, v. 154, March 28, 1947, p. 517-519.

Keyword(s): coal mining, surface subsidence damage

Nelson, A. Floor Movements and Their Control. Iron and Coal Trades Review, v. 154, no. 4136, 1947, p. 1211-1214.

Keyword(s): floor stability, coal mining

Nelson, A. Ground Movements due to Mining. Canadian Mining Journal, v. 85, no. 6, June, 1964, p. 69-73.

This paper discusses factors affecting subsidence such as mining methods, type of overburden, and the influence of faults. Damage to surface structures is described, and foundation construction to limit subsidence damage is briefly covered.

Keyword(s): surface subsidence damage, overburden, surface structural damage, foundations, geologic features
Location(s): Canada

Nelson, W., K. C. Fahrni. Caving and Subsidence at the Copper Mountain Mine. Canadian Institute of Mining and Metallurgy Transactions Bulletin, v. 43, 1950, p. 2-10.

Keyword(s): metal mining
Location(s): Canada

Neubert, K. The Effects of Disturbance of the Equilibrium of the Rock Mass Occasioned by Mining in the Saxony Coalfield. IN: Proceedings, European Congress on Ground Movements, Leeds, England, April 9-12, 1957, London Harrison, p. 167-175.

Keyword(s): overburden, surface subsidence damage, coal mining
Location(s): England

New South Wales Coal Association. Mine Subsidence: A Community Information Booklet. Jointly published by New South Wales Coal Association, Department of Minerals and Energy, and the Mine Subsidence Board of Australia, September 1989, 32 p.

Preparation of this booklet was undertaken to increase community awareness and discussion concerning underground mining and surface subsidence, thereby allowing better informed decisions concerning the management of valuable coal resources and the land surface above them.

Keyword(s): coal mining, vertical displacement, horizontal displacement, land-use planning, surface structural damage, longwall, room-and-pillar, shortwall, overburden
Location(s): Australia

Newhall, F. W., L. N. Plein. Subsidence at Merrittstown Air Shaft Near Brownsville, Pennsylvania. Transactions, AIME, v. 119, 1936, p. 58-94.

Effects of subsidence on a concrete-lined air shaft were monitored by surface survey. The factors of geologic conditions, mining methods, and survey techniques are discussed.

Keyword(s): subsurface subsidence damage, subsurface structural damage, survey methods, geologic features
Location(s): Pennsylvania, Appalachian Coal Region, United States

Newman, D. A. Coal Mine Ground Control: The Effect of Geology. American Association of Petroleum Geologists Bulletin, v. 67, no. 9, 1983.

Keyword(s): ground control, coal mining, geologic features
Location(s): United States

Newman, D. A. A Modified Version of the Geomechanics Classification for Use in Underground Coal Mines. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 64-71.

The Geomechanics Classification (Bieniawski 1979) was modified for use in underground room-and-pillar coal mines through the introduction of adjustment multipliers for strata weatherability, high horizontal stresses, and the roof support reinforcement factor. Sixty-two case histories of standing and fallen mine roof were collected from two mines. Each case history consisted of thirty-two engineering and geological parameters. Partial correlation analysis was conducted on the cases to determine which parameters have a significant impact upon the supported stand-up time of coal mine roof.

Keyword(s): ground control, coal mining, room-and-pillar, mine safety, prediction, geologic features

Location(s): Appalachian Coal Region, United States

Newman, D. A. Automated Data Acquisition System for Remote Monitoring of Pillar and Roof Deformation on a Longwall Panel. SME Preprint 88-64, for presentation at the SME Annual Meeting, Phoenix, AZ, January 25-28, 1988, 5 p.

The purpose of this research is to examine the post-failure behavior of coal as a mass and examine the relationship between the results of this study and prior laboratory investigations of the post-failure behavior of coal as a material. Instrumentation to measure changes in stress and deformation was placed in a headgate yield pillar and will be monitored as the face passes the area. A battery powered, automated data acquisition system, capable of recording up to 9,000 data points, is currently used to remotely monitor changes in vertical and horizontal pillar stress.

Keyword(s): coal mining, longwall, instrumentation, pillar strength, roof stability, monitoring equipment, monitoring installation, monitoring methods, yielding supports, lab testing, in situ testing

Location(s): United States

Newton, J. G., L. W. Hyde. Sinkhole Problem in and Near Roberts Industrial Subdivision, Birmingham, Alabama. Geological Survey of Alabama Circular 68, 1971, 42 p.

Keyword(s): geologic features

Location(s): Alabama, United States

Newton, J. G. Induced Sinkholes--A Continuing Problem Along Alabama Highways. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 453-463.

Keyword(s): surface subsidence damage, roads

Location(s): Alabama, United States

Newton, J. G. Sinkholes Resulting from Ground-Water Withdrawals in Carbonate Terranes--An Overview. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, Geological Society of America, 1984, T.L. Holzer, ed., p. 195-202.

Numerous sinkholes resulting from declines in the water table due to groundwater withdrawals in carbonate terranes have occurred in the eastern United States and elsewhere. In Alabama alone, it is estimated that more than 4,000 of these sinkholes, areas of subsidence, or related features have formed since 1900. Almost all occur where cavities develop in residual or other unconsolidated deposits overlying openings in carbonate rocks.

Keyword(s): fluid extraction

Location(s): Alabama, United States

Newton, J. G. Review of Induced Sinkhole Development. IN: Sinkholes: Their Geology, Engineering, and Environmental Impact, Proceedings 1st Multidisciplinary Conference on Sinkholes, Orlando, 1984, B.F. Beck, ed., Balkema, Rotterdam, p. 3-9.

Induced sinkholes are those caused or accelerated by human activity. They are divided into two types: those resulting from a decline of water level due to pumpage and those resulting from construction. Almost all occur where cavities develop in unconsolidated deposits overlying openings in carbonate rocks. Triggering mechanisms resulting from water level declines are loss of buoyant support, increase in water velocity, water-level fluctuations, and induced recharge. Those resulting from construction include piping, saturation, and loading.

Keyword(s): geologic features, fluid extraction

Location(s): United States

Newton, J. G. Natural and Induced Sinkhole Development in the Eastern United States. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association Hydrological Sciences Publication No. 151, 1986, p. 549-564.

Detailed investigations of sinkhole occurrence have been previously limited to Alabama and Missouri. A reconnaissance-type investigation of this occurrence in the eastern United States was made in 1981 to regionalize previous findings.

About 850 sites, at which an estimated 6,000 sinkholes have occurred, were identified in 19 states.
Keyword(s): geologic features, fluid extraction
Location(s): United States

Newton, J. G. Development of Sinkholes Resulting from Man's Activities in the Eastern United States. U.S. Geological Survey Circular 968, 1987, 54 p.
Keyword(s): geologic features
Appalachian Coal Region, United States

Neyman, B. Z., Z. Szecowka, W. Zuberek. Effective Methods for Fighting Rock Bursts in Polish Collieries. IN: Proceedings 5th International Strata Control Conference, 1972, Paper No. 23, 9 p.
Keyword(s): ground control, room-and-pillar, bumps, longwall
Location(s): Poland

Nicholls, B. Pillar Extraction on the Advance at Oakdale Colliery. IN: Proceedings 1st International Conference on Stability in Coal Mining, Miller Freeman Publishers, 1978, p. 182-196.
Keyword(s): room-and-pillar, pillar extraction, coal mining

Nieto, A. S. Evaluation of Damage Potential to Earth Dam by Subsurface Coal Mining at Rend Lake, Illinois. IN: Proceedings 10th Ohio River Valley Soils Seminar on Geotechnics of Mining, Lexington, KY, 1979, p. 9-18.
Presented are results of a study undertaken to evaluate probable effects of past, impending, and future coal-mining activity at Rend Lake Dam and Reservoir, near Benton, Illinois.
Keyword(s): surface structural damage, engineering, geotechnical, coal mining, surface water, inflow
Location(s): Illinois, Illinois Coal Basin, United States

Nieto, A. S., D. G. Russell. Sinkhole Development in Windsor-Detroit Solution Mines and the Role of Downward Mass Transfer in Subsidence. In Situ, 8, 1984, p. 293-327.
Keyword(s): non-metal mining
Location(s): United States

Nishida, R., T. Esaki, K. Aoki. Evaluation and Prediction of Subsidence in Old Working Areas and Practical Preventive Measures Against Mining Damage to New Structures. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, L. Ubertini, eds., IAHS Publication No. 151, 1986, p. 717-725.
The shortage of adequate construction sites has compelled many engineering structures to be planned in old mining areas in Japan. This paper shows the characteristic of the excavated underground environment and necessary measures for the safety of surface structures. Where the depth of a mined out area is relatively shallow, there is a tendency of cave-in consequent to surface loadings. The effect of surface loading is inversely proportional to the depth of working. In the case of heavy structures with limited allowable deformation, special preventive measures against differential subsidence must be taken into consideration. A power plant project is studied as an example.
Keyword(s): prediction, surface structural damage, construction, abandoned mines, subsurface water, finite element, modeling
Location(s): Japan

Nishida, T., K. Goto. On the Relationship Between the Geological Disturbance and Surface Movement Due to Mining Excavation. Research Institute of Science and Industry, Report 27, 1960, Kyshu University, Japan, p. 66-72.
Keyword(s): surface subsidence damage
Location(s): Japan

Nishida, T. Mining Subsidence. Research Institute of Science and Industry, Kyushu University, Japan, Report 32 , 1962, p. 1-74 (in Japanese).
Location(s): Japan

Nishida, T., K. Gotto. Damage to Irrigation Pond due to Mining Subsidence. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 89, v. 2, p. 496-501.
Keyword(s): surface water

Nishida, T., N. Kameda. On the Mechanism of Caving-In Due to Mining at a Shallow Depth. Journal Mining & Metallurgy Institute, Japan, v. 88, no. 1018, 1972, p. 863-868 (in Japanese).
Keyword(s): surface subsidence damage

Nishida, T., T. Esaka, N. Kameda. A Development of the Base Friction Technique and its Application to Subsidence Engineering. IN: Proceedings International Symposium on Engineering in Complex Rock Formations, November 3-7, 1986, Beijing, China, Pergamon Press.

The base friction apparatus, which is capable of supplying compressed air on the surface of the model, can provide an application of the similarity between in situ and model behavior of practical rock structures. This paper describes a new base friction apparatus, which has a stiff metal plate with urethane rubber instead of an endless belt and a lateral loading system. The phenomena of cave-in and surface subsidence in shallow coal mining are studied for a continuous and a discontinuous model.

Keyword(s): modeling, coal mining

Location(s): Japan

Nix, J. P. Unusual Disturbances in Belleville, Illinois. Report to Most Rev. Albert Zuroweste, D.D., Bishop of Belleville, IL, November 1960, John P. Nix Structural Engineers, St. Louis, MO.

Evidence is quite positive that sifts, fractures, subsidence, and other unusual disturbances have occurred and probably will continue to occur in the Belleville area. Many of the disturbances involve subsidence of the bedrock strata and are probably associated with subsidence of the coal mines that underlie a large part of the area.

Keyword(s): surface structural damage, abandoned mines, coal mining, foundations, architecture, construction, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Nogushi, T., R. Takahashi, U. Tokumitsu. Small Sinking Holes in Limestone Area with Special Reference to Drainage of Coal Mines. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 89, v. 2, p. 512-522.

Keyword(s): hydrology, coal mining

Norman, J. W. The Photogeological Detection of Unstable Ground. Journal Institute Highway Engineers, February, 1970, p. 19-22.

Keyword(s): photography, remote sensing, instrumentation

Norman, J. W., I. Watson. Detection of Subsidence Conditions by Photogeology. Engineering Geology, v. 9, no. 4, 1975, p. 359-381.

Keyword(s): fluid extraction, photography, instrumentation, remote sensing

Norris, R. V. Surface Support. Transactions, AIME, v. 88, 1930, p. 98-101.

This paper is an introduction to the article entitled, "Subsidence from Anthracite Mining," by H. W. Montz. The author discusses three problems of surface support and suggests methods that would limit surface subsidence.

Keyword(s): backfilling, mine design, anthracite, coal mining

Location(s): United States

North, C. Surface Subsidence Occasioned by Mine-Workings. Transactions Institute Mine Surveyors, v. 14, October, 1937, 18 p.

Keyword(s): surface subsidence damage

North, F. J. Some Geological Aspects of Subsidence Not Due to Mining. IN: Proceedings South Wales Institute Engineers, v. 75, no. 3, 1952, p. 127-158.

Keyword(s): geologic features

North of England Safety in Mines Research Committee. 7th Progress Report of an Investigation into the Cause of Falls and Accidents Due to Falls. Transactions Institute of Mining Engineers, v. 108, 1949, p. 489-510.

Keyword(s): roof stability, roof support, mine safety

Location(s): England

North, P. G., R. P. Callagahan. Subsidence Associated with Mining at Mt. Lyell. IN: Proceedings, New Zealand Conference, Australasian Institute of Mining Metallurgy, University of Auckland, May 19-23, 1980, p. 193-203.

Keyword(s): surface subsidence damage

Nottram, C. Some Notes on Roof Subsidence. Colliery Guardian, v. 148, 1934, p. 901-903.

The author discusses bending and fracturing of roof strata, including the influence of the rate of face advance upon the shape and failure of the roof.

Keyword(s): roof stability

Nunez, O., D. Escojido. Subsidence in the Bolivar Coast. International Association Hydrological Sciences Publication 121, 1977, p. 257-266.

Keyword(s): hydrology

O'Beirne, T. J., J. Shepherd. The Failure of Coal Pillar Ribs and Possible Methods of Control. IN: Australia/New Zealand Conference on Geomechanics, Perth, Australia, May 1984, Institute of Engineers, Barton, p. 661-667.
Keyword(s): mine design, ground control, pillar strength, coal mining
Location(s): Australia

O'Connor, K. M., J. E. O'Rourke, J. Carr. Influence of Rock Discontinuities on Coal Mine Subsidence. U.S. Bureau of Mines Mining Research Contract Report, Contract No. JO100087, September, 1983, 111 p. plus appendices.
This report documents the process of literature review, site selection, instrument installation, data acquisition, and preliminary data reduction performed to evaluate the influence of rock mass discontinuities on coal mine subsidence. A system of surface, subsurface, and mine level instrumentation was installed at a mine in West Virginia, where the overburden varied in thickness from 630 to 1,040 feet.
Keyword(s): coal mining, instrumentation, monitoring methods, monitoring equipment, geologic features, overburden, survey methods, survey equipment, survey data processing, in situ testing, longwall, active mines
Location(s): West Virginia, Appalachian Coal Region, United States

O'Connor, K. M., C. H. Dowding. Application of Time Domain Reflectometry to Mining. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 737-746.
Examples are presented in which Time Domain Reflectometry (TDR) was employed to locate deformation in rock masses induced by mining. The first example involved monitoring the propagation of overburden fractures above a longwall coal panel and the second example involved the use of TDR to monitor rock mass deformation in the vicinity of a strip mine highwall. Rock mass deformation, strata separation and large block movement generated strains and failure along coaxial cables which were installed in drill holes and the TDR reflections generated by these strains and failures were monitored. Analysis of field data and a preliminary laboratory test indicate that it may be possible not only to locate rock mass movements but also to quantify these movements with TDR data.
Keyword(s): monitoring methods, monitoring equipment, instrumentation, longwall, coal mining, overburden

O'Connor, K. M. Distinct Element Modeling and Analysis of Mining-Induced Subsidence. Ph.D. Dissertation, Northwestern University, Evanston, IL, 1988, 175 p.
A hybrid two-dimensional distinct element model has been developed by combining the Northwestern University Rigid Block Model with the Rigid Block Model developed by Peter Cundall. A specific case of subsidence induced by longwall mining in West Virginia was simulated with this model as an example application.
Keyword(s): coal mining, modeling, computer, longwall, rock mechanics, engineering, geologic features, geotechnical, instrumentation, monitoring methods, vertical displacement, horizontal displacement
Location(s): West Virginia, Appalachian Coal Region, United States

O'Connor, K. M., C. H. Dowding. Hybrid Discrete Element Code for Simulation of Mining-Induced Strata Movements. IN: Proceedings 1st U.S. Conference on Discrete Element Methods, G.G.W. Mustoe, M. Henriksen, and H.P. Huttelmaier, eds., Colorado School of Mines Press, 1989, 10 p.
Keyword(s): modeling, overburden
Location(s): United States

O'Connor, K. M., C. H. Dowding, M. B. Su. Monitoring Rock Mass Deformation Using Time Domain Reflectometry. IN: Proceedings International Conference, Surface Crown Pillar Evaluation for Active and Abandoned Metal Mines, Timmins, Ontario, Canada, November 15-17, 1989, M.C. Betournay, ed., p. 123-132.
Keyword(s): monitoring methods, monitoring equipment, overburden

O'Connor, K. M. Comparison of Mining-Induced Displacement of the Ground Surface and Residential Structures. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 301-310.
Residential structures located over chain pillars of two longwall panels as well as prototype structures constructed over the center line of a high extraction retreat mine were monitored in conjunction with ground surface displacements.

Plots have been developed to illustrate the dynamic displacement fields induced by high extraction mining and the spatial variation of computed slope and curvature profiles provides some explanation for conflicting published results relative to ground curvature and structure curvature. Computed values of angular distortion and deflection ratio for the ground and structures are compared with published criteria for cracking of unreinforced masonry walls. It was found that the angular distortions for all cases were consistent with the superstructure cracks observed or reported, while the deflection ratios were consistent with the foundation cracks observed or reported.

Keyword(s): surface structural damage, coal mining, active mines, high-extraction retreat, longwall, foundations, monitoring methods, monitoring design, survey design, survey data processing

Location(s): Illinois, Illinois Coal Basin, United States

O'Connor, K. M., C. H. Dowding. Distinct Element Modeling and Analysis of Mining-Induced Subsidence. Rock Mechanics and Rock Engineering, v. 25, no. 1, January-March 1992, p. 1-24.

The influence of rock discontinuities on mining-induced subsidence is addressed in this paper. A two-dimensional rigid block computer model was used to simulate discontinuities within strata overlying a longwall coal mine.

Keyword(s): longwall, coal mining, modeling, computer, horizontal displacement, vertical displacement, instrumentation, overburden, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

O' Donahue, T. A. Subsidence Caused by Coal Mining. Colliery Guardian, v. 139, 1929, p. 1771-1773, p. 1872-1875.

This paper includes observations of subsidence over steeply sloping seams.

Keyword(s): angle of draw, surface structural damage, coal mining, geologic features

O'Riordan, N. J., K. W. Cole, D. J. Henkel. Collapses of Abandoned Limestone Mines in the West Midlands of England. IN: Proceedings, International Society for Rock Mechanics Symposium on Design and Performance of Underground Excavations, Cambridge, England, September, 1984, E.T. Brown and J.A. Hudson, eds., British Geotechnical Society, London, p. 401-408.

Keyword(s): abandoned mines, non-metal mining

Location(s): England

O'Rourke, J. E., R. M. Mabry, B. B. Ranson, K. O'Connor. Subsidence Monitoring Systems for Undermined Areas. Department of Energy contract ET-76-C-01-9123, Woodward-Clyde Consultants, 1977, 304 p. (NTIS FE/9123-1)

Major applications and specifications of subsidence monitoring systems are reviewed, and the relevant data measurements for a cost-effective monitoring program are identified for each. Seven sets of measurements are formalized as individual measurement systems. Availability, cost, and ease of use are listed for more than 100 potentially useful instruments.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, economics, instrumentation

Location(s): United States

O'Rourke, J. E. Design and Demonstration of Subsidence Monitoring Systems. Report on U.S. DOE Contract/Grant no. ET-78-C-01-3436, Woodward-Clyde Consultants, San Francisco, CA, October 1978, 4 p. (NTIS TID-29016)

Design and demonstration of a subsidence monitoring system is briefly outlined, and the results expected are tabulated.

Keyword(s): instrumentation, monitoring methods, monitoring design

Location(s): United States

O'Rourke, J. E., B. B. Ranson, K. O'Connor, R. M. Mabry. Instrumentation Systems for Mining Subsidence. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 154-168.

This paper is based on a research project carried out by Woodward-Clyde and sponsored by the USBM. Its purpose is to facilitate subsidence monitoring for mine operators, surface users, and regulatory agencies by providing guidelines to help them select appropriate, low-cost accurate instrumentation suited to their individual subsidence problems. Because no single instrumentation program will satisfy all subsidence problems, seven monitoring programs were developed. Each consists of one or more measurements with specifications and detailed descriptions of the suitable instrumentation.

Keyword(s): instrumentation, prediction, monitoring equipment, monitoring design, monitoring methods, law, surface structural damage
Location(s): United States

O'Rourke, J. E. Instrumentation Plan for Characterization of Subsidence Over Longwall Mining Panels at Allen Mine, Weston, Colorado. 1980, 42 p. (NTIS DOE/PC/30117-T2)
Keyword(s): instrumentation, longwall, monitoring design, monitoring methods, monitoring equipment, active mines, coal mining
Location(s): Colorado, Rocky Mountain Coal Region, United States

O'Rourke, J. E., P. H. Rey, K. O'Connor. Characterization of Subsidence Over Longwall Mining Panel. Final Report to U.S. Department of Energy, Contract DE-AC22-80PC30117, 9/19/80-9/19/82, September, 1982, Woodward-Clyde Consultants, San Francisco, 180 p.
This report documents the process of site selection, instrument installation, data acquisition, and preliminary data analysis followed to characterize the physical response of overlying strata to longwall mining. A system of surface, subsurface and mine level instrumentation was installed in Colorado where the overburden thickness varied from 600 to 900 feet. Survey monuments, automatic-recording strain-meters, multi-point rod extensometers, inclinometer-extensometers, stressmeters, and tape extensometer convergence stations were installed to monitor displacements and stress changes. A preliminary analysis of the data acquired up until project termination has shown the system to be operative and strata response to be similar to that reported for other subsidence monitoring case histories. Recommendations for continued monitoring of the systems are presented.
Keyword(s): overburden, instrumentation, monitoring methods, monitoring equipment, horizontal displacement, vertical displacement, survey methods, longwall, coal mining, active mines
Location(s): Colorado, Rocky Mountain Coal Region, United States

O'Rourke, J. E. Monitoring Subsidence in the West: Problems and Analysis. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 164-179.
This paper describes results of a project for the design and demonstration of subsidence monitoring systems, including descriptions of the instrumentation systems, site conditions, problems of installation, resulting recommendations, and subsidence data.
Keyword(s): monitoring design, monitoring installation, monitoring equipment, monitoring methods, survey methods, survey equipment
Location(s): Utah, Rocky Mountain Coal Region, United States

O'Rourke, J. E., K. M. O'Connor, P. H. Rey. Instrumentation Systems for Subsidence Monitoring of Longwall Panels. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, SME-AIME, September, 1982, Y.P. Chugh and M. Karmis, eds., p. 235-244.
This paper evaluates construction and monitoring techniques for specific geotechnical instrumentation used to provide overburden and surface-subsidence data. Instrumentation for monitoring ground and subsurface deformations and mine-level stresses are discussed.
Keyword(s): monitoring equipment, monitoring methods, monitoring design, survey equipment, geotechnical, longwall, overburden, monitoring installation, instrumentation, vertical displacement, horizontal displacement
Location(s): Utah, Colorado, Rocky Mountain Coal Region, West Virginia, Appalachian Coal Region, United States

O'Rourke, J. E. Monitoring Subsidence in the West. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, 1983, p. 717-733.
Instrumentation systems of demonstrated capabilities are available for monitoring subsidence over underground coal mines, and guidelines for specific programs and cost elements of the programs are given. Many of the objectives of acquiring data that will aid in subsidence prediction modeling are being met. A certain amount of ground control data that will be found useful to optimize mine design will result from subsidence monitoring programs and can thus aid mining production, as well as help to minimize surface damage through improved mine planning relative to subsidence effects.

Keyword(s): monitoring methods, monitoring equipment, monitoring installation, monitoring design, instrumentation, vertical displacement, horizontal displacement, overburden
Location(s): Rocky Mountain Coal Region, United States

O'Rourke, J. E., K. O'Connor. Core Recovery of Soft or Poorly Consolidated Materials. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 97-111.
The problems of core recovery in soft or poorly consolidated material are broad and encompass numerous varieties of conditions and materials.
Keyword(s): monitoring installation, overburden, geologic features
Location(s): United States

O'Rourke, T. D., S. M. Turner. Longwall Subsidence Patterns: A Review of Observed Movements, Controlling Parameters and Empirical Relationships. U.S. Bureau of Mines, Geotechnical Engineering Report 79-6, 1979, School of Civil and Environmental Engineering, Cornell University, 82 p.
Keyword(s): longwall, geotechnical
Location(s): United States

O'Rourke, T. D., S. M. Turner. A Critical Evaluation of Coal Mining Subsidence Patterns. IN: Proceedings, AIME Annual Meeting, New Orleans, 1979.
Keyword(s): coal mining, prediction
Location(s): United States

O'Rourke, T. D., S. M. Turner. A Critical Evaluation of Coal Mining Subsidence Patterns. IN: Proceedings, Geotechnics of Mining, Ohio River Valley Soils Seminar, Lexington, KY, October 5, 1979, p. 1-8.
This paper examines subsidence patterns caused by longwall mining in both the United States and the United Kingdom. Special attention is directed to the subsidence prediction charts that have been developed for mining conditions in the United Kingdom. The regional geologies in several coal producing areas are surveyed and compared. Case histories of mining subsidence are summarized with special emphasis on lateral ground strains and surface curvatures. Consideration is extended to subsidence associated with retreat pillar mining.
Keyword(s): longwall, prediction, coal mining, geologic features, high-extraction retreat, pillar extraction
Location(s): United Kingdom, United States, Pennsylvania, West Virginia, Virginia, Appalachian Coal Region, Illinois, Illinois Coal Basin

O'Rourke, T. D., S. M. Turner. Empirical Methods for Investigating Subsidence in U.S. Coal Fields. IN: Proceedings, 22nd U.S. Symposium on Rock Mechanics, Massachusetts Institute of Technology, Cambridge, June 28-July 2, 1981, p. 322-327.
Keyword(s): coal mining, monitoring methods, subsidence research, empirical model
Location(s): United States

Oberhausen, J. The Compression of Stope Fillings. School of Mines Quarterly, v. 26, April, 1905, p. 271-276.
This paper describes compressibility of fill using data from a study at the Kaiser mine in Germany.
Keyword(s): backfilling
Location(s): Germany

Obert, L. Measurement of Pressures on Rock Pillars in Underground Mines, Part I. U.S. Bureau of Mines RI 3444, 1939-40.
This report presents a laboratory method that uses sound waves to determine pressure-velocity relationships for small rock columns. Measurements are given for 22 samples of varying materials.
Keyword(s): pillar strength, lab testing
Location(s): United States

Obert, L. Measurement of Pressures on Rock Pillars in Underground Mines. U.S. Bureau of Mines RI 3521, 1939-40.
This report presents an in situ method of measuring velocity of sound in rock mine pillars, which was tested in a lead mine. Results indicate that, due to the formation of a pressure arch, the pillars were not under great enough pressure to be measurable. Other testing was performed on concrete pillars.
Keyword(s): in situ testing, pillar strength, metal mining
Location(s): United States

Obert, L., S. L. Windes, W. I. Duvall. Standardized Tests for Determining the Physical Properties of Mine Rock. U.S. Bureau of Mines RI 3891, 1946, 67 p.
Keyword(s): rock mechanics, lab testing
Location(s): United States

Obert, L., W. I. Duvall. Microseismic Methods of Determining Stability of Underground Workings. U.S. Bureau of Mines B 573, 1957.

The rate of production of microseisms is related to the magnitude of stress and is an indicator of instability. Geophones in drill holes to monitor microseisms may detect accumulating stress conditions.

Keyword(s): seismic, in situ testing, monitoring methods, monitoring equipment, pillar strength

Location(s): United States

Obert, L., W. I Duvall, R. H. Merrill. Design of Underground Openings in Competent Rock. U.S. Bureau of Mines Bulletin, v. 587, 1960, 36 p.

This study considered both massive formations mined with an arched roof and bedded formations with flat roofs. Designs pertain to efficient mineral extraction rather than the prevention of surface subsidence.

Keyword(s): mine design, roof stability, tunnelling

Location(s): United States

Obert, L., W. I. Duvall. Seismic Methods of Detecting and Delineating Subsurface Subsidence. U.S. Bureau of Mines RI 5882, 1961, 28 p.

This report discusses traveltime, microseismic, traveltime difference, and seismic reflection methods of detecting subsurface subsidence.

Keyword(s): seismic, subsurface subsidence damage, monitoring methods

Location(s): United States

Obert, L. An Inexpensive Triaxial Apparatus for Testing Mine Rock. U.S. Bureau of Mines RI 6332, 1963.

Keyword(s): rock mechanics, lab testing

Location(s): United States

Obert, L. Deformation Behavior of Model Pillars Made from Salt, Trona, and Potash Ore. IN: Proceedings, 6th Symposium on Rock Mechanics, University of Missouri-Rolla, October, 1964, E.M. Spokes and C.R. Christiansen, eds., p. 539-560.

This investigation considered the deformational behavior of model pillars made from salt, trona, and potash ore tested under a constant applied load. Although load on the mine pillars is not constant at the time it is being formed, it is virtually constant over the larger part of its effective lifetime. As the load in the pillar prior to reaching this constant value is less than that after the pillar has assumed its maximum load, any design based on constant load conditions would be on the conservative side.

Keyword(s): modeling, pillar strength, non-metal mining, rock mechanics, lab testing

Obert, L., W. I. Duvall. Rock Mechanics and the Design of Structures in Rock. John Wiley & Sons, New York, 1967.

Keyword(s): rock mechanics, roof bolting, mine design, ground control, pillar strength, instrumentation

Location(s): United States

Ochab, Z. Rules Concerning New Instructions for the Determination of Safety Pillars in the Collieries of Upper-Silesian Coal Fields. Polish Ministry for Mining and Power, Report No. 271, 1961.

Keyword(s): mine design, pillar strength, coal mining

Location(s): Poland

Ogden, H. The Law Of Support. Transactions, Institute of Mining Engineers, London, v. 84, 1932, p. 1-8, 61-63.

Keyword(s): mine design

Ogden, H., R. J. Orchard. Ground Movements in North Staffordshire. Transactions, Institute of Mining Engineers, London, v. 119, 1959-60, p. 259-272.

Surface surveys were carried out over a 10-year period. The article describes the problems of surveying when the mine underlies buildings.

Keyword(s): surface structural damage, survey data processing, survey methods, survey design

Location(s): England

Oitto, R. H. Three Potential Longwall Mining Methods for Thick Coal Seams in the Western United States. U.S. Bureau of Mines IC 8792, 1979, 34 p.

Keyword(s): longwall, mine design, coal mining

Location(s): Rocky Mountain Coal Region, United States

Okonkwo, I. O., W. R. Judd, A. G. Altschaeffl. A Review of Some Aspects of Grouting for Mine Subsidence Control. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 127-145.

This paper presents an overview of the state-of-the-art of grouting as a technique for mine subsidence control. A review of some aspects of grouting theory is presented, and illustrative case histories are discussed. Limitations and factors underlying the successful application of grouting as a technique for controlling mine subsidence are presented.

Keyword(s): grouting, abandoned mines, active mines, coal mining, geologic features

Location(s): Wyoming, Rocky Mountain Coal Region, Indiana, Pennsylvania, Appalachian Coal Region, United States

Okonkwo, P. C. Ground Movements and Subsidence in Nigeria's Coal and Metal Mines. IN: Land Subsidence, Proceedings, 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, L. Ubertini, eds., IAHS Publication No. 151, 1986, p. 687-697.

Ground movements and subsidence result from uncontrollable tectonic forces to controllable human activities. Mining and quarrying industries have been identified as the contributory human activities, hence the scientific and technological research programs by nations to combat the adverse environmental effects and residual hazards to public health. Nigeria with its coal and metalliferous mines is facing two major hazards of surface subsidence from underground coal operations and ground movements and from erosion generated by unrehabilitated metalliferous mines.

Keyword(s): coal mining, metal mining, reclamation, geologic features, historical, government, subsidence research

Location(s): Nigeria

Oldroyd, D. C. Stooping Under An Overland Conveyer, Transvaal Navigation Collieries. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 89-96.

This paper describes the undermining of an overland conveyer belt, measurements of surface subsidence taken, and results obtained. It also describes the effect of subsidence on the conveyor and the preventative measures that could have been taken to prevent the relatively minor damage caused. Although the magnitude of the strains that occurred were very high, the conveyor remained functional and carried coal throughout the undermining.

Keyword(s): coal mining, pillar extraction, surface structural damage, monitoring methods, structural mitigation

Location(s): South Africa

Oravecz, K. I. Analogue Modeling of Stresses and Displacements in Bord and Pillar Workings of Coal Mines. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 14, 1977, p. 7-23.

Keyword(s): room-and-pillar, modeling, coal mining

Oravecz, K. I. Measurement of Surface Displacements Caused by Extraction of Coal Pillars. IN: Large Ground Movements and Structures, Proceedings International Conference, Univ. of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley, 1978, p. 60-85.

This paper summarizes the procedures used in a subsidence study conducted over a bord-and-pillar operation. Details are given on instrumentation used to determine surface subsidence, lateral displacements, and development and extent of the cave in relation to the mining geometry.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, survey data processing, instrumentation, room-and-pillar, pillar extraction, coal mining

Location(s): South Africa

Oravecz, K. I. Improved Prediction of Surface Subsidence Using the Influence Function Approach. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 73-80.

A shortcoming in the prediction of surface displacements resulting from caved tabular excavations at shallow and moderate depths stems from the lack of ability to estimate precisely the convergence or closure distribution. The development of a variety of numerical methods assist in the improved modeling of the complex mechanism of caving and the global response of the rock mass.

Keyword(s): prediction, empirical model, influence function, modeling, computer, finite element, boundary element

Orchard, R. J. Recent Developments in Predicting the Amplitude of Mining Subsidence. Journal Royal Institute Chartered Surveyor, no. 33, May, 1954, p. 864-876.

This paper evaluates the amplitude of mine subsidence through the examination of method of mining, geological conditions, rate of face advance, time factors, and differing mining conditions. The author refers to the partial subsidence curve, and how this curve can be used for practical applications.

Keyword(s): vertical displacement, horizontal displacement, prediction, time factor, geologic features

Orchard, R. J. Surface Effects of Mining--The Main Factors. Colliery Guardian, v. 193, 1956.

Keyword(s): surface subsidence damage

Orchard, R. J. Prediction of the Magnitude of the Surface Movement. IN: Proceedings, European Congress on Ground Movement, Leeds, April, 1957.

Keyword(s): prediction

Orchard, R. J. Prediction of the Magnitude of Surface Movements. Colliery Engineering, v. 34, 1957, p. 455-462.

The author examines various aspects of mine subsidence: the effects of backfilling on ground movements, geologic conditions, and an analysis of the relationship among subsidence, seam depth, and horizontal strain. Tensile strain, compressive strain, and the relationship of strain to slope are also evaluated.

Keyword(s): vertical displacement, horizontal displacement, prediction, backfilling, geologic features

Orchard, R. J. Surface Effects of Mining--The Main Factors. Transactions, Institute of Mining Engineers, London, v. 116, 1956-57, p. 941-958.

The various factors affecting surface movements are summarized, and the manner in which they influence the shape of the subsidence trough is described. The importance of the width-depth ratio in determining the maximum amplitude of subsidence is discussed. Also included is a brief discussion of surface damage and methods for reducing this damage.

Keyword(s): surface structural damage, mine design, backfilling, survey data processing

Orchard, R. J. The Effect of Mining Subsidence Upon Public Health Engineering Works. Journal Institute Public Health Engineering, v. 56, 1957, p. 188-204.

Keyword(s): utilities

Orchard, R. J. Underground Stowing. Colliery Guardian, v. 203, August 1961, p. 258-263.

The article discusses requirements for maximum subsidence and briefly compares pneumatic and hydraulic backfilling methods. Cost of solid backfilling methods are compared with damage produced by uncontrolled subsidence.

Keyword(s): pneumatic backfilling, hydraulic backfilling, economics

Orchard, R. J. Surface Subsidence Resulting from Alternative Treatment of Colliery Goaf. Colliery Engineering, v. 41, October, 1964, p. 428-435.

This paper compares surface subsidence caused by total and partial extraction methods when caving is allowed rather than backfilling. Roadways and packs and their effects upon convergence are discussed in relation to "effective" panel width and maximum subsidence.

Keyword(s): surface structural damage, mine design, pneumatic backfilling, stowing, mine waste, partial extraction, longwall

Orchard, R. J. Partial Extraction and Subsidence. The Mining Engineer, London, v. 123, no. 43, April, 1964, p. 417-430.

Subsidence and roof control are shown to be dependent upon the size of pillars in relation to the seam depth. With room-and-pillar workings, both safety and higher extraction can be obtained simultaneously only in shallow seams. With deeper seams, longwall partial extraction layouts are shown to produce greater mine safety and economical utilization of coal reserves.

Keyword(s): partial extraction, roof stability, room-and-pillar, longwall, National Coal Board, mine safety, mine design, coal mining

Location(s): England

Orchard, R. J., W. S. Allen. Ground Curvature Due to Coal Mining. Chartered Surveyor, v. 97, no. 11, 1965, p. 622-631.

Keyword(s): surface subsidence damage, survey methods, coal mining

Orchard, R. J. The Control of Ground Movements in Undersea Workings. The Mining Engineer, London, v. 128, no. 101, February, 1969, p. 259-273.

Laws governing coal extraction under bodies of water were revised in an attempt by the National Coal Board to standardize coal extraction legislation and to promote maximum use of reserves.

Keyword(s): surface water, ground control, National Coal Board, law, coal mining
Location(s): England

Orchard, R. J., J. Knecht, G. A. Voytko. State of Predictive Art in Subsidence Engineering--Discussion. IN: ASCE Proceedings, Journal Soil Mechanics and Foundations Division, v. 96, no. SM6, 1970, p. 2162-2163.
Keyword(s): prediction

Orchard, R. J., W. S. Allen. Longwall Partial Extraction Systems. The Mining Engineer, London, v. 129, no. 117, June, 1970, p. 523-535.
The author suggests an improved method for calculation of maximum subsidence, taking width and depth into account separately instead of combining them into a width/depth ratio. The mechanics of harmonious extraction are examined.
Keyword(s): longwall, partial extraction, prediction

Orchard, R. J. Vitrified Clay Pipes in Areas of Mining Subsidence. Clay Pipe Development Association, 1972.
Keyword(s): pipelines, utilities

Orchard, R. J. Some Aspects of Subsidence in the United Kingdom. IN: Proceedings 4th Annual Symposium, A.J. Hargraves, ed., Wollongong, Australia, February 20-22, 1973, Australasian Institute of Mining and Metallurgy, Illawarra Branch, Paper 3, p. 3-1--3-11.
This article represents a discussion of National Coal Board guidelines for undersea coal extraction in relation to the type of working, minimum depth of extraction, and monitoring of subsidence effects.
Keyword(s): surface water, monitoring design, mine design, National Coal Board, coal mining, inflow
Location(s): United Kingdom

Orchard, R. J. Working Under Bodies of Water. The Mining Engineer, London, v. 134, no. 170, March, 1975, p. 261-270.
This article discusses the consequences of extracting coal reserves located under bodies of water. Specific examples detail the results of mining beneath rivers, reservoirs, triassic sandstones, and aquifers.
Keyword(s): surface water, subsurface water, mine design, hydrology, coal mining

Orchard, R. J., W. S. Allen. Time Dependence in Mining Subsidence. IN: Proceedings, Symposium on Minerals and the Environment, London, June 4-7, 1974, Institute Mining and Metallurgy, London, 1975, p. 643-659.
An attempt is made to define the nature and size of post-mining subsidence having regard to the depth of mining, layout, nature of the strata, and sequence of mining. Examples show the measured residual effects under differing circumstances. Normal residual mining subsidence can be estimated to an acceptable degree of precision by analysis of the time-dependent effects shown during the period when coal faces are being worked. The phase relationship between the developing subsidence and the advance of the coal face can be compared, provided that a component of the surface subsidence can be measured with a high degree of accuracy. The use of one component is described and its sensitivity to the working cycle for underground extraction is shown.
Keyword(s): time factor, coal mining, prediction, National Coal Board, active mines
Location(s): United Kingdom

Orchard, R. J. Discussion of Kapp, W. A., "A Study of Mine Subsidence at Two Collieries in the Southern Coalfield, New South Wales." IN: Proceedings, Australasian Institute Mining and Metallurgy, no. 277, 1981, p. 53.
Keyword(s): coal mining
Location(s): Australia

Orlowski, A. C., W. F. Kane, R. M. Holbrook. Prediction of Subsidence-Induced Ground Movement and its Effects on a Coal Refuse Dam. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 61-68.
The stability of a coal refuse dam is as important as that of a water impoundment from a safety standpoint. Refuse dams exposed to potential mining-induced subsidence must be analyzed for such an occurrence. This paper presents some of the methods used in the evaluation of subsidence effects on a coal refuse dam and conclusions reached concerning the stability of the structure.
Keyword(s): surface structural damage, engineering, coal mining, mine waste, active mines, geologic features, prediction, pillar strength
Location(s): Virginia, Appalachian Coal Region, United States

Osterwald, F. W. Deformation and Stress Distribution Around Coal Mine Workings in Sunnyside No. 1 Mine, Utah. U.S. Geological Survey Professional Paper 424-C, 1961, p. C349-C353.

Keyword(s): rock mechanics, coal mining
Location(s): Utah, United States

Osterwald, F. W. USGS Relates Geologic Structures to Bumps and Deformation in Coal Mine Workings. Mining Engineering, v. 14, no. 4, 1962, p. 63-68.

Keyword(s): bumps, geologic features

Osterwald, F. W., C. R. Dunrud. Geology Applied to the Study of Coal Mine Bumps at Sunnyside, Utah. SME-AIME Preprint 65I27, AIME Annual Meeting, Chicago, IL, February 14-18, 1965.

Coal mine bumps, which are violent spontaneous failures of coal or other rocks in mine faces, ribs, roofs, and floors, are a serious hazard to life and property in the mines of east-central Utah. In seeking a better understanding of the factors causing bumps, the USGS studied relationships between geologic features and coal mine bumps at Sunnyside, Utah, for about 5 years.

Keyword(s): bumps, coal mining, active mines, geologic features
Location(s): Utah, Rocky Mountain Coal Region, United States

Osthof, H., J. C. Swain. European Underground Coal Mining Technology. Battelle Energy Program Report, Columbus, OH, June, 1975, 25 p. (NTIS PB 249 052)

This report is a review of the current technology of longwall mining in Europe.

Keyword(s): mine operation, mine design, coal mining, longwall, multiple-seam extraction
Location(s): Europe, France, West Germany

Otto, J. B. The Effect of Total Extraction Coal Mining on Transmission Towers. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 59-72.

Transmission towers, like many other surface structures, are a serious obstruction to total extraction coal mining and to longwall mining in particular. A 132-kV self-supporting suspension tower was monitored during undermining. The displacements were then used as the input to a computer model of the tower, in an attempt to simulate the effect of differential displacement of its foundation.

Keyword(s): modeling, prediction, computer, surface structural damage, foundations, longwall, coal mining, monitoring methods
Location(s): South Africa

Overbey, W. K. Jr., C. A. Komar, J. Pasini III. Predicting Probable Roof Fall Areas in Advance of Mining by Geological Analysis. U.S. Bureau of Mines, Health and Safety Research Program TPR 70, May, 1973, 17 p.

Surface fracture trace density, changes in roof rock type, and topographic unloading due to drainage were mapped for mining areas located in the Blacksville-Osage, West Virginia, quadrangles to investigate their influence on mine roof falls. A technique was developed, using these factors, to predict probable roof fall areas ahead of projected mining operations.

Keyword(s): roof stability, geologic features
Location(s): West Virginia, Appalachian Coal Region, United States

Owili-Eger, A. S. C. Geohydrologic and Hydrogeochemical Impacts of Longwall Coal Mining on Local Aquifers. SME-AIME preprint no. 83-376, for presentation at the SME-AIME Fall Meeting and Exhibit, Salt Lake City, UT, October 19-21, 1983, 16 p.

The author describes an investigation undertaken in the Appalachian coal basin in response to problems of impaired well yields and water quality deterioration.

Keyword(s): coal mining, subsurface water, hydrology, longwall, subsurface subsidence damage
Location(s): Appalachian Coal Region, United States

Owili-Eger, A. S. C. Predicting the Impacts of a Logical Mining Unit System on the Water Resources of an Area. IN: Proceedings 23rd Annual American Water Resources Association Symposium, November 1987.

Keyword(s): hydrology, subsurface water, prediction, overburden

Owili-Eger, A. S. C. Dynamic Fractured Flow Simulation Model. Mining Engineering, February 1989, v. 41, no. 2, p. 110-114.

An efficient state-of-the-art dynamic model to simulate and predict the rate of water production in longwall coal mining operations was developed as a tool for mine planning purposes. The model can also

provide an estimate of any potential resultant hydrogeological impacts of an operation via an array of element-specific, single-valued parameters referred to as the field-rating indices. The computational procedure was designed to exploit the benefits of hydrogeotechnology and use a combination of conceptual, physical, empirical, and numerical approaches to define, characterize, analyze, and evaluate flow-controlling properties of fractured rock systems.

Keyword(s): longwall, coal mining, modeling, hydrology, subsurface water, prediction, mine design, overburden, geologic features, surface water, computer, mathematical model, active mines

Location(s): Appalachian Coal Region, Pennsylvania, West Virginia, Wyoming, North Dakota, United States

Oyanguren, P. R. Simultaneous Extraction of Two Potash Beds in Close Proximity. IN: 5th International Strata Control Conference, London, 1973, Paper 32, 5 p.

Keyword(s): non-metal mining, multiple-seam extraction

Ozbay, M. U. The Stability and Design of Yield Pillars Located at Shallow and Moderate Depths. Journal of the South African Institute of Mining and Metallurgy, March 1989, p. 73-79.

The stability of pillars is analyzed on the assumption that pillars shed load in a stable manner if the slope of the strata load-deformation relation is steeper than that of pillars in the post-peak regime. Concepts of local stiffness, mine structural stiffness, and critical stiffness are discussed. Procedures are described for the determination of strata stiffness for various pillar layouts by use of the available boundary-element computer programs. The post-peak stiffness of pillars is assessed from the available data relating to the post-peak load-deformation relationship and width-height ratio.

Keyword(s): yielding supports, pillar strength, rock mechanics, boundary element

Location(s): South Africa

Ozkal, K. Practice of Hydraulic Sandstowing in Armutcuk Coalfield. Symposium on Coal, Zonguldak, Turkey, December, 1961.

This paper describes the hydraulic sandstowing process, practiced in active mines.

Keyword(s): hydraulic backfilling, coal mining, active mines, stowing

Location(s): Turkey

Padgett, M. F. Statistical Analysis of Residential Damage in an Area of Underground Coal Mining Boulder County, Colorado. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October, 1987, p. 95-97 (expanded abstract).

An engineering assessment of damage that has occurred to structures and property in the past 30 years was completed in order to examine the relationship between mine subsidence and residential damage, either to the structure or to the property. This study evaluated the effects of underground coal mines on residential damage using statistical tests. The database for this study was developed through field surveys of 230 randomly selected residences and the evaluation of mine maps and drill hole boring logs.

Keyword(s): abandoned mines, coal mining, surface structural damage

Location(s): Colorado, Rocky Mountain Coal Region, United States

Padgett, M. F. Residential Damage in an Area of Underground Coal Mining. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 1-17.

A statistical analysis of past residential damage in the Boulder-Weld, Colorado, coal field was performed to estimate the potential for future subsidence-related residential damage. The objectives of this study were to assess the difference in damage severity and frequency between undermined and non-undermined areas, and to determine, where applicable, which mining factors significantly influence the severity and frequency of residential damage.

Keyword(s): surface structural damage, abandoned mines, coal mining, geologic features

Location(s): Colorado, Rocky Mountain Coal Region, United States

Palarski, J. Przyczynek Do Wyjanienia Zjawiska Nieciaglych Deformacji Powierzchni I Znacznych Obnizen Nad Podsadzonymi Wyrobiskami (Contribution to the Explanation of Discontinuous Surface Deformations and Large Subsidences Over Stowed Workings). Przeglad Gorniczy, v. 34, no. 3, 1978, p. 120-125.

Keyword(s): stowing, surface subsidence damage

Palmer, R. E. Observation on Ground Movement and Subsidence at Rio Tinto Mines, Spain. Transactions, AIME, v. 91, 1930, p. 168-185.

Keyword(s): surface subsidence damage

Location(s): Spain

Palowitch, E. R. Shortwall Mining Applications in the United States. SME Fall Meeting and Exhibit, October, 1972, Birmingham, AL, Preprint No. 72-AM-356, 12 p.

This paper describes the shortwall mining method, reviews its history, and discusses the current status of shortwall mining in the United States.

Keyword(s): mine design, ground control, shortwall, roof stability, mine operation

Location(s): United States

Pam, E. Water-Borne Packing for Stope Filling. Mining Magazine, v. 5, 1911, p. 295.

Hydraulic sand backfilling of metal mines in South Africa is used for strata control and increased extraction.

Keyword(s): hydraulic backfilling, metal mining, ground control

Location(s): South Africa

Pampeyan, E. H., T. L. Holzer. Earth Fissures and Localized Differential Subsidence. U.S. Geological Survey Open-File Report 79-51, 1979.

Location(s): United States

Panek, L. Estimating Mine Pillar Strength from Compression Tests. Transactions, SME-AIME, v. 268, 1980, p. 1749-1761.

Keyword(s): coal mining, pillar strength, lab testing

Location(s): United States

Panek, L.A. Centrifugal Testing Apparatus for Mine Structure Stress Analysis. U.S. Bureau of Mines RI 4883, 1952.

Keyword(s): lab testing

Location(s): United States

Panek, L. A. Methods and Equipment for Measuring Subsidence. IN: Proceedings 3rd Symposium on Salt, J.L. Rau and L.F. Dellwig, eds., April 22-24, 1969, Cleveland, OH, Northern Ohio Geological Society, Inc., v. 2, 1970, p. 321-338.

This paper describes measurement techniques and equipment appropriate for determining the horizontal and vertical components of displacement and strain, tilt, and curvature. Particular attention is

given to the principal characteristics and uses of monuments, extensometers, tapes, electronic distance-measuring instruments, theodolite, alignment telescope, spirit level, tilt meter, and borehole inclinometer probe.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, monitoring methods, survey methods, survey equipment, ground control, horizontal displacement

Panek, L. A. Solutions of Mine Structure Problems Through Field Measurements and Theoretical Analysis. IN: Rock Mechanics Instrumentation for Mine Design, U.S. Bureau of Mines IC 8585, 1973, p. 23-24.

Keyword(s): mine design, instrumentation, rock mechanics, ground control

Location(s): United States

Panek, L. A. Longwall Problems. IN: Ground Control Aspects of Coal Mine Design, Proceedings Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 97-100.

Longwall strata control depends on the transfer of overburden weight to the perimeter of the mined area through bridging of the main roof strata. Cutting and transport of coal along the face is done under this strata bridge, where the roof support requirement is relatively small, compared to normal overburden pressure. For effective strata control, however, the support system must be able to yield while at the same time maintaining a high resistance to settling of the roof. The proper support characteristics depend on the relative strengths and stiffnesses of the roof strata, coal, and floor.

Keyword(s): longwall, ground control, overburden, coal mining, active mines, geologic features, roof support, roof stability

Location(s): United States

Panek, L. A. Evaluation of Roof Stability from Measurements of Horizontal Roof Strain. IN: Ground Control Aspects of Coal Mine Design, Proceedings Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 92-96.

The author discusses a field measurement technique intended for evaluating roof stability. It is a roof monitoring system based on the structural behavior concept that the horizontal roof strain necessarily increases as the roof sags, and increasing roof sag leads ultimately to a fall. The approach is particularly oriented toward evaluating the stability of a bolted roof.

Keyword(s): roof bolting, roof support, in situ testing

Location(s): United States

Panow, A. D., K. W. Ruppeneit. Problems Concerning Strata Control. IN: Proceedings, International Strata Control Congress, Leipzig, October 14-16, 1958, p. 97-111 and XLVII-XLVIII.

Research activities were directed to the following: (1) study of the mechanical properties of rocks, their deformability and strength, (2) investigations into stress distribution and displacements, (3) examination of rock pressure phenomena on models of equivalent and optically active material, and (4) strata control research in the pit using special instruments and equipment. C. Mohr's theory of strength was found to be the best suited for the description of rock strength characteristics.

Keyword(s): ground control, rock mechanics, modeling

Location(s): Russia

Paone, J., R. H. Cox, A. S. Allen. Subsidence-Control Project in the Belleville-Maryville Area, Illinois. Presented at the 1977 SME Fall Meeting and Exhibit, St. Louis, MO, October 19-21, 1977, Preprint No. 77-F-339, 21 p.

Subsidence movements have damaged houses, schools, streets, and public utility lines in some undermined sections of Belleville and Maryville, Illinois. In cooperation with local officials and the State of Illinois, the USBM is sharing experience in backfilling abandoned coal mines to demonstrate that bituminous mine workings in southwestern Illinois can be successfully backfilled and subsidence-prone areas stabilized. Subsurface investigations revealed that mine workings are dry and underlain by underclay deposits susceptible to instability upon wetting. Backfilling will be accomplished by pneumatic injection instead of the hydraulic methods used in previous subsidence-control projects.

Keyword(s): surface structural damage, ground control, pneumatic backfilling, abandoned mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Parate, N. S. A Study of Ground Movement in Relation to Buildings and Surface Features. Masters Engineering Thesis, 1965, University of Sheffield, United Kingdom.

Keyword(s): surface structural damage
Location(s): England

Parate, N. S. Reducing the Effects of Mining Subsidence on Surface Structures. Colliery Engineering, v. 44, May 1967, p. 190-195.

This paper investigates the mechanics of subsidence and methods of reducing surface subsidence damage. It includes discussions on the nature and amplitude of subsidence, subsidence profiles, area of influence, amplitude of strain, time factor, and design of new structures.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, time factor, ground control, architecture

Parate, N. S. Short Note on Subsidence Damage Problems. Journal Mines, Metals & Fuels, v. 18, August, 1970, p. 287-291.

Keyword(s): surface subsidence damage

Parate, N. S. Earth Movement Due to Mining; Subsidence and Deformation (Movimento de Terreno Devido Mineracao; Abaizamento e Deformacao). Abstract from Congreso Latinoamericano de Geologia, Resumenes, no. 3, 1976, p. 104 (in Portuguese and French). (NTIS Accession no. 77-02604)

Keyword(s): engineering, surface structural damage, coal mining

Parate, N. S. Sinkhole and Subsidence Damage and Protective Measures. IN: Sinkholes: Their Geology, Engineering and Environmental Impact, Proceedings 1st Multidisciplinary Conference on Sinkholes, Orlando, October 15-17, 1984, B.F. Beck, ed. Balkema, Rotterdam, p. 379-383.

Ground subsidence has long been recognized as a major problem in both middle and eastern Tennessee. This subsidence consists of downward and lateral movement of the ground surface and is a result of loss of support within the low level subsurface materials. This loss of support can result from extraction of solids or liquids from beneath the surface (particularly in the coal mining regions of eastern Tennessee), or may result from a subsurface erosion of overlying soil into either caverns or slots within the underlying limestone bedrock. Of prime importance to the engineer or geologists is reducing subsidence damage to man-made structures. The methods for reducing damage will vary according to the subsidence causes and mechanisms.

Keyword(s): coal mining, surface structural damage, engineering
Location(s): Tennessee, United States

Pariseau, W. G., H. D. Dahl. Mine Subsidence and Model Analysis. Transactions, AIME, v. 241, December, 1968, p. 488-494.

This paper summarizes approaches to subsidence studies, examines the possibility of duplicating subsidence phenomena in laboratory models, and analyzes a particular model using sand as the media. The results of the sand model application are discussed.

Keyword(s): modeling, phenomenological model, plastic model, physical model
Location(s): United States

Pariseau, W. G. Plasticity Theory for Anisotropic Rocks and Soil. IN: Proceedings, 10th U.S. Symposium on Rock Mechanics, University of Texas at Austin, 1972, p. 267-296.

Keyword(s): modeling, phenomenological model, plastic model, rock mechanics

Pariseau, W. G. Limit Design of Mine Pillars Under Uncertainty. IN: Design Methods in Rock Mechanics, Proceedings 16th U.S. Symposium on Rock Mechanics, Minneapolis, MN, September 22-24, 1975, C. Fairhurst and S.L. Crouch, eds., ASCE, New York, 1977, p. 287-301.

Limits to mine pillar stability are computed on the basis of flow and fracture mechanisms of local inelastic deformation following a review of the traditional approaches to mine pillar design. Emphasis is on pillars in flat-lying ore deposits. The advent of computers and finite element techniques has eliminated the historic necessity for one-dimensional pillar design thinking. Detailed analyses of stress as well as progressive failure are now possible on a routine basis. A return to fundamentals is explicit in the updated design approach advocated here. Ten examples are presented that simultaneously illustrate the oversimplification of the one-dimensional view and the improvement in design discrimination between stable and unstable pillar states obtained through application of existing rock mechanics technology.

Keyword(s): lab testing, modeling, phenomenological model, pillar strength, rock mechanics, finite element, mine design
Location(s): United States

Pariseau, W. G. Elastic-Plastic and Elastic-Brittle Finite Element Analysis of Cave Zone Growth in

Response to Longwall Face Advance. IN: Proceedings 20th U.S. Symposium on Rock Mechanics, June 4-6, 1979, University of Texas, Austin, p. 541-553.

Comparisons of finite element analyses of "cave" zone growth with longwall face advance using elastic-plastic and elastic-brittle material descriptions show some differences in cave zone extent, but the differences are not large relative to the loads on wood cribs used for support in the "bleeder" entry adjacent to the longwall starting room. The elastic-plastic description is based on pressure dependent yield and associated flow rules; the elastic-brittle description is based on a discontinuing strain softening concept appropriate to diffuse fracturing accompanied by an abrupt change in rock properties.

Keyword(s): finite element, modeling, longwall, mine design, roof support

Location(s): Utah, Rocky Mountain Coal Region, United States

Pariseau, W. G., A. C. Walkup, W. W. Carlson, K. K. Wu. Ropes Mine Crown Pillar Rock Mechanics. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 909-918.

A crown pillar cave occurred at the Ropes Mine in December 1987, resulting in closure of the mine. Production was resumed soon afterwards with the formulation of a rock mechanics plan designed to address several issues of safety and stability. The plan proved to be successful and shows what can be accomplished in the realm of applied rock mechanics where a cooperative atmosphere exists.

Keyword(s): rock mechanics, metal mining, instrumentation

Location(s): Michigan, United States

Park, D-W., D. A. Summers, N. B. Aughenbaugh. Model Studies of Subsidence and Ground Movement Using Laser Holographic Interferometry. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 14, no. 6, November, 1977, p. 235-245.

Keyword(s): instrumentation, modeling

Park, D-W. Model Studies of Subsidence Over Room-and-Pillar Coal Mines Using Holographic Interferometry. IN: Rock Mechanics: A State of the Art, Proceedings 21st Symposium, University of Missouri-Rolla, May 28-30, 1980, D.A. Summers, ed., p. 265-274.

The technique of holographic interferometry has been successfully applied to a self-loading, simple-cavity model simulating subsidence resulting from longwall mining. Holographic interferometry has the capability of detecting full-field movement on the surface of any material. A similar method was adopted for analyzing subsidence above room-and-pillar mines. This paper presents the modeling method and analysis of the results taken from that model.

Keyword(s): room-and-pillar, coal mining, modeling

Park, D-W., D. C. Kicker. Physical Model Study of a Longwall Mine. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 1261-1272.

A new physical longwall mine model was developed to study stress distributions around a longwall face in both the chain pillars and panel. State-of-the-art stress detection devices combined with a new excavation technique and model material have provided reproducible results on the manner of stress redistributions caused by longwall mining. The model has successfully simulated the mode of stress changes in the chain pillars and has measured the development of the panel front abutment.

Keyword(s): modeling, longwall, coal mining, physical model

Location(s): Alabama, United States

Park, D-W, N. F. Ash. Subsidence Study of Alabama Coal Fields. IN: Proceedings, 4th Annual Workshop Generic Mineral Technology Center Mine Systems Design and Ground Control, Moscow, ID, October 21-26, 1986, Department of Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, p. 81-92

Underground coal mining has been a serious cause of subsidence problems in the Warrior Coal Field of Alabama, where few subsidence data are available. A thorough monitoring program at two sites has been ongoing for the past 3 years to study factors that contribute to subsidence. A variation in depth of mining between the two sites from deep to shallow has demonstrated striking differences in subsidence behavior. A numerical simulation of the subsidence was carried out using the finite element method. The modeling of the two case studies has been successfully completed. Also included in this study has been the effect of mining subsidence on the groundwater hydrology. The results show that subsidence influences groundwater hydrology when mining activity is nearby, but that when mining is completed, the groundwater level returns to normal.

Keyword(s): coal mining, subsidence research, monitoring design, monitoring methods, hydrology, subsurface water, modeling, finite element, longwall, overburden, mine design

Location(s): Alabama, United States

Park, D-W. Effect of Mine Subsidence on Ground Water Hydrology. SME-AIME Preprint 87-98, for presentation at the SME-AIME Annual Meeting, Denver, CO, February 24-27, 1987, 8 p.

Underground mining alters ground condition, producing a disturbance in the groundwater regime. The level of disturbance is dependent on the local hydrology, geology, and type of mining. The primary objective of this study was to investigate the effects of mine subsidence on the groundwater hydrology in the Warrior Coal Basin in Alabama.

Keyword(s): hydrology, subsurface water, coal mining, metal mining, abandoned mines, multiple-seam extraction, geologic features

Location(s): Alabama, United States

Park, D.-W. Two Case Histories of Subsidence in the Warrior Coalfield. Mining Engineering, March 1988, p. 185-191.

Underground openings resulting from coal mining activities have been a serious cause of subsidence problems in the Warrior Coalfield of Alabama. The problem will be even more serious in the future because most of Alabama's coal reserves are classified as an underground resource.

Keyword(s): coal mining, geologic features, longwall, survey data processing, monitoring methods, monitoring equipment, National Coal Board

Location(s): Alabama, United States

Park, D-W., V. Gall. Supercomputer Assisted Three-Dimensional Finite Element Analysis of a Longwall Panel. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 133-140.

The failure criterion that considers rock mass properties applied in three-dimensional finite element modeling of a longwall panel has shown encouraging results. The availability of a supercomputer enables large scale modeling. An automated procedure for progressive failure simulation provides the tool for easy data processing. The combination of a three-dimensional model with the technique of progressive failure simulation produces a realistic simulation of the mining of a longwall panel. The model allows detailed study not only of sections near the face location, as presented in this study, but also analysis of the pressure arch and surface and subsurface subsidence.

Keyword(s): computer, modeling, finite element, longwall, coal mining, yielding supports, rock mechanics

Location(s): Alabama, United States

Park, D-W. Yield Pillar Analysis in a Deep Coal Mine. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 257-267.

In longwall coal mines, the size of chain pillars has a great influence on the stability of entries. When applied to deep coal mines in the Warrior Coalfield, conventional pillar systems consisting of equally sized pillars have created problems, such as floor heaves and roof failures due to the high stress concentrations in the area adjacent to the longwall panel. A mine has adopted a yield pillar system as a solution for the instability and has proven the yield pillar system to be an effective alternative. This paper presents the results of a study that analyzed the behavior of the yield pillar system in comparison to conventional pillar systems.

Keyword(s): pillar strength, yielding supports, coal mining, longwall, active mines, mine design, instrumentation, modeling, finite element, ground control

Location(s): Alabama, United States

Park, D. W., Y. M. Jiang, L. A. Morley, W. Keeton. Stability Analysis of a Room-and-Pillar Mine with Thinly-Laminated Roof, Strong Pillars and Weak Floor. Mining Engineering, v. 44, no. 11, November 1992, p. 1355-1360.

Underground room-and-pillar mining operations in the Warrior Coalfield in Alabama frequently suffer instability due to soft floors and thinly-laminated immediate roofs. This investigation concerns a mine that was experiencing ground-control problems with weak floor conditions. Several roof falls occurred locally, and floor heaves as great as 2 feet have been experienced. The paper presents the results of comprehensive analyses conducted on floor heave,

roof sagging, pillar penetration, and floor-bearing capacity using instrumentation and numerical modeling.
Keyword(s): room-and-pillar, floor stability, geologic features, ground control, roof stability, pillar strength, instrumentation, modeling
Location(s): Alabama, United States

Parker, J. What Can Be Learned from Surface Subsidence? Part 2: Practical Rock Mechanics for the Miner. Engineering & Mining Journal, v. 174, July, 1973, p. 70-73.
Keyword(s): rock mechanics

Parker, J. M. Salt Solution and Subsidence Structures, Wyoming, North Dakota, and Montana. Bulletin American Association of Petroleum and Geology, v. 51, no. 10, 1967, p. 1929-1947.
Keyword(s): non-metal mining
Location(s): Wyoming, North Dakota, Montana, United States

Parry-Davies, R. Consolidation of Old Mine Workings. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 223-227.
This paper describes case histories of the applications of consolidation of old coal mine workings, both in the United Kingdom and in South Africa. Different techniques are included for old coal mine workings and for steeply dipping gold mine workings.
Keyword(s): coal mining, metal mining, backfilling, grouting
Location(s): United Kingdom, South Africa

Pasamehmetoglu, A. G. An Investigation into Time-Dependent Aspects of Mining Subsidence. Ph.D. Thesis, University of Nottingham, 1972.
Keyword(s): time factor

Patey, D. R. Grouting Old Mine Workings at Merthyr Tydfil. Ground Engineering, November, 1977, v. 10, no. 8, p. 24-27.
Keyword(s): abandoned mines, grouting

Pathak, B. D. Investigation of the Hydrogeological Problems in Some Mines in India. IN: Mine Water, Proceedings 2nd International Congress, Granada, Spain, September 1985, R. Fernandez-Rubio, ed., v. 1, p. 181-189.
An accurate knowledge of groundwater flow into the mine working is essential to plan for safe mining operations. The salient features and results of investigations on different groundwater problems in three selected collieries and mines in India have been presented in this paper. In a copper ore mine, the studies indicated that due to slow movement of groundwater in the mine area, conditions do not exist for sudden inundation of mines through the fracture systems, but caving of water stored solution cavities in the dolomites and old slopes may cause inundation depending upon the size and extent of caverns. The problem of groundwater inrush in a few selected colliery areas have also been investigated.
Keyword(s): coal mining, metal mining, hydrology, subsurface water, mine safety
Location(s): India

Pattee, C. T., C. J. Booth. Long-Term Hydraulic Changes in a Shallow Confined Aquifer Induced by Longwall Coal-Mine Subsidence, Illinois. Geological Society of America North-Central Section meeting, Iowa City, April 30, 1992, Abstracts with Programs, v. 24, no. 4, p. 59.
Keyword(s): hydrology, subsurface water, coal mining, longwall, monitoring methods, geologic features
Location(s): Illinois, Illinois Coal Basin, United States

Patton, J. D. Hydraulic Stowing. Transactions, Institution of Mining Engineers, v. 47, part 4, 1914, p. 468.
The author discusses reasons for development of hydraulic backfilling in Britain and indicates major objections and solutions.
Keyword(s): economics, hydraulic backfilling
Location(s): England

Paul, J. W., J. N. Geyer. A Study of Falls of Roof and Coal in Mines of Harrison County, West Virginia. U.S. Bureau of Mines RI 3110, 1931.
Keyword(s): roof stability, coal mining
Location(s): West Virginia, Appalachian Coal Region, United States

Paul, J. W., J. N. Geyer. Caving Chambers in Bituminous Mines. Transactions, AIME, v. 108, 1934, p. 79-87.
Keyword(s): coal mining, roof stability, roof support, bituminous
Location(s): Pennsylvania, Appalachian Coal Region, United States

Paul W. J., L. N. Plein. Methods of Development and Pillar Extraction in Mining the Pittsburgh Coalbed in Pennsylvania, West Virginia and Ohio. U.S. Bureau of Mines IC 6872, 1935.

Keyword(s): coal mining, pillar extraction, active mines, mine design

Location(s): Pennsylvania, West Virginia, Ohio, Appalachian Coal Region, United States

Pauvlik, C. M. The Effects of Longwall Mining Subsidence on the Ground Water Conditions of a Shallow, Unconfined Aquitard Proximate to Old Ben Mine 25, West Frankfort, Illinois. M.S. Thesis, Southern Illinois University, 1986, 149 p.

This study presents the results of monitoring a shallow, unconfined, unconsolidated aquitard during the course of undermining and subsidence.

Keyword(s): subsurface water, longwall, monitoring methods, hydrology, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Pauvlik, C. M., S. P. Esling. The Effects of Longwall Mining Subsidence on the Groundwater Conditions of a Shallow, Unconfined Aquitard in Southern Illinois. IN: Proceedings, National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, December 7-11, 1987, Springfield, IL, University of Kentucky, Lexington, UKY BU145, p. 189-195.

This study investigated the effect of subsidence associated with longwall mining on a shallow surficial aquitard composed of glacially related sediments. A coal seam 2.4 meters thick and 150 meters deep was mined from a panel 150 meters wide. Three monitoring wells, two installed over the panel and one over nearby chain pillars to serve as a control, were drilled to bedrock. They ranged in depth from 10 to 14 meters. Monthly monitoring of hydraulic conductivity, head, and groundwater chemistry began 2 months before undermining and continued for 10 months. In addition, hydraulic conductivity and head were measured every few days as mining progressed. The possible effects of subsidence on groundwater chemistry were complicated by the application of fertilizer to the agricultural field. Water table elevations fell as a function of subsidence, and groundwater flow shifted from a northerly direction toward a stream to a northwesterly direction. Flow returned to the original configuration by the end of the study, but the gradient remained elevated by 63%.

Keyword(s): coal mining, subsurface water, hydrology, monitoring methods, active mines, longwall, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Payne, A. R., A. K. Isaac. The Application of Numerical Models in Coal Rib Pillar Design at Longwall Panels. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 685-692.

The rib pillars left between adjacent longwall panels are intended to protect the gateroads from harmful stress abutments, with a reduction in pillar width generally requiring an increase in strength of the gateroad support system. Numerical model simulation provides one method of investigating the effect of separate support elements to be evaluated together.

Keyword(s): modeling, mine design, longwall, coal mining, pillar strength

Location(s): United Kingdom

Payne, H. M. European Practice of Filling Abandoned Workings With Sand. Engineering and Mining Journal, v. 89, 1910, p. 522.

This article describes hydraulic sand backfilling at a mine in Poland, including methods, costs, and materials used.

Keyword(s): hydraulic backfilling, abandoned mines, economics

Location(s): Europe, Germany, Poland

Payne, H. R. Opportunities and Responsibilities. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference of the Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 617-621.

Some of the administrative and social responsibilities facing local authorities in dealing with hazardous events such as landslides, rock falls, mining subsidence, and coastal erosion are considered. These are illustrated by examples drawn from Wales.

Keyword(s): land-use planning, engineering, geologic features, government

Location(s): Wales, United Kingdom

Payne, H. R., ed. Mining Subsidence: South Wales Desk Study: Summary of Research and Description of the Mapping Techniques Developed. Department of the Environment/Welsh Office, Cardiff, 1986, 39 p.
Keyword(s): coal mining, literature search
Location(s): Wales

Payne, V. E. Coal Mining Subsidence and Golden Eagle Habitat. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 167-172.
Issues between resource utilization and resource preservation often develop in connection with coal mining. One such conflict exists in eastern Utah where PacifiCorp and Energy West Mining Company are working with state and federal agencies to address the resource recovery/resource preservation dispute. The effects of underground longwall coal mining on golden eagle cliff nesting sites have been studied at the Cottonwood Mine since 1986. Subsidence, escarpment spalling, and nesting activities of the local eagle population were monitored.
Keyword(s): environment, longwall, coal mining, active mines, wildlife
Location(s): Utah, Rocky Mountain Coal Region, United States

Peabody Coal Company. Ground Control and Slope Stability. Information Circular No. 138, 5/75, 1975, 14 p.
The main object of the study of slope stability and rock mechanics is to learn to predict rock behavior in and around excavations with increased confidence and to develop ground control. This paper presents attempts to study what happens and when and where slopes fail to possibly determine why the slope failed and to develop ground control by determining how to prevent future failures.
Keyword(s): ground control, rock mechanics, coal mining

Peabody Coal Company. Impact of Subsidence Regulations on Peabody Coal Company. Prepared by Peabody Coal Company, Illinois Division, Industrial Engineering Department, August 20, 1982.
This report was prepared to determine the potential effect of the proposed subsidence regulations on Peabody Coal Company's mines and reserve areas. Studies were made of key areas, and the results were applied to present operations and those in the most probable case for the next 10 years. The studies were conducted in the states of Kentucky, Illinois, and Ohio. The following information was evaluated: tonnage within the reserve, projected extraction ratio as presently mined, preventive factors affecting extraction ratio, projected extraction ratio to prevent subsidence under the proposed regulations, tonnage loss, topography of the area, and the potential percentage of recoverable reserves lost.
Keyword(s): law, coal mining, active mines, geologic features, room-and-pillar, high-extraction retreat, roof stability
Location(s): Kentucky, Illinois, Indiana, Ohio, Illinois Coal Basin, United States

Peck, R. B. Deep Excavation and Tunnelling in Soft Ground. IN: 7th International Conference on Soil Mechanics and Foundation Engineering, Mexico City, 1969.
Keyword(s): tunnelling, soil mechanics, engineering

Peele, R. Mining Engineers' Handbook. v. 1, 3rd edition, John Wiley & Sons, New York, 1944.
This handbook was written in 1929 and revised in 1941. It is useful as a historical and developmental reference for mining procedures, but it is not current enough for modern subsidence control techniques.
Keyword(s): historical
Location(s): United States

Pellissier, J. P., A. A. B. Williams, B. G. Lunt. Predicting and Assessing Undermining-Induced Distress in Typical South African Buildings. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 117-123.
High-extraction coal-mining has the advantage that a high percentage of the available coal can be extracted, but a disadvantage in that it causes surface subsidence. Buildings on the surface may show distress if undermined and a method of predicting this distress and of assessing the potential damage is required to help mine authorities make decisions about the economics of undermining.
Keyword(s): surface structural damage, active mines, prediction, geologic features, foundations, horizontal displacement, structural mitigation
Location(s): South Africa

Pellissier, J. P., A. A. B. Williams. The Cellular Raft Foundation for Buildings Over Mined Areas. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May, 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 125-130.

This paper discusses design of new buildings to resist or accommodate soil deformation due to high-extraction coal mining. Also included is information on foundation design for structures in the gold fields of South Africa. The most appropriate methods of construction for South African conditions are reviewed.

Keyword(s): coal mining, metal mining, active mines, foundations, engineering, structural mitigation, vertical displacement, horizontal displacement, lab testing, in situ testing, geologic features, pillar extraction, longwall

Location(s): South Africa

Pells, P. J. N., J. C. Braybrooke, J. Mong, G. P. Kotze. Cliff Line Collapse Associated with Mining Activities. IN: Proceedings, Extension Course on Soil Slope Instability and Stabilisation, Sydney, Australia, November 30-December 2, 1987, B.F. Walker and R. Fell, eds., Balkema, Rotterdam, p. 359-385.

This paper gives information on rockfalls and landslides within eight areas in the Sydney Basin where coal or oil shale mining has occurred beneath, or adjacent to, sandstone escarpments. The failures have occurred between about 1914 and the present day and have varied from minor rockfalls to approximately 30 million ton rocks at Nattai North.

Keyword(s): geologic features, coal mining, longwall, surface subsidence damage

Location(s): Australia

Pendleton, J. A. The Regulation of Coal Mine Subsidence in Colorado. IN: Mine Subsidence, M.M. Singh, ed., Society of Mining Engineers Fall Meeting, September, 1986, St. Louis, MO, SME, Littleton, CO, p. 101-108.

In response to Public Law 95-87 (SMCRA), Colorado promulgated regulations governing the mining of coal. These regulations require the prediction, monitoring, and mitigation of "material damage" caused by subsidence. All permitted underground coal mines within Colorado have approved subsidence programs. Preliminary monitoring results indicate the subsidence mechanical predictions have been sufficiently accurate to preclude material subsidence damage. The State of Colorado has developed a practical approach to regulating subsidence. It stresses monitoring verification of predicted subsidence phenomena. However, shortcomings exist in our ability to predict precisely the secondary consequences of subsidence, including effects to structures, the hydrologic balance, and the environment. Lack of accuracy in predicting these secondary consequences results in uncertainty, necessitating conservatism in permitting. Future research should emphasize the secondary consequences of subsidence to avoid increasingly stringent permit restrictions.

Keyword(s): coal mining, law, mitigation, monitoring methods, prediction, hydrology, surface structural damage, partial extraction, longwall, angle of draw, land-use planning, mine design, mine operation

Location(s): Colorado, Rocky Mountain Coal Region, United States

Peng, S. S. How Five Different Mines Apply Shortwall Methods to Mine Coal. Coal Age, March, 1976, p. 82-88.

Keyword(s): roof support, ground control, shortwall, coal mining, mine design, active mines

Peng, S. S. Roof Control Study of Low Coal Area, Olga No. 1 Mine, Coalwood, WV. Final report, U.S. Bureau of Mines Contract JO155125, July, 1976, 22 p.

Keyword(s): longwall, roof stability, ground control, pillar strength, mine design, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Peng, S. S., D. W. Park. A Review of Shortwall Mining in the United States. Coal Mining & Processing, December, 1977, p. 54-59.

Keyword(s): roof support, shortwall, coal mining

Location(s): United States

Peng, S. S., D. W. Park. Rock Mechanics Study for the Shortwall Mining at the Valley Camp No. 3 Mine, Triadelphia, WV. Final report, U.S. Bureau of Mines Contract JO155125, December, 1977.

Keyword(s): mine design, ground control, shortwall, rock mechanics, roof stability, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Peng, S. S. Roof Control Studies at Olga No. 1 Coal Mine, Coalwood, WV. IN: Energy Resources and Excavation Technology, Proceedings 18th U.S. Symposium on Rock Mechanics, Keystone, CO, June 22-24, 1977, F.-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, Golden, p. 1C3-1--1C3-6.

Two factors appeared to control the fall of roof in the Low Coal Area of the Olga No. 1 Mine: one is related to coal extraction; the other is independent of coal extraction and has to do with local geological features.

Keyword(s): geologic features, roof stability, coal mining, active mines

Location(s): West Virginia, Appalachian Coal Region, United States

Peng, S. S., M. H. Maung. Formula for Shape and Size Effects of U.S. Coal Pillar Strength, A Comprehensive Review. College of Mineral and Energy Resources, West Virginia University, Morgantown, December, 1978.

Keyword(s): pillar strength, coal mining

Location(s): United States

Peng, S. S. Surface Subsidence. IN: Coal Mine Ground Control, Chapter 9, John Wiley & Sons, New York, 1978, p. 281-342.

This chapter classifies and discusses two ground movement theories: descriptive theories and continuum mechanics theories. The author analyzes subsidence trough determination including descriptions of profiles, strains, profile slopes, and profile curvatures. Subsidence measurement techniques, surface damage, and prevention of damage to surface facilities are also covered.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, mine design, monitoring design, survey methods, survey equipment, prediction, descriptive theories, continuum mechanics, coal mining, prediction theories, ground control

Peng, S. S., K. K. Kohli, S. L. Cheng. Surface Subsidence and Structural Damages Due to Underground Longwall Coal Mining--A Case Study. IN: Rock Mechanics: A State of the Art, Proceedings 21st U.S. Symposium on Rock Mechanics, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 275-284.

This paper presents a case history of surface subsidence over a longwall section at an eastern Ohio mine, including surface monitoring plans, measured results, and subsequent surface structural damages.

Keyword(s): surface structural damage, monitoring design, survey design, mine operation, longwall, coal mining

Location(s): Ohio, United States, Appalachian Coal Region

Peng, S. S., S. L. Cheng. Evaluation of Surface Subsidence Potential Due to Underground Coal Mining at Upper Shavers Fork, Monongahela National Forest, Randolph/Pocahontas County, WV. Report on Office of Surface Mining PO P5211006, West Virginia University, 1980, 62 p.

Keyword(s): surface subsidence damage, environment, coal mining, land-use planning

Location(s): West Virginia, Appalachian Coal Region, United States

Peng, S. S., U. Chandra. Getting the Most from Multiple Seam Reserves. Coal Mining & Processing, v. 17, no. 11, 1980, p. 87-84.

Keyword(s): multiple-seam extraction, coal mining

Peng, S. S., K. Matsuki, W. H. Su. 3-D Structural Analysis of Longwall Panels. IN: Rock Mechanics: A State of the Art, Proceedings, 21st U.S. Symposium on Rock Mechanics, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 44-56.

Three-dimensional finite element analyses were performed to determine the major controlling factors in the design of an advancing longwall panel and its support systems. Comparisons of stress redistribution between advancing and retreating longwall systems and between rigid and soft support systems are presented along with the evaluations of the importance of those parameters, such as panel size, caved area, packwall material, packwall width and state of in situ stress. The analyses show that the most influential factors in the design evaluation are face width, Young's modulus of the packwall material, packwall width, and in situ lateral stresses. An example is presented to illustrate how these influential factors can be incorporated into the selection of design alternatives.

Keyword(s): longwall, coal mining, rock mechanics, modeling, finite element

Location(s): United States

Peng, S. S., S. L. Cheng. Predicting Surface Subsidence for Damage Prevention. Coal Mining & Processing, v. 18, no. 5, 1981, p. 84-95.

This paper contains background information on subsidence engineering, with reference to subsidence-related structural damage, and damage prevention techniques. An empirical subsidence prediction method is discussed.

Keyword(s): vertical displacement, surface structural damage, prediction, coal mining

Peng, S. S., S. L. Cheng. House Damages Due to Room and Pillar Mining. IN: Proceedings, 22nd U.S. Rock Mechanics Symposium, Cambridge, MA, June 1981, p. 335-340.

Keyword(s): surface structural damage, room-and-pillar

Peng, S. S., D. Y. Geng. Surface Subsidence, Overburden Behavior and Structural Damages Due to Longwall Mining--Two Case Studies. IN: Proceedings, 2nd International Conference on Stability in Underground Mining, 1982, University of Kentucky, p. 497-523.

Keyword(s): longwall, overburden, surface structural damage, coal mining

Peng, S. S., C. T. Chyan. Surface Subsidence, Surface Structural Damages and Subsidence Predictions and Modeling in the Northern Appalachian Coalfield. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 73-84.

This paper is a summary document of five previously published papers on subsidence over 24 longwall panels and 5 room-and-pillar sections in the northern Appalachian coalfield; it includes the physical characteristics of 54 surface subsidence profiles collected for longwall and room-and-pillar mining. Empirical and analytical methods of prediction and modeling are discussed in detail.

Keyword(s): vertical displacement, surface structural damage, longwall, room-and-pillar, prediction, modeling

Location(s): Appalachian Coal Region, United States

Peng, S. S., D. Y. Geng. Methods of Predicting the Subsidence Factor, Angle of Draw and Angle of Critical Deformation. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, SME-AIME, Y.P. Chugh and M. Karmis, eds., September, 1982, p. 211-221.

This report analyzes the effects of geology and mining methods on subsidence factor, angle of draw, and angle of critical deformation based on the results of 40 longwall subsidence profiles in the northern Appalachian coalfield.

Keyword(s): vertical displacement, horizontal displacement, longwall, prediction, ground control, angle of draw, geologic features, coal mining

Location(s): Appalachian Coal Region, United States

Peng, S. S., H. S. Chiang. Roof Stability in Longwall Coal Faces. IN: Proceedings, 1st International Conference on Stability in Underground Mining, Vancouver, British Columbia, August, 1982, p. 295-335.

Keyword(s): coal mining, roof stability, longwall, ground control

Peng, S. S., S. M. Hsiung. Development of Roof Control Criteria for Longwall Mining--Parametric Modeling I. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 51-58.

Keyword(s): coal mining, roof stability, longwall, modeling

Peng, S. S., H. S. Chiang. Longwall Ground Control--U.S. Experiences Journal of Mines, Metals, and Fuels, September, 1983, Special Number on Update on Longwall Mining--Evolving Trends, p. 397-415.

For over a decade, longwall mining in the United States has been demonstrated to be safe and easily in compliance with current laws. It is highly productive provided it is properly designed and operated.

Keyword(s): longwall, roof support, roof stability, mine design

Location(s): United States

Peng, S. S., D. Y. Geng. The Appalachian Field: General Characteristics of Surface Subsidence and Monitoring Methods. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, 1983, p. 627-646.

This paper discusses the zones of caving and deformation found from just above the mined-out coal seam up to the surface. In addition, many terms and concepts are defined.

Keyword(s): vertical displacement, horizontal displacement, angle of draw, coal mining, overburden, prediction, longwall, monitoring methods, survey methods

Location(s): United States

Peng, S. S., H. S. Chiang. Longwall Mining. John Wiley & Sons, New York, 1984, 708 p.

Keyword(s): longwall, mine design, surface structural damage , active mines, coal mining, monitoring methods, survey data processing, overburden, vertical displacement, horizontal displacement

Peng, S. S. Longwall Mining in the US: Where Do We Go From Here? Mining Engineering, March, 1985, p. 232-234.

Modern longwall mining, introduced to the United States coal industry in the mid-1960s, is the latest coal mining technique. Today, longwall mining produces more than 15% of all underground coal production. The growth of longwall mining in the United States is slow. Nearly two decades of longwall mining have demonstrated that its benefits outweigh the disadvantages.

Keyword(s): longwall, coal mining, mine safety, economics, active mines, mine design

Location(s): United States

Peng, S. S., W. H. Su. Socio-Economic, Subsidence, Transportation and Legal Ramifications of Potential Liquefaction Plant Sitings. Task: Prediction of Subsidence Potential Over Abandoned Mine Land. Final Report to Pittsburgh Energy Technology Center, U.S. DOE, Grant No. DE-FG22-83PC60053, 1986, West Virginia University, Morgantown, 32 p.

The purpose of this study is to investigate the causative factors for subsidence over abandoned coal mines. Roof caving, pillar failure, and pillars punching into soft mine floor are discussed in detail. Aging and creep are considered two of the most important processes controlling the causative factors. Creep tests of coal measure rocks were conducted in the laboratory to better define the time-dependent behavior of coal pillars and the rocks surrounding them. Procedures for predicting subsidence potential over an abandoned coal mine were proposed using a combined statistical and material strength approach.

Keyword(s): coal mining, abandoned mines, roof stability, pillar strength, floor stability, lab testing, prediction

Location(s): United States

Peng, S. S. Case Studies Illustrate the Need for a New Concept of Coal Pillar Design. Mining Engineering, v. 38, no. 11, November, 1986, p. 1033-1035.

The most commonly used ground control design in coal mining is the determination of pillar size by various pillar strength formulas for mine layout. However, there have been few documented case histories concerning the validity of those strength formulas.

Keyword(s): pillar strength, room-and-pillar, mine design, roof support, finite element, coal mining, ground control

Location(s): United States

Peng, S. S., W. M. Ma, W. L. Zhong. Longwall Mining Under Linear Structures--A Case Study. IN: Mine Subsidence, M.M. Singh, ed., Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, SME, Littleton, CO, p. 51-64.

Across a longwall section that consisted of seven panels, there were two high pressure gas transmission pipelines buried from 3 to 10 feet below the surface. Strain gages were mounted on the pipelines above three of the panels to investigate the stress conditions sustained by the pipelines during underground longwall mining. Survey monuments were also installed along, but near, the pipelines. This paper presents a subsidence prediction method and the preliminary results of pipeline stress conditions as affected by underground longwall mining.

Keyword(s): longwall, pipelines, survey methods, monitoring methods, prediction, survey data processing, horizontal displacement, influence function

Peng, S. S., A. W. Khair, Y. Luo. Topographical Effects of Surface Subsidence--A Case Study. IN: Proceedings, National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, Springfield, IL, December 7-11, 1987, University of Kentucky, Lexington, p. 223-228.

Surface movement, including vertical subsidence and horizontal displacement due to longwall mining, was measured for a panel located in a steep terrain. The measured vertical subsidence matched fairly well with that predicted by the probability integration function method while the measured horizontal displacement differed considerably from that predicted by the focal point method for flat surfaces. In most cases the horizontal displacement moved downward along the true dip direction regardless of face location and panel geometry. It was hypothesized that top soil moved separately from the bedrock and contributed to the excessive horizontal displacement.

Keyword(s): vertical displacement, horizontal displacement, longwall, geologic features, overburden, computer, modeling, coal mining, survey design, survey methods, survey data processing

Location(s): West Virginia, Appalachian Coal Region, United States

Peng, S. S., P. M. Lin, S. M. Hsiung. Subsidence Over AML and Its Causes--A Case Study. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 147-167.

Subsidence over abandoned mined lands can be attributed to several causes. For purposes of compensation, liability, and development of remedial measures, it is essential to identify the real causes. Detailed procedures for a subsidence investigation are given in this paper. The keys to identification and determination of the causes and severity of damages are illustrated and discussed through a case study in this paper.

Keyword(s): abandoned mines, surface structural damage, monitoring methods, instrumentation, monitoring equipment

Location(s): Pennsylvania, Appalachian Coal Region, United States

Peng, S. S. Development of an Improved Longwall Mining Technique--An Integrated Multidisciplinary Approach. SME Preprint 89-188, for presentation at SME Annual Meeting, Las Vegas, NV, February 27-March 2, 1989, 18 p.

An expert team consisting of geology, civil engineering, and mining engineering professors was organized to investigate several problems of longwall mining in three mine sites. Problems included site investigation, panel layout and support selection, overburden strata movement, surface subsidence and structural damages, slope stability, well and stream dewatering, and other topics. The results include the development of a PC software package such as powered support selection, surface subsidence prediction, optimum panel dimension, and pillar design.

Keyword(s): longwall, overburden, surface structural damage, surface water, subsurface water, computer, prediction, coal mining

Location(s): United States

Peng, S. S., Y. Luo. Slope Stability Under the Influence of Ground Subsidence Due to Longwall Mining. Mining Science and Technology, v. 8, no. 2, 1989, p. 89-95.

Surface subsidence, especially horizontal displacements, induced by underground longwall mining in hilly regions is reportly different from that in level areas. The mechanisms behind this phenomenon are not clear however. Here, this problem is considered to be a slope stability problem, and a mathematical model is proposed to assess the slope stability under the influence of subsidence due to longwall mining.

Keyword(s): coal mining, longwall, horizontal displacement, mathematical model, overburden, modeling

Peng, S. S. Some Basic Problems in Coal Mine Ground Control Discussed. Mining Engineering, v. 41, no. 8, August, 1989, p. 835-838.

The biggest problem in coal mine ground control is that miners are dealing with materials of rapidly varying properties and occurrence and only the exposed surface can be identified positively. Thus, in attempting to solve ground control problems, many unknown factors are assumed. Some of the problems deriving from such assumptions are discussed here, including coal pillars, geological conditions, in situ stress, instrumentation, computer modeling, surface subsidence, and floor heave.

Keyword(s): coal mining, ground control, instrumentation, computer, modeling, floor stability, roof stability, rock mechanics, geologic features, vertical displacement, horizontal displacement, subsurface water

Location(s): United States

Peng, S. S. Comments on Surface Subsidence Prediction. Mining Science and Technology, v. 11, 1990, p. 207-211.

The problems concerning the application of various types of subsidence prediction models are discussed, including model imperfection, errors in representative coefficients or parameters and subsidence survey, and human errors. Prediction accuracy and methods of evaluating model prediction accuracy are also discussed.

Keyword(s): prediction, prediction theories, coal mining, modeling, finite element, geologic features, profile function, influence function

Peng, S. S. Surface Subsidence Engineering. Society for Mining, Metallurgy, and Exploration, Inc., Littleton, CO, 1992, 161 p.

Surface subsidence caused by underground mining is an old problem that did not receive its due attention in the United States until after the mid-1960s. The increasing use of longwall mining and further housing development into the abandoned mined lands in suburban areas further accelerated public concerns about surface subsidence resulting from underground mining. Many research programs have been initiated and completed since the passage of SMCRA in 1977. The data obtained from these intensified research programs have demonstrated that surface subsidence due to underground mining is a complicated problem resulting from the interaction between mining operation, overburden geological conditions, and time. As such, the exact process and its prediction and prevention tend to be site specific, although there are general trends and principles applicable to most subsidence problems. In this book, the general trends and principles about surface subsidence due to underground coal mining are discussed.

Keyword(s): active mines, coal mining, engineering, overburden, geologic features, vertical displacement, horizontal displacement, prediction, profile function, influence function, finite element, mathematical model, modeling, prediction theories, surface structural damage, structural mitigation, monitoring methods, room-and-pillar, longwall, abandoned mines, subsurface water, hydrology

Peng, S.S. Underground Design Models Prove Practical. Coal, v. 97, no. 5, May, 1992, p. 46-49.

Combining developmental theories and field validation, four ground control programs have been developed: PILLAR, ROOFBOLT, DEPOWS, AND CISPM. All of the programs can be used for longwall and room-and-pillar mine design.

Keyword(s): modeling, mine design, active mines, longwall, room-and-pillar, surface structural damage, coal mining, finite element, geologic features, yielding supports, prediction, pillar strength

Location(s): Kentucky, West Virginia, Appalachian Coal Region, United States

Peng, S. S., Y. Luo. Comprehensive and Integrated Subsidence Prediction Model -CISPM (V2.0). IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 22-31.

This paper presents a computer program for predicting surface movement and deformation caused by underground coal extractions. The program is capable of predicting final surface movement and deformation over underground openings, predicting dynamic surface movement and deformation process associated with underground longwall mining operations, processing subsidence data, recommending subsidence parameters for those new coal mines where no subsidence data are available, and deducing subsidence parameters from collected data.

Keyword(s): computer, prediction, coal mining, active mines, longwall, geologic features, mathematical model, influence function

Peng, S. S., Y. Luo. A New Method for Designing Support Area to Protect Surface Structures Over Underground Coal Mining Areas. Society for Mining Metallurgy and Exploration Preprint 93-265, for presentation at SME-AIME Annual Meeting, Reno, NV, February 15-18, 1993, 7 p.

The size of the support area for structures designed as stated in the Pennsylvania Underground Coal Mining Rules (1985) will be excessively large, resulting in wasteful use of the coal reserve when the overburden depth is more than 350 feet. A more scientific method is proposed for designing the support area. This method is based on a large amount of subsidence data collected throughout a number of major coal fields in the United States and the authors' experience with monitoring and protecting surface structures undermined by longwall panels. It considers the critical deformation indices that a structure can tolerate, and depth and height of underground extraction. The support area designed by this new method will not only assure the safety of the structure to be supported but also maximize the extraction of the coal reserve.

Keyword(s): coal mining, surface structural damage, active mines, longwall, partial extraction, overburden, influence function

Location(s): Pennsylvania, Appalachian Coal Region, United States

Peng, S. S. Strength of Laboratory-Sized Coal Specimens vs. Underground Coal Pillars. Mining Engineering, v. 45, no. 2, February 1993, p. 157-158.

Is the laboratory-sized coal specimen much stronger than underground coal pillars? The answer to this question has a profound implication for many coal operators. It will decide how much of the coal reserve can be recovered.
Keyword(s): pillar strength, lab testing, coal mining, rock mechanics
Location(s): United States

Peng, S. S., ed. Proceedings, 1st Conference on Ground Control in Mining. Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, July 1981, 259 p.
Keyword(s): ground control, coal mining, pillar strength, roof stability, roof bolting, longwall, prediction, monitoring methods

Penman, D. Hydraulic Stowing in Thick Seams of India. Transactions, Institution of Mining Engineers, v. 80, 1930-31, p. 123.
Hydraulic backfilling in India is described, where many seams are more than 20 feet thick and range up to 90 feet thick.
Keyword(s): hydraulic backfilling, pillar extraction, room-and-pillar
Location(s): India

Pennington, D., J. G. Hill, G. J. Burgdorf, D. R. Price. Effects of Longwall Mine Subsidence on Overlying Aquifers in Western Pennsylvania. U.S. Bureau of Mines OFR 142-84, 1984, 129 p. (NTIS PB84 236710)
Groundwater levels and subsidence were monitored over a longwall panel of a deep coal mining operation located in western Pennsylvania.
Keyword(s): subsurface water, longwall, hydrology, coal mining, geophysical, overburden, inflow
Location(s): Pennsylvania, Appalachian Coal Region, United States

Pennsylvania Anthracite Subsidence Commission. Final Report. Submitted to the Legislature, March 15, 1943, 12 p.
Keyword(s): government, anthracite, coal mining, law
Location(s): Pennsylvania, Appalachian Coal Region, United States

Pennsylvania Department of Commerce, Bureau of Appalachian Development. Mine Subsidence Information Center. June, 1977, 47 p. (NTIS PB 274 108)
Keyword(s): land-use planning, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Pennsylvania Department of Commerce, Bureau of Appalachian Development. Bituminous Mining Laws of Pennsylvania. 1953, 305 p.
Keyword(s): law, coal mining, government, bituminous
Location(s): Pennsylvania, Appalachian Coal Region, United States

Pennsylvania Department of Mines. Anthracite Mining Laws of Pennsylvania. 1954, 240 p. (Available for consultation at the USBM Denver Research Center.)
This document contains laws enacted in 1954 that pertain to subsidence resulting from anthracite mining in northeastern Pennsylvania.
Keyword(s): law, anthracite, coal mining, surface subsidence damage
Location(s): Pennsylvania, Appalachian Coal Region, United States

Pennsylvania Department of Mines and Minerals. Bituminous Mining Laws of Pennsylvania for Underground Mines. 1961, 231 p.
Keyword(s): law, coal mining, bituminous, government
Location(s): Pennsylvania, Appalachian Coal Region, United States

Pennsylvania Subsidence Committee. Report of the Subsidence Committee to the General Assembly of the Commonwealth of Pennsylvania. March 1, 1957, 54 p.
Keyword(s): government, law, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Perin, R. J., D. G. Puglio. Bailey Mine Slurry Impoundment Longwall Subsidence Monitoring. IN: Proceedings, 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., West Virginia University, p. 83A.
Subsidence monitoring was conducted in proximity to the 1-A and 2-A longwall panels at the Bailey Mine slurry impoundment of Consol Pennsylvania Coal Company. Monitoring fulfills federal Mine Safety and Health Administration mandated requirements. Monitoring was conducted before, during, and after mining of the panels. The embankment was not deleteriously impacted by longwall mining.

Keyword(s): longwall, monitoring methods, geologic features, geotechnical, survey methods, foundations, instrumentation, vertical displacement, horizontal displacement, prediction, modeling, surface water

Location(s): Pennsylvania, Appalachian Coal Region, United States

Persche, E. P. Architectural Mitigating Measures to Control Subsidence Damage. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 215-221.

With development of the Rocky Mountain region, damage to buildings due to mine subsidence has increased. Much of the reported damage could be avoided by prudent planning and zoning. Where zoning does not keep building away from mine subsidence areas, other measures have to be employed to avert or mitigate potential subsidence damage.

Keyword(s): surface structural damage, abandoned mines, geotechnical, structural mitigation, architecture, construction, foundations, utilities, coal mining

Location(s): Rocky Mountain Coal Region, United States

Perz, F. Mathematical Relationships and Subsidence Troughs. Mine and Quarry Engineering, v. 23, June 1957, p. 256-260.

This paper describes a subsidence prediction method that uses mathematical relationships to model the formation of subsidence troughs above mine workings, taking into account the properties of overlying strata.

Keyword(s): vertical displacement, horizontal displacement, prediction, mathematical model, modeling, geologic features

Perz, F. A New Method of Expressing the Mathematical Relationships Governing the Formation of Subsidence Troughs Above Mine Workings. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 21-26.

Keyword(s): mathematical model, modeling

Perz, W. Subsidence Observations on Workings in Austrian Tertiary Carboniferous Synclines. U.S. Bureau of Mines Translation No. 199, 1956, 6 p.

Keyword(s): coal mining

Location(s): Austria

Perz, W. Observations of Subsidence Over Underground Workings in the Tertiary Coal Basins. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 92-98.

Keyword(s): surface subsidence damage, coal mining

Location(s): Austria

Perz, W. Subsidence Observations in Austria. Colliery Engineering, v. 35, no. 12, 1958, p. 533-535.

Keyword(s): coal mining

Location(s): Austria

Peterlee Development Corporation. The Master Plan--Report. 1952.

The development of the new town of Peterlee in northeast England provides an instance of successful coordination of surface building and underground coal mining.

Keyword(s): multiple-seam extraction, land-use planning, surface structural damage, construction, National Coal Board, coal mining, architecture

Location(s): England

Peters, D. C., R. A. Speirer, V. R. Shea. Lineament Analysis for Hazard Assessment in Advance of Coal Mining. IN: ERIM Symposium, 6th Thematic Conference on Remote Sensing and Geology, Houston, TX, 1988, p. 253.

Lineament analysis, a common remote sensing tool for petroleum and mineral exploration, can be used for coal mine properties to assess potential ground control hazards by estimating the relative degrees of risk associated with geologic structures that cause the lineaments. This assessment can be applied to unmined properties to provide a preliminary analysis for mine feasibility planning or to active mines to evaluate potential hazards in undeveloped reserves. Studies using this analysis, in-mine observation of lineament locations and ground control problems, and ancillary data have been conducted in Utah and northern Alabama.

Keyword(s): coal mining, active mines, remote sensing, geologic features

Location(s): Utah, Alabama, United States

Peters, W. R., T. M. Campbell, V. R. Sturdivant. Detection of Coal Mine Workings Using High-Resolution Earth Resistivity Techniques. Report on Contract HO292030, SW Research Institute, U.S. Bureau of Mines OFR 55-81, 1980, 80 p. (NTIS PB 81-215378)

Keyword(s): coal mining, monitoring equipment, abandoned mines, geophysical
Location(s): United States

Peterson, D. E. Problems of Basin Subsidence in the Southwest. Mining Engineering, v. 17, 1965, p. 51.
Keyword(s): fluid extraction
Location(s): United States

Petley, D. J., F. G. Bell. Settlement and Foundations. IN: Foundation Engineering in Difficult Ground, F.G. Bell, ed., Butterworth, London, 1978, p. 293-321.
Keyword(s): foundations, soils

Pflaging, K. Quantifying the Effects of Continuous Underground Mining. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 354-376.
The influence of continuous underground mining operations on movements was first described by Lautsch (1969). He found that the results of level measurements carried out during the period from 1950 to 1966, covering successive underground workings in one tectonic zone, showed increasing deviation from precalculated figures after every measurement interval.
Keyword(s): prediction, coal mining, horizontal displacement, remote sensing, vertical displacement
Location(s): Germany

Philbrick, S. S. Investigation and Proposed Treatment of Caved Mine Beneath a 20-Story V. A. Hospital. Geological Society of America Bulletin, v. 59, 1948, p. 1344.
This abstract describes pressure grouting of an undermined site.
Keyword(s): surface structural damage, backfilling
Location(s): Pennsylvania, Appalachian Coal Region, United States

Philbrick, S. S. Cyclic Sediments and Engineering Geology. IN: Proceedings, 21st International Geological Congress, 1960.
The concept of cyclic sedimentation is related to common problems encountered in foundation investigations in coal sequences. The author discusses remedial measures required over undermined areas.
Keyword(s): engineering, foundations, structural mitigation, coal mining, soils

Phillips, D. W. The Nature and Physical Properties of Some Coal Measure Strata. Transactions, Institute of Mining Engineers, v. 80, 1930-31, p. 212-242; v. 81, 1930-31, p. 30-33; v. 82, 1931-32, p. 432-449; v. 83, 1931-32, p. 229-237.
The results of laboratory strength tests on different types of coal measure rocks are given, including a description of the nature of fractures which form in the roof.
Keyword(s): pillar strength, angle of draw, time factor, modeling, coal mining, overburden, lab testing, geologic features

Phillips, D. W., T. J. Jones. Strata Movements Ahead of and Behind Longwall Faces. Transactions, Institute of Mining Engineers, v. 101, 1941, p. 348-351.
This paper discusses results of observations ahead of and behind a longwall face at a depth of 900 yards. A seam 250 yards above the longwall face was monitored for subsidence effects.
Keyword(s): subsurface subsidence damage, multiple-seam extraction, longwall
Location(s): England

Phillips, D. W., H. Henshaw. Underground and Surface Strata Movements. Transactions, Institute of Mining Surveyors, January, 1942, v. 21, Pt. I.
Keyword(s): surface subsidence damage, subsurface subsidence damage

Phillips, D. W. Research on Strata Control in Great Britain. Transactions, AIME, v. 168, 1946, p. 27-50.
Roof and roadway maintenance pertaining to ground control in Great Britain are described. Strain distribution near roadways and methods for measuring strain and loading are discussed.
Keyword(s): ground control, roof support, mine operation, monitoring methods, subsidence research
Location(s): United Kingdom

Phillips, D. W. American Coal Mining. Colliery Guardian, v. 175, no. 4523, 1947, p. 37-43.
Keyword(s): mine design, coal mining
Location(s): United States

Phillips, R. A., D. V. Holmquist. Backfilling of the Pikeview Mine Manway. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 255-265.

Evaluation of subsidence potential over the Pikeview Coal Mine sloping entryway in Colorado Springs, Colorado, indicated a substantial risk of future ground movements. A procedure was formulated to block the lower end of the entryway and backfill the upslope portion of the opening with cement slurry.

Keyword(s): abandoned mines, hydraulic backfilling, historical, reclamation, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, United States

Phillips, R. A., D. V. Holmquist, J. S. L. Morgan. Rock Springs, Wyoming Subsidence Abatement Project--Downtown Area. IN: Proceedings, Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 356-366.

Evaluation of subsidence potential over a portion of a mine that underlies the southern half of downtown Rock Springs, Wyoming, indicated a high risk of future ground movements. A procedure was formulated to isolate the portion of the mine underlying the project site with grouted gravel or zero slump grout barriers. The area would then be stabilized with grout backfill or by pressure injection of low strength grout into the mined zone where sand slurry had previously been placed. This paper details some of the findings of the subsidence evaluation and describes the methods used to stabilize the underlying mined zone.

Keyword(s): coal mining, abandoned mines, grouting, railroads

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Pielok, J. Bestimmung Der Senkungen In Dynamischen Zwischenstufen Des Sendungstroges (Determining the Subsidence in the Dynamic Intermediate Stages of the Subsidence Trough). Academy of Mining & Metallurgy, Cracaw, Poland, Neue Bergbautechnik, v. 3, no. 9, 1973, p. 642-644.

Keyword(s): prediction

Pierce, R. L. Reducing Land Subsidence in the Wilmington Oil Field By Use of Saline Waters. IN: Proceedings, Saline Water Symposium, Water Resources Research, v. 6, 1970, p. 1505-1514.

Keyword(s): oil extraction

Pierson, F. L. Application of Subsidence Observations to Development of Modified Longwall Mining System for Potash. SME-AIME Annual Meeting, New York, February 14-18, 1965, SME-AIME Preprint 65-AM-22, 19 p.

Two-stage extraction room-and-pillar mining of potash was found to increase pressure on the extraction face; the solution was to reduce the extraction rate, resulting in yielding pillars, rather than caving. Increased extraction resulted since no pillars were completely abandoned as a result of unstable roof conditions.

Keyword(s): longwall, non-metal mining, room-and-pillar, pillar extraction, pillar strength, yielding supports

Location(s): United States

Piggford, J. Notes on Subsidence Caused by Coal Workings at Teversal and Pleasby Collieries. Transactions, Institute of Mining Engineers, London, 1909.

Keyword(s): surface subsidence damage, coal mining

Location(s): England

Piggott, R. J., P. Eynon. Ground Movements Arising from the Presence of Shallow Abandoned Mine Workings. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 749-780.

Underground mineral extraction has taken place for many centuries. Mining methods did not develop at the same rate for all minerals, either in the same or in different countries. Because of the scope of this subject, in this brief review of the historical background, only the development of coal mining practice at shallow depth in the United Kingdom is discussed.

Keyword(s): coal mining, abandoned mines, historical, surface subsidence damage

Location(s): United Kingdom

Pillar, C. L., A. D. Drummond. Importance of Geological Data in Planning Underground Ore Extraction. SME-AIME Fall Meeting and Exhibit, Pittsburgh, PA, September 19-21, 1973, Preprint No. 73-1-312.

Keyword(s): roof stability, ground control, mine design, geologic features

Location(s): United States

Pineda, L., J. Lucas. For Better or for Worse: Public Involvement in Subsidence Abatement Decisions at the Virginia Mine, Colorado. IN: Proceedings National Symposium and Workshops on Abandoned Mine

Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 661-675.

In 1981 Colorado found itself overwhelmed by concerned citizens with a major subsidence problem in a suburban neighborhood area. Unlike previous subsidence events in Colorado, this was the first occurrence of damage that resulted in local government action to rezone an entire neighborhood using geological hazard zoning authority. The residents soon discovered that their homes were not salable, even at deeply discounted prices. They could not obtain building permits without performing detailed geotechnical evaluations, and they could not obtain loans for repairs or new construction. The affected homeowners filed a major law suit against the county and the developer.

Keyword(s): abandoned mines, surface structural damage, government, coal mining, reclamation

Location(s): Colorado, Rocky Mountain Coal Region, United States

Piper, T. B. Surveys for Detection and Measurement of Subsidence. Solution Mining Research Institute, Project Report 81-0003-SMRI, January, 1981, Woodstock, IL, 53 p.

This report was prepared for companies engaged in solution mining and is intended to serve as an outline of the technology of detecting, measuring, and reporting subsidence. It is intended for use by the industry or others faced with similar problems.

Keyword(s): survey design, monitoring design, non-metal mining, survey methods, survey data processing, survey equipment, monitoring equipment

Location(s): United States

Pittsburgh Coal Company. Subsidence...Its Cause, Effect, and Prevention. Pittsburgh Coal Company Library, Pittsburgh, PA, 1957, 6 p. (Available for consultation at the USBM Denver Research Center.)

Keyword(s): coal mining, active mines

Location(s): Pennsylvania, Appalachian Coal Region, United States

Platt, J. Underclays of South Wales Coalfields and Their Influence on Floor Penetration. Ph.D. Thesis, University of Wales, Cardiff, 1956.

Keyword(s): floor stability, coal mining

Location(s): Wales

Plewman, R. P., F. H. Deist, W. D. Ortlepp. The Development and Application of a Digital Computer Method for the Solution of Strata Control Problems. South African Institute of Mining and Metallurgy Journal, v. 70, no. 2, September, 1969, p. 33-44.

The design of a completely digital mathematical model to be used in place of previously used analog models is described in detail. The application of the model to an actual problem is included.

Keyword(s): computer, ground control, modeling, phenomenological model, elastic model, mathematical model

Location(s): South Africa

Poland, J. F., G. H. Davis. Subsidence of the Land Surface in the Tulare-Wasco (Delano) and Los Banos-Kettleman City Area, San Joaquin Valley, California. American Geophysical Union Transactions, v. 37, 1956, p. 287-296.

Keyword(s): fluid extraction

Location(s): California, United States

Poland, J. F. Land Subsidence Due to Ground Water Development. Journal of Irrigation and Drainage Division, ASCE, v. 84, no. IR3, Paper 1774, September, 1958, p. 11.

This paper describes subsidence in six areas of California caused by development of groundwater resources; mitigation or elimination procedures are suggested for the problem.

Keyword(s): subsurface water, fluid extraction

Location(s): California, United States

Poland, J. F. The Coefficient of Storage in a Region of Major Subsidence Caused by Compaction of an Aquifer System. U.S. Department Interior Geological Survey Professional Paper 424-B, Geological Survey Research 1961, p. B52-B54.

Keyword(s): fluid extraction, hydrology

Location(s): United States

Poland, J. F., J. H. Green. Subsidence in the Santa Clara Valley, California--A Progress Report. U.S. Department Interior, Geological Survey, Water-Supply Paper 1619-C, 1962, 16 p.

Keyword(s): fluid extraction

Location(s): California, United States

Poland, J. F., R. L. Ireland. Shortening and Protrusion of a Well Casing Due to Compaction of Sediments in a Subsiding Area in California. Geological Survey Research 1965, U.S. Department of the Interior, Geological Survey Professional Paper 525-B, p. B180-B183.

Keyword(s): fluid extraction
Location(s): California, United States

Poland, J. F., W. I. Gardner, M. N. Mayuga, T. Leps, P. Saint Amand. Symposium--What Studies of Land Subsidence Problems Should be Initiated or Further Implemented? IN: Proceedings, Landslides and Subsidence--2nd Geologic Conference, Los Angeles, California Resources Agency, Sacramento, 1966, p. 156-169.
Keyword(s): fluid extraction, subsidence research
Location(s): California, United States

Poland, J. F., R. E. Evenson. Hydrogeology and Land Subsidence, Great Central Valley, California. Geology of Northern California, California Division Mines and Geology Bulletin 190, 1966, p. 239-247.
Keyword(s): fluid extraction
Location(s): California, United States

Poland, J. F. Role of Pore Pressure in Subsidence Caused by Ground Water Withdrawal. Geological Society of America Paper 115, 1968, p. 179.
Keyword(s): fluid extraction, hydrology
Location(s): United States

Poland, J. F. Land Subsidence and Compaction, 1960-1964, in the Santa Clara Valley, California. Geological Society of America, Special Paper 101, (abstract), 1968, p. 167.
Keyword(s): fluid extraction
Location(s): California, United States

Poland, J. F. Status of Present Knowledge and Needs for Additional Research on Compaction of Aquifer Systems. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 88, v. 1, 1969, p. 11-21.
Keyword(s): fluid extraction, hydrology

Poland, J. F., G. H. Davis. Land Subsidence Due to Withdrawal of Fluids. IN: Reviews in Engineering Geology, v. 2, 1969, D.J. Varnes and G. Kiersch, eds., Geological Society of America, p. 187-269.
Keyword(s): fluid extraction
Location(s): United States

Poland, J. F. Subsidence and its Control. IN: Underground Waste Management and Environmental Implications, T.D. Cook, ed., Memoir No. 18, 1972, American Association Petroleum Geologists, Houston, p. 50-71.
Keyword(s): fluid extraction, ground control
Location(s): United States

Poland, J. F., B. E. Lofgren, F. S. Riley. Glossary of Selected Terms Useful in the Studies of the Mechanics of Aquifer Systems and Land Subsidence Due to Fluid Withdrawal. U.S. Department Interior, Geological Survey, Water-Supply Paper 2025, 1972, 9 p.
Keyword(s): fluid extraction
Location(s): United States

Poland, J. F., B. E. Lofgren, R. L. Ireland, R. G. Pugh. Land Subsidence in the San Joaquin Valley, California, as of 1972. Professional Paper 437-H, USGS, 1975.
Keyword(s): surface subsidence damage, fluid extraction
Location(s): California, United States

Poland, J. F. Land Subsidence Stopped by Artesian-Head Recovery, Santa Clara Valley, California. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 124-132.
Keyword(s): fluid extraction
Location(s): California, United States

Poland, J. F., ed. Guidebook to Studies of Land Subsidence Due to Groundwater Withdrawal. Studies and Reports in Hydrology, IAHS-UNESCO, 40, 1984, 323 p.
Keyword(s): fluid extraction, hydrology

Poole, G., J. T. Whetton. Stowage of the Goaf. Transactions, Institute of Mining Engineers, v. 82, 1931, p. 514 (abstract).
Keyword(s): stowing, mine waste
Location(s): England

Popovich, J. M., R. F. J. Adam, A. J. Miscoe, G. R. Desko. Returning Coal Waste Underground. IN: Proceedings, International Congress on Technology & Technology Exchange: Technology & the World Around Us, Pittsburgh, PA, October 8-10, 1984. International Technology Institute, Pittsburgh, p. 140-141.
The authors describe a backfilling system developed to hydraulically transport and dispose of preparation plant refuse into an underground mine section at a coal mine complex in southwestern Virginia. This design is adaptable to other mines with minor site-specific variations. Underground disposal will eliminate surface disposal sites with

their safety and health risks, and will reduce surface subsidence, increase pillar stability, and improve water quality. However, groundwater may still be affected, and this is a major concern. Because the drainage water is collected and recycled, no detrimental effect on groundwater is anticipated.

Keyword(s): hydraulic backfilling, mine waste, pillar strength, economics, coal mining

Location(s): Virginia, Appalachian Coal Region, United States

Popp, J. T. Surface Subsidence Due to Coal Mining in the Greater Egypt Region of Southern Illinois. Geological Society of America, North Central Section, Abstracts with Programs, v. 9, 1977, p. 642-643.

Keyword(s): surface subsidence damage, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Potash Company of America, Division of Rio Algom Ltd. The Study and Predictive Modelling of Subsidence Induced by Potash Mining. Canada/New Brunswick Mineral Development Agreement, contract number 23440-8-9083/01-SQ, July 13, 1990, 125 p. (NTIS MIC-91-00377)

The Potash Company of America mines potash and rock salt from an evaporite structure to the east of Sussex in southern New Brunswick. Mining of the potash is by a continuous cut-and-fill method, while the rock salt is mined using a room-and-pillar method. The mining operation takes place under the Trans Canada Highway as well as the low-lying Kennebecasis River valley. A preliminary finite element analysis was carried out and a high quality geodetic monitoring network was established to precisely determine ground surface movements caused by the mining activity. Surveys of various types were carried out over 2 years. This work will form the basis for a case history of surface subsidence induced by mining a complex evaporite body and will act as the first stage in the development of a predictive subsidence model.

Keyword(s): non-metal mining, finite element, monitoring methods, survey methods, instrumentation, modeling, prediction, roads, surface water

Location(s): Canada

Pothini, B. R. Finite Element Elastic Model Analyses of Mine Subsidence. M.S. Thesis, Pennsylvania State University, University Park, 1969, 119 p.

Keyword(s): finite element, modeling, elastic model

Pottgens, J. J. E. Ground Movements by Coal Mining in the Netherlands. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 267-282.

This paper discusses the Dutch coal-mining area, ground movement components, and prediction of subsidence by the integration net method (an empirical method).

Keyword(s): surface subsidence damage, surface structural damage, angle of draw, coal mining, prediction, empirical model, time factor

Location(s): Netherlands

Pottgens, J. J. E. Ground Movements Caused by Mining Activities in the Netherlands. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, L. Ubertini, eds., International Association of Hydrological Sciences Publication No. 151, 1986, p. 651-659.

The mining activities in the Netherlands consist of coal mining from the beginning of this century to the mid-1970s. Presently, oil and gas on- and offshore production takes place, particularly from one major gas reservoir. Subsidence results from the interaction between the compacting reservoir and its visco-elastic surroundings. This displacement interaction can be calculated for a disc-shaped reservoir using the theory of poro-elasticity. An outline is given of the subsidence due to coal mining in the past.

Keyword(s): coal mining, oil extraction, subsurface water, historical, abandoned mines, prediction, modeling

Location(s): Netherlands

Potts, E.L.J. Underground and Surface Strata Movements in Mining Areas. Colliery Guardian, v. 179, October 1949, p. 425-430.

Keyword(s): subsurface subsidence damage, surface subsidence damage

Potts, E.L.J. Ground Subsidence From Mining. Engineering, London, v. 168, 1949, p. 321-324.

Keyword(s): surface subsidence damage

Potts, E.L.J. The Influence of Time-Dependent Effects on the Design of Mine Pillars. IN: Proceedings, International Bureau of Rock Mechanics 6th International Meeting, 1964.
Keyword(s): time factor, mine design, pillar strength, rock mechanics

Potts, E.L.J. Current Investigations in Rock Mechanics and Strata Control. IN: Proceedings 4th International Conference on Strata Control and Rock Mechanics, May 4-8, 1964, Henry Krumb School of Mines, Columbia University, New York, 1965, p. 29-45.
The author describes trends in ground control and rock mechanics, especially with the use of rapidly advancing faces in longwall mining. The growth of rock mechanics research is of primary importance to the mining engineer.
Keyword(s): ground control, rock mechanics, mine design, mine operation, longwall
Location(s): England

Potts, E.L.J., W. H. Potts, A. Szeki. Development of Ground Control Techniques and Mining Design Parameters in Rock-Salt Mining. IN: Proceedings, 5th International Strata Control Conference, London, 1972, Paper No. 26, 8 p.
Keyword(s): ground control, non-metal mining, mine design

Potts, E.L.J. Mining Subsidence and the Environment. IN: Proceedings, International Symposium on Mining and the Environment, London, June 4-7, 1974, Institute of Mining and Metallurgy, London, 1975, p. 661-683.
Keyword(s): environment

Powell, L., R. Yarbrough, L. Harp. Planning for Subsidence at Rend Lake, Illinois. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 158-166.
High extraction mining is approaching low-lying environmentally sensitive and high public use areas on the east edge of Rend Lake. Advanced planning is required to maximize coal extraction and minimize the potential for adverse effects from subsidence on current and future land use. Premining assessment of the potential effects of subsidence on wildlife habitats, drainage, and structures is helping to develop mining plans that meet mining and environmental regulations and ensuring the continued surface land use of the areas with minimum amount of disruption.
Keyword(s): land-use planning, active mines, coal mining, environment, surface water, mine design, government, law, longwall, subsidence research, wildlife
Location(s): Illinois, Illinois Coal Basin, United States

Powell, L. R. Longwall Subsidence Case History Number 1. Northern Appalachian Coal Region. U.S. Bureau of Mines OFR 124(1)-81, v. 1, 1981, 12 p.
Keyword(s): longwall, coal mining
Location(s): Appalachian Coal Region, United States

Powell, L. R. Longwall Subsidence Case History Number 2. Northern Appalachian Coal Region. U.S. Bureau of Mines OFR 124(2)-81, v. 2, 1981, 10 p.
Keyword(s): longwall, coal mining
Location(s): Appalachian Coal Region, United States

Powell, L. R. Longwall Subsidence Case History Numbers 3 and 4. Northern Appalachian Coal Region. U.S. Bureau of Mines OFR 145-81, 1981, 17 p.
Keyword(s): longwall, coal mining
Location(s): Appalachian Coal Region, United States

Powell, L. R. Longwall Subsidence Case History Number 1. Northern Appalachian Coal Region. Technical Progress Report, U.S. Bureau of Mines, 1985.
Keyword(s): longwall, coal mining
Location(s): Appalachian Coal Region, United States

Powell, L. R. Longwall Subsidence Case History Number 2, Northern Appalachian Coal Region. Technical Progress Report, U.S. Bureau of Mines, 1985.
Keyword(s): longwall, coal mining
Location(s): Appalachian Coal Region, United States

Powell, L. R., P. B. DuMontelle. The Illinois-Bureau of Mines Cooperative Mine Subsidence Research Program. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 29-31, 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, v. 2, p. 13-17.
The USBM and the State of Illinois have periodically cooperated on mine subsidence research since 1911. In 1985 Congress provided

research funds to the Bureau for a study of Illinois subsidence problems with matching funds to be provided from non-federal state sources. The Bureau and the State of Illinois are cooperating to develop guidelines for underground mining methods to maximize coal recovery, minimize the surface effects of subsidence, and maximize mine stability. This paper highlights past and present subsidence research projects within Illinois.

Keyword(s): subsidence research, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Powell, L. R., T. L. Triplett, R. E. Yarbrough. Measurement and Analysis of Foundation Tilt Resulting From Mine Subsidence in Southern Illinois. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 142-152.

The USBM, in cooperation with the Illinois Mine Subsidence Insurance Fund, is monitoring the response of two foundations to ground movements induced by subsidence from high-extraction mining in southern Illinois. The objectives of the monitoring program are to study the interaction between the ground surface and a foundation during a subsidence event and to determine the capability of the tiltmeter to detect and monitor subsidence movements.

Keyword(s): insurance, foundations, monitoring methods, monitoring equipment, vertical displacement, survey methods, coal mining, active mines, instrumentation, high-extraction retreat

Location(s): Illinois, Illinois Coal Basin, United States

Powell, L. R., R. Yarbrough. Analysis of Level Survey Data Over Mine Subsidence Events in Illinois, USA--Abandoned and Active Mines. IN: Proceedings, International Symposium on Deformation Measurement Analysis and Prediction, June 6-9, 1988, University of New Brunswick, Fredericton, p. 430-439.

The major technique for monitoring ground movements caused by active and abandoned mines in Illinois is by level survey. This technique is used to monitor the growth and duration of mine subsidence events to determine when structural repairs can safely begin. Because surveying is costly over long periods of time, several alternative, less costly monitoring techniques are under investigation by the USBM in conjunction with the Illinois Mine Subsidence Insurance Fund (IMSIF). New survey guidelines adopted by the IMSIF and procedures for monitoring subsidence events in urban areas of Illinois are presented. Three case histories, including both abandoned and active mines, are discussed to illustrate the suggested survey guidelines and monitoring methods.

Keyword(s): insurance, monitoring equipment, survey data processing, abandoned mines, active mines, coal mining, computer, modeling, prediction, instrumentation, monitoring methods, surface structural damage, foundations, high-extraction retreat, room-and-pillar, horizontal displacement, vertical displacement

Location(s): Illinois, Illinois Coal Basin, United States

Powell, L. R., T. L. Triplett, R. E. Yarbrough. Foundation Response to High-Extraction Mining in Southern Illinois. U.S. Bureau of Mines RI 9187, 1988, 54 p.

The USBM, in cooperation with the Illinois Mine Subsidence Insurance Fund, instrumented and monitored the response of two foundations to ground movements induced by subsidence from high-extraction retreat mining in southern Illinois. The objective was to study the interaction between the ground surface and a foundation during a subsidence event to enhance the understanding of the mechanisms that produce subsidence effects in structures. This study measured the response of two differently constructed foundations to subsidence, evaluated the capability of the instrumentation and monitoring program to detect and track foundation and ground movements, and provided data for developing mitigative techniques to reduce foundation damage and formulate economic repair strategies. The instrumentation and monitoring plan successfully measured the response of the foundations to the ground movements.

Keyword(s): foundations, high-extraction retreat, instrumentation, monitoring methods, monitoring design, structural mitigation, construction, monitoring equipment, vertical displacement, horizontal displacement, insurance, partial extraction, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Powell, L. R., R. E. Yarbrough. Monitoring Subsidence-Induced Structural Movements Over Abandoned Coal Mines in Illinois. IN: Proceedings, Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 56-78.

The USBM and the Illinois Mine Subsidence Insurance Fund (IMSIF) have cooperated since the early 1980s in instrumenting, monitoring, and analyzing subsidence-induced ground movements in Illinois. The major objective has been to understand, describe, and analyze the response of surface structures to ground movements. The coal mining industry and IMSIF are both responsible for repairing structures that have been affected by mine subsidence in Illinois. Industry is responsible for active mines and mines over which they do not own a subsidence waiver.

Keyword(s): active mines, abandoned mines, coal mining, surface structural damage, monitoring methods, monitoring equipment, monitoring design, instrumentation, foundations, insurance, survey methods, survey data processing, high-extraction retreat, vertical displacement, horizontal displacement, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Powell, W. J., P. E. LaMoreaux. A Problem of Subsidence in a Limestone Terrain at Columbiana, Alabama. U.S. Geological Survey, Water Resources Division, and Geological Survey of Alabama, Circular 56, 1969.

Subsidence problems in a karst area are aggravated by groundwater withdrawal from deep wells.

Keyword(s): fluid extraction, subsurface water, geologic features, land-use planning, hydrology

Location(s): Alabama, United States

Pratt, W. E., D. W. Johnson. Local Subsidence of the Goose Creek Oil Field (Texas.) Journal of Geology, v. 34, 1926, p. 577-590.

Keyword(s): oil extraction

Location(s): Texas, United States

Preece, D. S., W. R. Wawersik. Leached Salt Cavern Design Using a Fracture Criterion for Rock Salt. IN: Proceedings, 25th U.S. Symposium on Rock Mechanics, Northwestern University, June, 1984.

Keyword(s): rock mechanics, non-metal mining, mine design

Location(s): United States

Price, D. G., A. B. Malkin, J. L. Knill. Foundations of Multi-Story Blocks On the Coal Measures with Special Reference to Old Mine Workings. Quarterly Journal Engineering Geology, v. 1, no. 4, 1969, p. 271-322.

Foundation investigations for undermined apartment sites are discussed. This article considers various corrective measures that have arrested subsidence.

Keyword(s): abandoned mines, foundations, engineering, construction, surface structural damage, backfilling, overburden, coal mining

Price, N. J. The Compressive Strength of Coal Measure Rocks. Colliery Engineering, v. 37, 1960, p. 283-292.

Keyword(s): rock mechanics, lab testing, coal mining, overburden

Prickett, T. A. Geohydrologic Data Review and Pumping Test Possibilities--70th Street and Canterbury Mine Areas, Belleville, Illinois. Report to Illinois State Geological Survey, April 2, 1979, by Camp, Dresser & McKee, Champaign, IL.

This is a letter-type report on the findings and possibilities of pump testing the mines in question to determine void volumes for backfilling purposes.

Keyword(s): hydraulic backfilling, abandoned mines, coal mining, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Priest, A. V., R. J. Orchard. Recent Subsidence Research in the Nottinghamshire and Derbyshire Coalfield. Colliery Guardian, July 4, 1957, p. 4-10.

Routine observation of ground movement due to mining operations was begun in the area of the southwestern extremity of the North Derbyshire and Nottinghamshire coalfield. The seams are relatively shallow, especially in the south and west, where working is carried on near the outcrop to within 50 yards of the surface.

Keyword(s): coal mining, monitoring methods, monitoring equipment, survey methods, survey equipment, pipelines, surface structural damage, architecture, subsidence research

Location(s): United Kingdom

Priest, A. V., R. J. Orchard. Recent Subsidence Research in the Nottinghamshire and Derbyshire Coalfield. Transactions, Institute of Mining Engineers, London, v. 117, 1957-58, p. 499-512.

This paper describes monitoring of vertical and horizontal subsidence displacements such that steps could be taken to prevent or reduce structural damage to existing pipelines and buildings in the Nottinghamshire and Derbyshire coalfield, England.

Keyword(s): surface structural damage, subsurface structural damage, mine design,

monitoring design, utilities, monitoring methods, monitoring equipment, pipelines, survey methods, subsidence research, survey equipment, coal mining
Location(s): England

Prokopovich, N. P. Land Subsidence Along Delta-Mendota Canal, California. Rock Mechanics, v. 1/2-3, 1969, p. 134-144.
This subsidence was caused essentially by an irrigation overdraft of the confined groundwater. Due to the overdraft from 1905 to 1953, decline of piezometric levels along the alinement varied from 90 to 200 feet. With canal water delivery in 1951 to 1953, the overdraft virtually ceased. Subsidence at the time was, therefore, a progressively diminishing "lag" inherited from past overdraft. Active subsidence in neighboring areas may also have affected the canal.
Keyword(s): subsurface water, fluid extraction, hydrology, surface structural damage, engineering, agriculture, surface water
Location(s): California, United States

Prokopovich, N. P. Prediction of Future Subsidence Along Delta-Mendota and San Luis Canals, Western San Joaquin Valley, California. IN: Proceedings, Association Internationale d'Hydrologie Scientifique, Tokyo, September 1969, p. 600-610 (in English).
About 120 miles of the Delta-Mendota and San Luis Canals, constructed by the Bureau of Reclamation, have been affected by subsidence caused by overdraft of ground water. Estimates of ultimate future subsidence, varying from traces to 3.6 feet, were derived from bench mark data treated as an exponential decay function.
Keyword(s): subsurface water, fluid extraction, hydrology, surface structural damage, engineering, agriculture, surface water, prediction
Location(s): California, United States

Prokopovich, N. P. Land Subsidence and Population Growth. IN: Proceedings, 24th International Geologic Congress, 13, 1972, p. 44-54.
Keyword(s): fluid extraction, land-use planning

Prokopovich, N. P., M. J. Marriott. Cost of Subsidence to the Central Valley Project, California. Bulletin Association Engineering Geologists 20, 1983, p. 325-332.
Keyword(s): economics, fluid extraction
Location(s): California, United States

Prokopovich, N. P. Classification of Land Subsidence by Origin. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association Hydrological Sciences Publication No. 151, 1986, p. 281-290.
Data collected during the last decades allow classification of subsidence into two groups: endogenic, caused by processes originating within the planet; and exogenic, caused by processes originating near the surface. Exogenic subsidence can be subdivided into subsidence caused by removal or weakening of support and subsidence caused by an increase in actual or effective loading.
Keyword(s): fluid extraction, geologic features

Prokopovich, N. P. Economic Impact of Subsidence on Water Conveyance in California's San Joaquin Valley, USA. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication 151, 1986, p. 795-804.
Agriculture in the arid San Joaquin Valley depends on irrigation. Depletion of aquifers prior to surface water delivery by the Central Valley Project caused subsidence, locally up to 8 to 9 meters. Subsidence-related rehabilitation of old canals and design modification of new ones cost $67 million. Surface water importation is achieved by pump lifting water from the Sacramento-San Joaquin Delta. The Delta was a tidal marsh with thick peat deposits. Oxidation of peat in the reclaimed delta caused locally more than 6.5 meters of subsidence, resulting in numerous floods and repairs.
Keyword(s): hydrology, economics, utilities, fluid extraction, agriculture
Location(s): California, United States

Propokovich, N. P. Land Subsidence Terminological Confusion. Bulletin Association of Engineering Geologists 22, 1985, p. 106-108.
Keyword(s): fluid extraction

Proust, A. Etude Sur Les Affaissements Miniers Dans Le Rassin Du Nord Et Due Pas-De-Calais (Study of Mine Subsidence in Nord and Pas-De-Calais Coal Fields). Revue de l'Industrie Minerale, v. 46, no. 6, 1964, p. 513-516; v. 46, no. 7, 1964, p. 547-581.
Keyword(s): coal mining, subsidence research
Location(s): France

Pryke, J.F.S. Eliminating the Effects of Subsidence. Colliery Engineering, December, 1954.

The author discusses methods of correcting subsidence effects on the surface in relation to structures.

Keyword(s): structural mitigation, surface structural damage

Pryke, J.F.S. Underpinning and Jacking Buildings Affected by Mining Subsidence or Other Differential Foundation Movement. Royal Institute Chartered Surveyors, 1960.

Keyword(s): structural mitigation, surface structural damage, foundations

Location(s): England

Public Record Corporation (Denver, CO) The Code of Colorado Regulations. 2 CCR 407-2, 1980, p. 91-96, 285-288.

Pertinent sections deal with the responsibilities of the mine operator in regard to subsidence due to underground mining in Colorado.

Keyword(s): law, mine operation, government

Location(s): Colorado, Rocky Mountain Coal Region, United States

Pula, O., Y. P. Chugh, W. M. Pytel. Estimation of Weak Floor Strata Properties and Related Safety Factors for Design of Coal Mine Layouts. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 93-100.

This paper presents regression equations for the estimation of weak floor strata properties from engineering index properties that can be used for the design of coal pillars. It also illustrates the application of probability concepts for the design of single pillars. The analysis indicates that significantly higher extraction ratios may be achieved by using more reliable data in mine design. The authors plan to extend these analyses to the design of coal pillars in a panel with consideration of roof-pillar-floor interaction.

Keyword(s): coal mining, floor stability, in situ testing, lab testing, rock mechanics, geotechnical, pillar strength

Location(s): Illinois, Illinois Coal Basin, United States

Pula, O., Y. P. Chugh, W. M. Pytel. Estimation of Weak Floor Strata Properties and Related Safety Factors for Design of Coal Mine Layouts. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 91-103.

The authors present modified statistical correlations for estimation of representative ultimate bearing capacity (UCB) and deformability modulus (DM) for weak floor strata based on data from six mines in Illinois. Based on dispersion characteristics of the data in statistical analysis, the authors also present concepts to develop appropriate safety factors based on reliability concepts developed for structural engineering.

Keyword(s): floor stability, geotechnical, mine design, partial extraction, pillar strength, geologic features, lab testing, in situ testing

Location(s): Illinois, Illinois Coal Basin, United States

Pytel, W., Y. P. Chugh, B. Zabel, R. D. Caudle. A Simplified Two-Dimensional Analysis of the Roof-Pillar-Floor Interaction Problem in Coal Mines. IN: Proceedings, 7th International Conference in Ground Control in Mining, August, 1988, S.S. Peng, ed., Morgantown, WV, p. 271-281.

A two-dimensional, time-dependent analysis of an overburden-pillar-weak floor strata interaction problem is presented as a beam model consisting of a composite roof beam resting on multiple elastic foundations (pillars) underlain by a composite rock mass representing immediate floor strata. Several different material models may be considered for the immediate floor strata. The analysis can include all openings and pillars in a panel and permits bed separations in the roof composite beam. The model has enabled identification of the relative significance of different geometric and mechanical behavior parameters governing the system. The paper presents the theoretical background for the model as well as its application to a mine in Illinois where surface and underground geotechnical observations were conducted.

Keyword(s): modeling, overburden, coal mining, floor stability, prediction, instrumentation

Location(s): Illinois, Illinois Coal Basin, United States

Pytel, W. M., Y. P. Chugh. An Analysis of Roof-Pillar-Weak Floor Interaction in Partial Extraction Room-and-Pillar Mining. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 621-628.

The applicability of the beam theory in analysis of roof-pillar-weak floor interaction in partial extraction room-and-pillar mining is presented. The mine structure is modeled as an equivalent multi-indeterminate overburden elastic beam supported by elasto-plastic pillars resting on a viscoelastic layer of immediate weak floor strata underlain by a competent rock mass. The developed analytical model was initially used to conduct sensitivity analyses of different variables affecting the mining system, such as the deformability of coal and weak floor strata, thickness of weak floor strata, number of pillars in a panel, width of pillars, and width of panel. These analyses were then extended to three overburden strata - coal pillar - floor strata lithologies typical of active coal mining areas in Illinois.

Keyword(s): partial extraction, room-and-pillar, coal mining, modeling, overburden, floor stability, pillar strength, active mines

Location(s): Illinois, Illinois Coal Basin, United States

Pytel, W. M., Y. P. Chugh, O. Pula. An Approach for Design of Coal Pillars in Partial Extraction Coal Mining Panels With a Consideration of Roof-Pillar-Floor Interaction. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 101-108.

This paper presents an approach for design of coal pillars in a panel with a consideration of roof-pillar-floor interaction. The main goal of this analysis is to design mine layouts that would maximize coal recovery in different sections of the panel while maintaining pillar, floor, and roof stability. Overriding considerations may include factors such as equipment size and panel geometry.

Keyword(s): room-and-pillar, partial extraction, coal mining, floor stability, pillar strength, modeling, roof stability, computer

Location(s): Illinois, Illinois Coal Basin, United States

Pytel, W. M., Y. P. Chugh. Simplified Three-Dimensional Roof-Pillar-Floor Interaction Analysis Including Time Effect. IN: Rock Mechanics as a Multidisciplinary Science, Proceedings 32nd U.S. Symposium, The University of Oklahoma, Norman, July 10-12, 1992, J.-C. Roegiers, ed., Balkema, Rotterdam, p. 781-790.

A simplified three-dimensional roof-pillar-floor interaction analysis model, based on the theory of thin plates on inelastic foundations has been developed. The mine structure is modeled as an equivalent indeterminate plate resting on multiple deformable foundation elements transmitting the load to the weak floor strata. The problem solution is based on the finite difference method, which permits one to relate the actual mining progress with equivalent time-dependent overburden/floor deformability, using an incremental advance approach, including all mined-out areas, with suitable time, or time differences of extraction.

Keyword(s): modeling, floor stability, time factor, room-and-pillar, lab testing, in situ testing, overburden

Location(s): Illinois, Illinois Coal Basin, United States

Pytel, W. M., Y. P. Chugh. Subsidence Prediction in Longwall Mining Using a Beam Theory Based Simplified Analytical Model. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 66-75.

A simplified two-dimensional model to analyze time-dependent load distribution and surface subsidence associated with longwall mining geometries is described. The model is based on the theory of beams resting on inelastic foundations and includes visco-elastic behavior of coal pillars, elastic behavior of face supports, and visco-elastic behavior of the overburden strata. The relative importance of the different variables affecting the performance of longwall mining geometries from a ground control point of view is also analyzed. The model has been validated for field observations from one Illinois longwall mine.

Keyword(s): modeling, longwall, active mines, elastic model, overburden, ground control, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Pytlarz, T., K. Trojanowski. Subsidence Calculation With an Arbitrary Shape of the Exploitation Area by the Segment Network Method on Basis of S. Knothe's Theory. 1974, 52 p. (NTIS TT 74-54011)

This report details calculation of surface subsidence using Knothe's theory of the exploitation effect on the ground surface for the case of a spatial problem with an arbitrary shape of the given exploitation area.

Keyword(s): vertical displacement, horizontal displacement, prediction theories, empirical model, profile function, prediction

Qian, M-G., G-J. Zhao. The Behaviour of the Main Roof Fracture in Longwall Mining and its Effect on Roof Pressure. IN: Rock Mechanics, Proceedings of the 28th U.S. Symposium, Tucson, AZ, June 29-July 1, 1987, I.W. Farmer, et al., eds., Balkema, Rotterdam, p. 1123-1128.

This paper explains a model as a semi-infinite long beam to be clamped on a Winkler elastic foundation.

Keyword(s): modeling, roof stability, longwall, coal mining

Location(s): China

Quan, C. K. Overview of the Bureau of Mines Subsidence Research Program. SME-AIME Annual Meeting, New Orleans, LA, February 18-22, 1979, SME-AIME Preprint 79-84, 1979, 9 p.

The state of the art in subsidence prediction, control, and prevention and in subsidence-related damage abatement has not progressed in the United States to the level achieved in other countries. To bridge this gap, the USBM is pursuing a comprehensive subsidence investigation, specifically designed to address major problems on the local, regional, and national level.

Keyword(s): prediction, economics, structural mitigation, land mitigation, ground control, subsidence research

Location(s): United States

Rad, P. F. Mechanical Properties and Cutting Characteristics of Coal. U.S. Bureau of Mines IC 8584, 1973, p. 1-46.
Keyword(s): rock mechanics, coal mining, lab testing, pillar strength
Location(s): United States

Radcliffe, D. E., R. M. Stateham. Effects of Time Between Exposure and Support on Mine Roof Stability, Bear Coal Mine, Somerset, Colo. U.S. Bureau of Mines RI 8298, 1978, 13 p.
Keyword(s): roof support, roof stability, coal mining, mine operation
Location(s): Colorado, Rocky Mountain Coal Region, United States

Railway Gazette. Trackside Foundations in Subsidence Areas. April 3, 1959, p. 390-391.
This paper discusses the construction of concrete rafts to carry steel structures for overhead electrification.
Keyword(s): railroads, foundations, utilities

Ramani, R. V., C. B. Manula. A Master Environmental Control and Mine System Design Simulator for Underground Coal Mining. Volume I. Executive Summary. Grant GO111808, Pennsylvania State University, U.S. Bureau of Mines OFR 84(1)-76, 1975, 31 p. (NTIS PB 255 421)
Keyword(s): mine design, environment, modeling, coal mining
Location(s): United States

Ramani, R. V., ed. Longwall-Shortwall Mining, State-of-the-Art. AIME, New York, 1981, 296 p.
Keyword(s): longwall, environment, mine design, shortwall, surface subsidence damage, coal mining
Location(s): United States, Europe, Ohio, Appalachian Coal Region, Pennsylvania, Alabama, New Mexico, Illinois, Canada, United Kingdom

Ramsay, R. Discussion on Deep, Long-Wall Workings. Journal of the Illinois Mining Institute, v. 1. no. 3, 1892, p. 227-231.
Keyword(s): longwall, coal mining, geologic features, historical
Location(s): Illinois, Illinois Coal Basin, United States

Randolph, B. S. The Theory of the Arch in Mining. Colliery Engineering, v. 35, March, 1915, p. 427-429.
Keyword(s): roof stability
Location(s): England

Rankilor, P. R. An Approach to the Simulation of Mining Subsidence Phenomena in an Elastic Layered Model. Quarterly Journal of Engineering Geology, v. 3, December, 1970, p. 55-63.
The author comments on the background to model analysis of mining problems, and describes the use of urethane rubber in the construction of a layered model simulating strata over mine workings. In this paper, the author describes angles of draw below 35 degrees and also describes the subsidence development profile of the model in relation to those observed for some European mining. Possible future applications for this type of model work are suggested.
Keyword(s): phenomenological model, elastic model, modeling, overburden, angle of draw, prediction
Location(s): Europe

Rankilor, P. R. The Construction of a Photoelastic Model Simulating Mining Subsidence Phenomena. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 8, no. 5, September, 1971, p. 433-444.
The author has adopted the use of a soft, photoelastic polyurethane rubber to construct a two-dimensional model section through the earth's strata in to simulate mining extraction with its consequent surface subsidence phenomena. The model is used to make in initial assessment of the effect on subsidence of varying panel-to-pillar width ratios in a partial-extraction system. From photoelastic observations on the model, the author demonstrates the formation of an inverted "wedge" over the mine workings, instead of the classical "arch" so frequently postulated in mining papers.
Keyword(s): modeling, phenomenological model, elastic model, rock mechanics, pillar extraction, partial extraction

Rankilor, P. R. Engineering Geology and Mining. Ground Engineering, v. 9, no. 7, October, 1976, p. 22-26.
Keyword(s): engineering

Ratigan, J. L. User Information Manual. SUBSID: A Nonlinear, Two-Dimensional Finite Element Program for Static Evaluation of Mining Subsidence. Lawrence Berkeley Laboratory, University of California, June 1980, 74 p. (NTIS LBL-113 56)

Keyword(s): finite element, modeling, computer
Location(s): United States

Ratigan, J. L., R. E. Goodman. Modeling of Static Subsidence in a Nonlinear Medium. Lawrence Berkeley Laboratory, University of California, December 1980, 17 p. (NTIS LBL-11896)
Keyword(s): modeling
Location(s): United States

Ratigan, J. L., T. J. Vogt. Technical Note: A Note on the Use of Precision Level Surveys to Determine Subsidence Rates. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 28, no. 4, 1991, p. 337-341.
The purpose of this paper is to present an algorithm for reducing level survey data to subsidence rates. The algorithm accounts for ground movement taking place during the level surveys. Two level surveys at a specific site are analyzed with the new algorithm as well as with an algorithm that neglects the ground movement during the level surveys. The resulting subsidence rates for the two algorithms are compared and errors are discussed.
Keyword(s): survey data processing, survey methods, vertical displacement

Rau, J. L., P. Nutalaya, M. Boonsener. Subsidence and Chloride Contamination at Nong Bo Reservoir, Northeast Thailand. Geotechnical Engineering, 13, 1982, p. 51-72.
Keyword(s): surface water
Location(s): Thailand

Rauch, H. W. A Summary of Ground Water Impacts from Underground Mine Subsidence in the North Central Appalachians. IN: Proceedings Special Institute on Coal Mine Subsidence in Pittsburgh, Eastern Mineral Law Foundation, Morgantown, WV, 1989, p. 2.01-2.31.
Keyword(s): subsurface water, surface water, hydrology, coal mining, longwall
Location(s): Appalachian Coal Region, United States

Rayburn, J. M. Subsidence in Thick Freeport Coal. Transactions AIME, Coal Division, v. 88, 1930, p. 144-150.
Survey lines were established parallel and perpendicular to the line of pillar extraction in an attempt to determine the shape of the traveling subsidence trough.
Keyword(s): pillar extraction, angle of draw, survey design, survey methods, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Read, T. T. Lake Superior Copper Mining: Present and Future II. Mining and Scientific Press, v. 140, 1915, p. 215.
Stamps sands were used for backfilling and for subsidence prevention.
Keyword(s): backfilling, metal mining, ground control
Location(s): United States

Reddish, D. J. Study of Ground Strain in Relation to Mining Subsidence. Ph.D. Thesis, 1984, University of Nottingham, U.K.
Keyword(s): horizontal displacement, coal mining
Location(s): United Kingdom

Reed, J. J. Mine-Opening Stabilization by Stress Redistribution. Colorado School of Mines Quarterly, v. 51, no. 3, July, 1956.
Keyword(s): rock mechanics, mine design
Location(s): United States

Reed, J. J. Case History in Pillar Recovery. Transactions, AIME (Mining Engineering), v. 11, July, 1959, p. 701-705.
Keyword(s): pillar extraction
Location(s): United States

Rees, D. W. Subsidence in Anthracite Areas. Colliery Guardian, v. 74, no. 3234, December 22, 1922.
This paper describes subsidence observations in the anthracite area, where one seam is worked at a moderate depth, the floor is hard and no heaving takes place, and the coal serves as a true boundary because of its resistant nature.
Keyword(s): anthracite, coal mining, roof support, floor stability, angle of draw

Reeves, A. Legal Aspects of Development in Coal Mining Areas: The National Coal Board Involvement. IN: Mineworkings 84: Proceedings International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1984, M.C. Forde, B.H.V. Topping, and H.W. Whittington, eds., Engineering Technics Press, p. 189-195.
Keyword(s): law, coal mining, land-use planning, National Coal Board
Location(s): United Kingdom

Reifsnyder, R. H., J. F. Peters. Sodium Silicate Grouts: The Solution to Difficult Subsidence Problems. IN: Proceedings Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 329-335.

A new cement grouting technique is now available for use for a wide variety of grouting applications. This process not only results in a superior grout in terms of strength, acid resistance, and angle of repose, but it also significantly reduces the costs associated with completing the job. Initially designed for subsidence abatement in flooded abandoned mines, it has been proven to be adaptable to a number of different end uses and sites.

Keyword(s): grouting, abandoned mines, structural mitigation, surface structural damage

Location(s): Ohio, United States

Reiss, I. H. Total Utilization of a Land Resource. Mining Congress Journal, v. 63, no. 10, 1977, p. 55-59.

This paper discusses coal as a legitimate crop in terms of a long-term land-use program, and describes grassland farming as a viable alternative to cornland. The author concludes that corn, coal, and cattle are still compatible.

Keyword(s): agriculture, reclamation, land-use planning, coal mining

Location(s): United States

Reitz, H. M., D. S. Eskridge. Construction Methods Which Recognize the Mechanics of Sinkhole Development. Hydrologic Problems in Karst Regions, 1977, R.R. Dilamarter and S.C. Casallany, eds., Western Kentucky University, p. 432-438.

Keyword(s): construction, land-use planning, geologic features

Location(s): United States

Rellensmann, O., E. Wagner. The Effect on Railways of the Ground Movements Due to Mining. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 74-82.

This paper analyzes partial-extraction methods that can be used to minimize subsidence damage to railway lines, with discussions on the use of safety pillars and various mine designs. A short explanation of the mechanics of ground deformations is also given.

Keyword(s): mine design, railroads, partial extraction, room-and-pillar, pillar strength

Location(s): Europe

Rellensmann, O. Rock Mechanics in Regard to Static Loading Caused by Mining Excavation. Colorado School of Mines Quarterly, v. 52, no. 3, July 1957, p. 35-48.

This paper pertains to the behavior of strata overlying mined-out areas and the calculation of surface movements. The author briefly mentions the use of empirical data to predict subsidence.

Keyword(s): rock mechanics, overburden

Location(s): United States

Ren, G., D. J. Reddish, B. N. Whittaker. Mining Subsidence and Displacement Prediction Using Influence Function Methods. Mining Science and Technology, v. 5, 1987, p. 89-104.

A flexible influence function/zone area approach to subsidence and horizontal displacement prediction is described in detail, with particular emphasis being placed on the applicability of the method to computer prediction. The method is compared to the National Coal Board Subsidence Engineers' Handbook empirical model for ground movement prediction over a full panel. Examples of graphical output from the program, and comparisons to field cases and other models are provided.

Keyword(s): prediction, empirical model, influence function, profile function, stochastic model, zone area, computer, modeling, National Coal Board, horizontal displacement, longwall, active mines

Location(s): United Kingdom

Ren, G., D. J. Reddish, B. N. Whittaker. Computerised Subsidence and Displacement Prediction Using Influence Function Methods. IN: Proceedings 7th International Conference on Ground Control in Mining, Morgantown, WV, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 101-115.

A computerized influence function approach to subsidence and horizontal displacement prediction is described, with particular emphasis being placed on the applicability of the method to irregularly shaped mine workings. Based on previous work, this approach has been put forward for inclined seam situations. Examples are given of graphical output presenting surface subsidence contours, horizontal displacement vectors and principal strain vectors and their significance discussed in relation to current problems.

Keyword(s): computer, influence function, prediction, prediction theories, empirical model,

horizontal displacement, multiple-seam extraction, National Coal Board, stochastic model, modeling, coal mining
Location(s): United Kingdom

Ren, G., B. N. Whittaker, D. J. Reddish. Mining Subsidence and Displacement Prediction Using Influence Function Methods for Steep Seams. Mining Science and Technology, v. 8, no. 3, 1989, p. 235-252.
The prediction of subsidence and displacements arising from longwall mining of steep seams is examined. Various influence function methods and the National Coal Board Subsidence Engineers' Handbook empirical design technique are compared for different mining conditions. Comparisons are made between the methods reviewed. The results of predictions with these methods are compared with field observations.
Keyword(s): prediction, influence function, longwall, coal mining, empirical model, National Coal Board
Location(s): United Kingdom

Repa, J. V., J. W. McMullen, P. D. Smith. Conceptual Design for a Subsidence Simulator. February, 1980, 7 p. (NTIS LA-8239-MS)
Keyword(s): modeling

Research Committee of Midland County Institute of Mining Engineers. The Influence of Variation in the Nether Roof on the Incidence of Falls. Transactions Institute of Mining Engineers, v. 84, 1932-33, p. 93-110; v. 85, 1932-33, p. 27.
This report describes a series of studies made in a mine seam that, in different areas, has a roof composed of sandstone, stone bind, shale, clod, and coal.
Keyword(s): roof stability, coal mining, geologic features
Location(s): United Kingdom

Reynolds, J. F. First North American Longwall in Pitching Seams Proven Feasible. Mining Engineering, December 1983, p. 1615-1618.
Snowmass Coal Company, in cooperation with the U.S. Department of Energy, introduced the longwall mining method in pitching seams to North America. This venture is a coal mining research program directed toward the profitable production of coal under difficult mining conditions as found in pitching seams of the western United States.
Keyword(s): longwall, coal mining, active mines, mine operation
Location(s): Colorado, Rocky Mountain Coal Region, United States

Rhodes, G. W. Plate Bearing Tests on Coal Mine Underclays. M.S. Thesis, University of Missouri-Rolla, 1978.
Keyword(s): floor stability, coal mining, in situ testing

Rhodes, H., R. H. Horsley. Observations on the Working of a Seam of Coal Under a Railway Tunnel. Transactions, Institution of Mining Engineers, v. 87, 1933-34, p. 129-139.
A brick-lined railway tunnel was successfully undermined, by a 5-foot-thick seam of coal lying 613 to 701 feet below the tunnel floor. The tunnel required only minor repairs after mining.
Keyword(s): railroads, backfilling, coal mining

Ricca, V., M. Hemmerich. Underground Mine Drainage Quantity and Quality Generation Model. IN: Proceedings 1st World Congress on Water in Mines and Underground Works, SIAMOS--78, Granada, Spain, September 18-22, 1978, R. Fernandez-Rubio, ed., p. 863-882.
This computer model is capable of simulating underground mine makewater and its consequent discharge rates from adits. An additional feature is its ability to generate acid loads associated with the drainage. A hydrologic model using climatological data, watershed parameters, and mine operation information is used to calculate the amount of water passing to the geologic strata of the mine. As the water movement through the mine works is modeled, the acid generated is simulated by mathematical formulations describing the chemical productions and removal mechanisms. The component contributions are summed, with time preservation, and expressed as discharge rates and loads. The model is presented as a case study application to a coal mine in the United States.
Keyword(s): modeling, computer, subsurface water, hydrology, coal mining, environment, geologic features
Location(s): West Virginia, Appalachian Coal Region, United States

Rice, G. S. Mining-Wastes and Mining Costs in Illinois. Illinois Geological Survey Bulletin No. 14, Year-Book for 1908, H.F Bain, Director. University of Illinois, Urbana, 1909, p. 211-222.
In this chapter, the author discusses the range of coal extraction and the variation in yield from different parts of the state. The percentage of yield

varied from about 50% to 90%. Surface subsidence and its effect on agricultural land was cited as one of the reasons for decreased extraction in some areas. The author also discusses reasons why hydraulic backfilling would not be applicable in Illinois for subsidence prevention.
Keyword(s): historical, economics, hydraulic backfilling, mine waste, agriculture, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Rice, G. S. Some Problems in Ground Movement and Subsidence. Transactions AIME, v. 69, 1923, p. 374-405, 413-433.
The author discusses subsidence from mining, mechanics of ground movement, pillar extraction, and prediction methods.
Keyword(s): coal mining, metal mining, room-and-pillar, pillar extraction, longwall, angle of draw
Location(s): Illinois Coal Basin, Appalachian Coal Region, Rocky Mountain Coal Region, United States

Rice, G. S., C. Enzian. Tests of Strength of Roof Supports Used in Anthracite Mines of Pennsylvania. U.S. Bureau of Mines Bulletin 303, 1929, 44 p.
Tests of coal pillar strength and other roof supports were reviewed.
Keyword(s): roof support, anthracite, pillar strength, ground control, mine design, coal mining, lab testing, in situ testing
Location(s): Pennsylvania, Appalachian Coal Region, United States

Rice, G. S. The Question of the Angle-of-Draw. Mining & Metallurgy, v. 10, March, 1929, p. 132-133.
Keyword(s): angle of draw

Rice, G. S. Recent Researches on Ground Movement Effects in Coal Mines and on the Strength of Coal and Roof Supports. Transactions, AIME, v. 101, 1932, p. 269-293.
Keyword(s): roof stability, roof support, pillar strength, coal mining
Location(s): United States

Rice, G. S. Ground Movement from Mining in Brier Hill Mine, Norway, Michigan. Transactions, AIME, v. 109, 1934, p. 118-152.
Keyword(s): surface subsidence damage, metal mining
Location(s): Michigan, United States

Rice, G. S. Bumps in Coal Mines of the Cumberland Field, Kentucky and Virginia--Cause and Remedy. U.S. Bureau of Mines RI 3267, 1935, 36 p.
Keyword(s): ground control, room-and-pillar, mine design, bumps, coal mining
Location(s): Kentucky, Virginia, Appalachian Coal Region, United States

Rice, G. S. Bumps in Coal Mines--Theories of Causes and Suggested Means of Prevention or of Minimizing Effects. Transactions, AIME, Coal Division, v. 119, 1936, p. 11-39.
Keyword(s): ground control, room-and-pillar, floor stability, mine design, bumps, coal mining
Location(s): United States

Rice, G. S. Ground Movement and Subsidence Studies Aid in Solving Mining Problems. Mining and Metallurgy, v. 17, January, 1936, p. 15-16.
The author reviewed work by P. Bucky, Helmut Landsberg, and Ryojun College, on the strength and elastic recovery of rocks.
Keyword(s): mine design, pillar strength, room-and-pillar
Location(s): England

Rice, G. S. Ground Movement and Subsidence Studies in Mining Coal, Ores and Nonmetallic Minerals. Transactions, AIME, v. 139, 1937, p. 140-154.
Keyword(s): coal mining, metal mining, non-metal mining
Location(s): United States

Rice, G. S. Notable Studies in the Kolar Gold Field and at a Pittsburgh Coal Mine. Mining and Metallurgy, v. 19, January, 1938, p. 24-25.
This paper reviews subsidence studies in the gold fields of India, as well as those by the USBM at the Montour mine in Pittsburgh.
Keyword(s): metal mining, coal mining
Location(s): India, Pennsylvania, Appalachian Coal Region, United States

Rice, G. S., I. Hartmann. Coal Mining in Europe. A Study of Practices in Different Coal Formations and Under Various Environmental Regulatory Conditions Compared with Those in the United States. U.S. Bureau of Mines B 414, 1939, 369 p.
This report describes hydraulic, pneumatic, and mechanical backfilling; it also deals with many aspects of European mining including filling problems and procedures.

Keyword(s): environment, mine operation, law, hydraulic backfilling, pneumatic backfilling, geologic features

Location(s): United States, Europe

Rice, G. S. Ground Movement and Subsidence. Mining and Metallurgy, v. 21, January, 1940, p. 8-9.

This article is a review of subsidence investigations in 1939.

Keyword(s): backfilling

Location(s): Pennsylvania, Appalachian Coal Region, United States

Richardson, A. Mine Subsidence. Journal Chemical Metallurgy & Mining Society South Africa, v. 7, March, 1907, p. 279-288.

Location(s): South Africa

Richert, G. I. Filling Stopes with Mill Tailings. Engineering and Mining Journal, v. 127, 1929, p. 348; and U.S. Bureau of Mines IC 6145, 1929.

This report discusses increased efficiency and lowered cost involved using recycled mine waste as fill in a Cuban copper mine.

Keyword(s): backfilling, metal mining, mine waste, mine operation, economics

Location(s): Cuba

Richey, J. E. Surface Effects of Mining Subsidence. Elements of Engineering Geology, Pitman, London, 1964, Ch. 12, 137 p.

Keyword(s): surface subsidence damage

Riddle, J. M. Dealing With Subsidence and SMCRA. Mining Engineering, December 1980, v. 32, no. 12, p. 1702-1704.

The subsidence permitting process involves just one part of the mass of Surface Mining Control and Reclamation Act (SMCRA) regulations. But of the 18 main SMCRA sections, subsidence is critical to the permitting process for coal operators. Permitting is an area in which applicants have had problems interpreting regulations and preparing permit applications. SMCRA regulations apply to any coal operations "that exhibits surface effects." Thus they apply to surface strip mines as well as underground coal operations. This article discusses frequently asked questions in an attempt to help individuals trying to interpret subsidence regulations or prepare permit applications.

Keyword(s): law, reclamation, coal mining, subsurface water, surface water, surface structural damage, land-use planning, pillar strength, roof stability, land mitigation

Location(s): United States

Rightnor, T. A., J. P. McHale, C. H. Johnson, W. D. Shrader, M. D. Loy. Analysis of the Impact of Public Law 95-87 on Mining Performance. U.S. Department of Energy Contract ET-77-CO-1-8914, Skelly and Loy, 1979, 417 p. (NTIS FE 8914-3)

Keyword(s): law, mine operation, government, coal mining, economics

Location(s): United States

Rigsby, K. B. Mine Subsidence at the Kathleen Mine. IN: Proceedings, Illinois Mining Institute, Centennial Year, 1992, p. 53-59.

At the Kathleen Mine, coal is being mined by caving methods at depths as shallow as 100 to 145 feet. The amount of subsidence and the angle of draw at this mine have been less than expected for this type of mining. A railroad spur and a power line were also successfully undermined. There are four limestone members in the overburden that may be creating a blocking effect, reducing the amount of subsidence seen at the surface.

Keyword(s): coal mining, pillar extraction, active mines, angle of draw, overburden, land mitigation, room-and-pillar

Location(s): Illinois, Illinois Coal Basin, United States

Riley, F. S., S. N. Davis. A Tiltmeter to Measure Surface Subsidence Around a Pumping Artesian Well. Journal Geophysical Research, (abstract), v. 65, 1960, p. 1637.

Keyword(s): fluid extraction, monitoring equipment, subsurface water

Riley, F. S. Land Surface Tilting Near Wheeler Ridge, California. American Geophysical Union Transactions, v. 49, 1968, p. 664.

Keyword(s): fluid extraction

Location(s): California, United States

Riley, F. S. Land-Surface Tilting Near Wheeler Ridge, Southern San Joaquin Valley, California. U.S. Department of the Interior, Geological Survey Professional Paper 497-G, 1970, p. G1-G29.

Keyword(s): fluid extraction

Location(s): California, United States

Riley, F. S. Developments on Borehole Extensometry. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March

19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication No. 151, 1986, p. 169-186.

Progressive development of the deep-well extensometer over a period of 30 years facilitated the evolution of fundamental concepts and predictive capability in studies of aquifer-system compaction and land subsidence due to fluid withdrawal.

Keyword(s): instrumentation, monitoring equipment, fluid extraction

Location(s): United States

Rimant, A. Extraction of Shaft Pillars. Freiberger Forschungshefte, A448, 1968, p. 157-179 (in German).

Keyword(s): pillar extraction

Location(s): Germany

Robeck, K. E. Potential Land Use Impacts of Coal Production: 1975-2000. Argonne National Laboratory, July, 1980, 71 p. (NTIS DE 82003264)

Keyword(s): land-use planning, environment, land values, coal mining, economics

Location(s): United States

Roberts, A. Partial Extraction in Restricted Workings. Colliery Engineering, v. 24, no. 284, 1947, p. 335-340.

The principles of surface support in areas where partial extraction of underlying minerals is made are discussed, and some examples from various coalfields are described. A short discussion of recommended pillar dimensions and the development of pressure arches is included.

Keyword(s): pillar strength, mine design, overburden, partial extraction, coal mining

Roberts, A. A. A Problem of Strata Control in Bord and Pillar Working. Colliery Guardian, v. 170, no. 4404, 1945, p. 663-668.

Keyword(s): ground control, room-and-pillar

Roberts, E. W. A History of Land Subsidence and its Consequences Caused By the Mining of Anthracite Coal in Luzerne County, Pennsylvania. Ph.D. Thesis, New York University, 1948, 230 p.

Keyword(s): historical, anthracite, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Roberts, J. M., A. L. Masullo, Jr. Pneumatic Stowage Becomes Affordable. Reprinted from Coal Age, 1986, 5 p.

In recent years, the economics have changed and the equipment and technology improved to the point where pneumatic stowing of material underground may now make some money sense to coal operators.

Keyword(s): coal mining, backfilling, stowing, pneumatic backfilling, economics

Location(s): United States

Roberts, J. M., F. W. Tobias, A. L. Massulo, J. A. Holbrook. Remote Pneumatic Stowing in Abandoned Room and Pillar Mines. IN: Proceedings 8th Annual National Abandoned Mine Lands Conference, August 10-15, 1986, Billings, MT, p. 111-139.

A review and feasibility study of the state-of-the-art of remote pneumatic stowing for backfilling abandoned room-and-pillar mines was completed. Technical specifications to permit implementation of a project were prepared, and a subsurface investigation was also performed. The investigation included the use of a borehole video camera.

Keyword(s): pneumatic backfilling, room-and-pillar, abandoned mines, stowing

Location(s): Pennsylvania, Appalachian Coal Region, United States

Robertson, T. Mining Subsidence--The Geological Aspects and Their Relations to Town Planning in County Durham. Colliery Guardian, v. 179, no. 4634, 1949, p. 575-578.

This paper discusses geological aspects of town planning, with special reference to limestone solution with fluctuating water tables and surface disturbance over undermined areas.

Keyword(s): land-use planning, surface structural damage, hydrology, geologic features, subsurface water

Location(s): England

Robinson, G. L., J. C. Swain, R. P. Yantis, H. W. Ray. A Systems Approach to Underground Coal Mining: Phase I. Problem Analysis and Research Recommendations. Battelle Labs, Columbus, OH, June 1975, 293 p. (NTIS PB 249 054)

Keyword(s): mine operation, coal mining, subsidence research

Location(s): United States

Robinson, K. E., B. Stimpson. Geotechnical and Ground Control Design Parameters for a Proposed Shallow Longwall Coal Mine. IN: Geotechnical Research and its Application to Canadian Resource Development, Preprint Volume for 36th Canadian Geotechnical Conference, June 22, 1983, Vancouver, British Columbia.

The Clover Bar coal seam has been widely worked in the Edmonton area since the 19th century. A proposal to expand production of one of the few currently operating mines in this seam, by converting from a room-and-pillar system to a longwall caving operation required an investigation of the geotechnical properties of the strata, and an assessment of its behavior under a longwall system of mining. The proposed mine would remove coal ranging in thickness from 1.0 to 3.5 meters, from a depth of only 20 to 25 meters. The depth of the proposed operation would make the mine one of the shallowest longwall operations in the world.

Keyword(s): coal mining, longwall, room-and-pillar, geotechnical, active mines, mine design, rock mechanics, in situ testing, lab testing

Location(s): Canada

Rockaway, J. D., R. W. Stephenson. Investigation of the Effects of Weak Floor Conditions on the Stability of Coal Pillars. IN: Site Characterization, Proceedings 17th U.S. Symposium on Rock Mechanics, Snowbird, UT, August 25-27, 1976, W.S. Brown, S.J. Green, and W.A. Hustrulid, eds., University of Utah, Salt Lake City, p. 4A5-1 (abstract only).

This project studied the engineering properties of underclays to determine those factors which contribute to their development or loss of strength. In addition, the process by which floor failures occur is being investigated and the applicability of bearing capacity analysis to solving floor stability evaluated. The study includes an evaluation of underclay properties from all major coal fields of the United States, although the areas of extensive testing have been concentrated in the mid-continent coal field in Indiana, Illinois, and western Kentucky.

Keyword(s): floor stability, coal mining, pillar strength

Location(s): Illinois, Indiana, Kentucky, Illinois Coal Basin, United States

Rockaway, J. D., R. W. Stephenson. Investigations of the Effect of Weak Floor Conditions on the Stability of Coal Pillars. USBM Contract No. JO-155153, July, 1979, 225 p. (NTIS PB 81-181109)

Keyword(s): floor stability, pillar strength, coal mining

Location(s): United States

Rockaway, J. D., R. W. Stephenson. Investigation of the Effects of Weak Floor Conditions on the Stability of Coal Pillars. Final Report, June 27, 1975-December 31, 1978, U.S. Bureau of Mines OFR-12-81, July 15, 1979, 227 p. (NTIS PC A11/MF A01)

Keyword(s): coal mining, floor stability, pillar strength

Location(s): United States

Rockaway, J. D., C. D. Elifrits. Investigation of the Effects of Mining Subsidence I: The Vicinity of Rend Lake Dam, Illinois. Report prepared for the U.S. Army Corps of Engineers, St. Louis, MO, 1979, 51 p.

Keyword(s): coal mining, surface water, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Rockaway, J. D., R. W. Stephenson. Evaluation of the Effects of Weak Underclays on the Support of Coal Pillars in Illinois Basin Mines. IN: Proceedings 1st Conference on the Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 59-69.

Failure of the mine floor supporting coal pillars frequently occurs when the subcoal strata include "underclays" or other low strength strata. The failure process has been studied to define the response of these materials to applied coal pillar loads and also to determine the applicability of bearing capacity analysis for evaluating unsafe conditions. The study has been accomplished through an investigation of both the intact and in situ geotechnical properties of the subcoal strata, as well as through the installation of floor movement monitoring instrumentation. Results indicated that both the shear strength of the underclay and the stratigraphy of the subcoal strata must be considered in the analysis.

Keyword(s): floor stability, pillar strength, room-and-pillar, ground control, coal mining, geotechnical, lab testing, in situ testing

Location(s): Illinois, Illinois Coal Basin, United States

Rockaway, J. D., R. W. Stephenson. Influence of Moisture Content on the Bearing Capacity of Coal Mine Floors. SME-AIME Annual Meeting, Chicago, IL, 1981.
Keyword(s): floor stability, coal mining

Roenfeldt, M. A., D. V. Holmquist. Analytical Methods of Subsidence Prediction. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 191-209.
This paper summarizes the history of subsidence prediction, current practices in subsidence engineering, and recent developments of predictive subsidence models. The discussions include analytical approaches for longwall and room-and-pillar mining techniques.
Keyword(s): prediction, prediction theories, empirical model, coal mining, modeling, influence function, National Coal Board, profile function, historical, room-and-pillar, longwall
Location(s): Europe, United Kingdom, United States

Roll, R. J. Effect of Subsidence on Well Fields. Journal of American Water Works Association, v. 59, no. 1, 1967, p. 80-88.
Keyword(s): fluid extraction, subsurface water, hydrology, subsurface subsidence damage
Location(s): United States

Ropski, St., R. D. Lama. Subsidence in the Near-Vicinity of a Longwall Face. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 10, 1973, p. 105-118.
Keyword(s): longwall

Roscoe, G. H. Saint Wilfrid's Church, Hickleton: Mining Subsidence and Remedial Works. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 257-264.
This paper describes the new foundation required as part of the restoration of a church that had been badly damaged by mining subsidence. Damage is related to the geology and mining history of the church site in order to determine the right course of remedial action. The case history illustrates the influence that ground conditions at shallow depth can have on the surface effects of deep mining. The church has settled by more than 2 meters as a result of coal mining activity. Surface movements due to deep mining were predicted by conventional methods and are compared with the damage to the church. Most damage resulted from the horizontal ground movements caused by workings that were some distance from the site, and these movements were concentrated by fissures in the rock.
Keyword(s): coal mining, foundations, surface structural damage, horizontal displacement, vertical displacement, surface subsidence damage, geologic features, multiple-seam extraction, longwall, room-and-pillar, partial extraction, structural mitigation
Location(s): United Kingdom

Roscoe, M. S. Longwall Subsidence Over the Pittsburgh No. 8 Coal on North American Coal Corporation's Eastern Ohio Properties. IN: Longwall-Shortwall Mining, State-of-the-Art, 1981, R.V. Ramani, ed., SME-AIME, New York, p. 87-98.
In order to more accurately predict longwall surface subsidence over the Pittsburgh No. 8 Coal Mine in eastern Ohio, this company undertook or participated in several subsidence studies. Due to the changing roof geology and rapid variations in the amount of cover, two separate areas were investigated at two different mines to determine the subsidence response, if any, to these changes. Data generated were compared with data derived from the National Coal Board for accuracy and then used to predict subsidence under houses, gas lines, and other critical man-made structures.
Keyword(s): longwall, coal mining, utilities, monitoring methods, angle of draw, rock mechanics, surface structural damage, National Coal Board, prediction, geologic features, overburden
Location(s): Ohio, United States

Ross, A. J. M. Sand Filling at the Homestake Mine. Transactions, AIME, v. 141, 1940, p. 146.
The author describes hydraulic flushing techniques used in the Homestake Gold Mine, South Dakota.
Keyword(s): metal mining, hydraulic backfilling
Location(s): South Dakota, United States

Rothwell, R. J., H. J. Payne. Longwall Coal Mining Under S.M.C.R.A. 1977--The Ohio Experience. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 9-12.

Underground mining of coal by longwall mining methods has not been a predominant technique in Ohio. To date, only five mines in the state use this method; however, the technique has sparked a certain amount of controversy. As a mining technique, longwalling was introduced into southeastern Ohio in the early 1970s, but it did not attract public attention until the mines began moving into privately held surface lands. This occurred coincidentally at about the same time that the State of Ohio began to regulate the environmental impacts of underground mining.

Keyword(s): law, longwall, government, subsurface water, surface water, coal mining

Location(s): Ohio, United States

Rousset, G., B. Bazargan-Sabet, R. Lenain. Time-Dependent Behavior of Rocks: Laboratory Tests on Hollow Cylinder. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 385-391.

This paper presents laboratory experiments on hollow cylinder samples. The advantage of such a geometry is to approach in situ conditions around cylindrical openings, especially for borehole stability applications. Time-dependent behavior has not been well studied; for this purpose, two different tests were set up on a deep clay: a quick unloading test, and a creep and relaxation test. The experimental results were then compared with those given by a theoretical model developed in the laboratory.

Keyword(s): time factor, rock mechanics, lab testing, modeling, computer, geologic features

Location(s): France, Belgium

Royse, K. W. Daylighting of an Abandoned Underground Mine. IN: Proceedings National Symposium and Workshops on Abandoned Mine Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 277-293.

Several hundred voids created by subsidence from past mining activity existed at this site at the start of the project. The holes measured 30 to 40 feet in diameter and 20 feet deep. The original mined level was known to be 30 to 70 feet below the surface, and drilling showed the mine to be almost completely flooded. Several tests were conducted before the reclamation method "daylighting" (overexcavation and backfill) was chosen, including drilling, dragline and scraper tests, and dynamic consolidation tests.

Keyword(s): backfilling, reclamation, surface subsidence damage, land mitigation, abandoned mines, coal mining

Location(s): North Dakota, United States

Rozier, I. T., T. J. R. Godfrey. The Acquisition and Application of Underground Mine Design Criteria Derived from a Geological Exploration Program. Canadian Institute of Mining and Metallurgy 2nd District Five Meeting, September 10-13, 1985, Hinton, Alberta, Paper/Presentation No. 12, 18 p.

To investigate the engineering geological parameters that could impact on the potential underground mining of a coal seam in Alberta, a geotechnical data collection program was integrated with overall geological exploration. A combination of geological, geotechnical, and hydrological parameters were identified that could have a significant impact on the selection of preferential areas for further exploration, planning, and development of an underground mine. The joint program proved the feasibility of deriving both geological and geotechnical mine design criteria from cored exploration drillholes without compromising the objectives of either program.

Keyword(s): geotechnical, active mines, coal mining, geologic features, hydrology

Location(s): Canada

Rudenko, D., J. S. Walker, A. M. Richardson, H. D. Ackerman, J. W. Reil. P-Wave and S-Wave Velocity Measurements Related to Subsidence Over a Longwall Mine. IN: Society of Exploration Geophysics 59th International Meeting and Exposition, October 29-November 2, 1989, Dallas, Extended Abstracts, p. 363-367.

This paper is the result of ongoing research to develop a monitoring system for detection of mine subsidence using geophysical techniques. The seismic technique was judged to be the most insensitive to human interference, and most directly related to material properties of the rock overlying the mines. An active longwall mine was used as a control site to relate changes in seismic properties with subsidence. The initial phase of the project consisted of running seismic traverse lines before, during, and after mining. The data showed significant changes in the compressional and shear wave velocities. These changes are related to induced changes in the stress regime, and fractures in the rock due to subsidence.

Keyword(s): seismic, geophysical, longwall, coal mining, overburden, monitoring methods, monitoring equipment, monitoring design

Location(s): Maryland, Appalachian Coal Region, United States

Runkle, J. R. Effects of Longwall Mining on Surface Soil Moisture and Tree Growth. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 173-182.

Studies in eastern Ohio, northern West Virginia, and southwestern Pennsylvania determined whether subsidence caused by longwall mining influences soil moisture and tree growth. Soil moisture was measured over new longwall panels and an unmined control area throughout the growing seasons of 1990, which was a wet year when the panels were excavated, and 1991, a dry year. No significant effects of mining could be detected. Tree growth was studied in two pairs of woodlots. Differences in tree growth between mined and unmined areas were neither significant (for most species) nor consistent in direction. The results imply that if mining does have impacts, they are likely to be highly site-specific and localized, such as by disruptions of springs or soil slippage.

Keyword(s): soils, environment, longwall, active mines, agriculture, subsurface water, hydrology

Location(s): Ohio, West Virginia, Pennsylvania, Appalachian Coal Region, United States

Russell, J. E. Strength of Mine Pillars. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 703-704 (abstract only).

Bieniawski (1984) notes that the strength of mine pillars depends on three factors: (1) the size effect, whereby the strength of the material is reduced; (2) the shape effect, generally included in the form of the width-to-height ratio; and (3) the effect of the properties of the pillar material. In this paper, the size effect is studied using an elastic-plastic material model employing the empirical strength criterion for rock masses published by Hoek and Brown (1980) as the yield criterion. A conventional finite-element code with Mohr-Coulomb material model is used for the calculations.

Keyword(s): pillar strength, mine design, rock mechanics

Russell, O. R., R. V. Amato, T. V. Leshendok. Remote Sensing and Mine Subsidence in Pennsylvania. ASCE Transportation Engineering Journal, v. 105, no. 2, March, 1979, p. 185-198.

Keyword(s): remote sensing

Location(s): Pennsylvania, Appalachian Coal Region, United States

Russnow, A. L., W. W. Beck, Jr., G. H. Emrich. Coal Mine Subsidence and Mine Pools--Northern Anthracite Field, Pennsylvania. Geological Society of America Abstracts with Programs, 1975, v. 7, p. 1331-1332.

Keyword(s): anthracite, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Rutledge, J. J. Examples of Subsidence in Two Oklahoma Coal Mines. Transactions, AIME, v. 69, 1923, p. 406-433.

This paper discusses two subsidence events, including structural damage, geologic and mine features, and surface evidence of subsidence.

Keyword(s): coal mining, surface structural damage, room-and-pillar

Location(s): Oklahoma, United States

Ryan, C. R. High-Volume Grouting to Control Sinkhole Subsidence. IN: Sinkholes: Their Geology, Engineering and Environmental Impact, Proceedings 1st Multidisciplinary Conference on Sinkholes, Orlando, October 15-17, 1984, B.F. Beck, ed., Balkema, Rotterdam, p. 413-417.

Sinkhole subsidence caused by underground mining activities and natural solution cavities is a problem found in many areas of the United States. High-volume grouting techniques have been used to correct the problem by filling the underground voids on many sites, both as a preventative and as a remedial measure. Several case examples are presented, including limerock subsidence and mine subsidence.

Keyword(s): grouting, backfilling, coal mining

Location(s): Florida, Pennsylvania, Alabama, Appalachian Coal Region, United States

Ryder, J. A., N. C. Officer. An Elastic Analysis of Strata Movements Observed in the Vicinity of Inclined Excavations. South African Institute of Mining and Metallurgy Journal, v. 64, no. 6, 1964, p. 219-244.

Keyword(s): modeling, phenomenological model, elastic model

Location(s): South Africa

Rymer, T., D. Yeatts, R. Boswell, A. Donaldson. RYBAD Empirical Field Model for Prediction of Maximum Land Subsidence Associated with Longwall Coal Mining. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 174-178.

Mathematical modeling of mine subsidence measured at 21 locations in Pennsylvania and northern West Virginia allows for the refinement of current methods of predicting maximum land subsidence associated with longwall coal mining. This model predicts subsidence more accurately for a greater range of mining and geological parameters through the recognition of the following: (1) subsidence increases at a decreasing rate (curvilinear relationship) with greater overburden thickness up to a critical value beyond which subsidence decreases; (2) subsidence is strongly influenced by the stratigraphic proximity of strong rocks to the coal (size of potential caving zone); and (3) subsidence index is related to overburden thickness by a family of curves, each for incremental variations in the effective percentage of strong rock in the overburden.

Keyword(s): empirical model, modeling, prediction, prediction theories, coal mining, longwall, mathematical model, geologic features, overburden

Location(s): West Virginia, Appalachian Coal Region, United States

Ryncarz, T. Influence of Surface Load on Formation of Subsidence Trough In Light of Equation of Stochastic Processes. Bulletin, Academie Polonaise des Sciences, Serie des Sciences Techniques, v. 9, no. 9, 1961, p. 535-540.

Keyword(s): modeling, empirical model, stochastic model

Ryncarz, T. Factors Influencing the Load on Longwall Support. IN: Proceedings 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 216-225.

It has been found through by trial and error that the required load capacity is generally greater in coal mines in the United States than the one applied in European deep coal mines. In this paper, an attempt is made to assess the interaction between the powered supports and surrounding rocks and the appropriate evaluation of required support capacity for longwall mining.

Keyword(s): longwall, coal mining

Location(s): United States, Europe

Sadykov, N. M., V. Y. Setkov. Probability, Statistical Indices of Sudden Roof Subsidences. Soviet Mining Science, v. 14, no. 2, March, 1978, p. 195-200 (English translation).
Keyword(s): roof stability
Location(s): Soviet Union

Safai, N. M., G. F. Pinder. Numerical Model of Land Subsidence Due to Pumpage from Fully and Partially Penetrating Wells. Water Resource Program Technical Report No. 78-WR-1, Princeton University, 1977.
Keyword(s): modeling, subsurface water, fluid extraction
Location(s): United States

Safai, N. M., G. F. Pinder. Vertical and Horizontal Land Deformation Due to Fluid Withdrawal. International Journal of Numerical and Analytical Methods in Geomechanics, v. 4, no. 2, 1980, p. 131-142.
A non-linear distribution of vertical displacement versus aquifer depth is calculated in the case of a partially penetrating well. For a fully penetrating well, however, a linear distribution is observed. The solution exhibits a vertically uniform horizontal displacement in the case of a fully penetrating well and, for a partially penetrating well, the maximum horizontal displacement occurs at the elevation of the well bottom.
Keyword(s): vertical displacement, horizontal displacement, subsurface water, hydrology, modeling, finite element, fluid extraction
Location(s): United States

Salamon, M.D.G. The Influence of Strata Movement and Control on Mining Development and Design. Ph.D. Thesis, University of Durham, England, 1962.
Keyword(s): mine design, ground control

Salamon, M.D.G. Elastic Analysis of Displacements and Stresses Induced by the Mining of Seam or Reef Deposits. Journal of the South African Institute of Mining and Metallurgy, Pt. 1, v. 64, November 1963, p. 128-149; Pt. 2, v. 64, January 1964, p. 197-218; Pt. 3, v. 64, March 1964, p. 468-500; Pt. 4, v. 65, December 1964, p. 319-341.
The author discusses fundamental principles and basic solutions derived from idealized models, practical methods of determining subsidence parameters from a given mining geometry, application of elastic theory, and protection of surface installations by underground pillars.
Keyword(s): phenomenological model, elastic model, continuum mechanics, modeling, pillar strength, surface structural damage, room-and-pillar
Location(s): South Africa

Salamon, M.D.G., K. I. Oravecz. Displacements and Strains Induced by Bord and Pillar Mining in South African Collieries. IN: Proceedings 1st International Congress on Rock Mechanics, Lisbon, Portugal, 1966, v. 2, p. 227-232.
Field experiments were performed in order to establish the behavior of coal measure strata, including displacement patterns, when these strata are subjected to mining conditions. The experiments were designed to obtain the displacement pattern in the zone of expected compression and tension over pillars and bords, respectively.
Keyword(s): room-and-pillar, overburden, coal mining, in situ testing
Location(s): South Africa

Salamon, M.D.G. A Method of Designing Bord and Pillar Workings. Journal of the South African Institute of Mining and Metallurgy, v. 68, September, 1967, p. 68-78.
The author formulates a procedure to determine mining dimension in bord-and-pillar workings, using a pillar strength formula devised statistically from surveys of mines in South Africa. This formula assumes that the entire weight of the overburden is carried by the pillars.
Keyword(s): room-and-pillar, pillar strength, mine design, overburden
Location(s): South Africa

Salamon, M.D.G., A. Munro. A Study of the Strength of Coal Pillars. Journal of the South African Institute of Mining and Metallurgy, v. 68-2, September, 1967, p. 55-67.
This paper uses data obtained from actual surveys of mining conditions to derive empirically a coal pillar strength formula.
Keyword(s): pillar strength, coal mining
Location(s): South Africa

Salamon, M.D.G. Two-Dimensional Treatment of Problems Arising from Mining Tabular Deposits in Isotropic or Transversely Isotropic Ground. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 5, 1968, p. 159-185.
The analysis is restricted to geometries that do not alter appreciably when moving along their long axes. It is postulated that (1) the mining takes place

in an inclined seam, (2) the depths of the excavations below surface are effectively infinite, and (3) all three components of displacement are independent of the coordinate parallel with the long axis of the mining layout. Expressions for the displacement and stress components are given in terms of a single complex potential in both models.

Keyword(s): rock mechanics, metal mining, coal mining, modeling

Location(s): South Africa

Salamon, M.D.G., K. I. Oravecz, D. R. Hardman. Rock Mechanics Problems Associated with Longwall Trials in South Africa. IN: 5th International Strata Control Conference, London, 1972, Paper 14, 8 p.

Keyword(s): rock mechanics, longwall

Location(s): South Africa

Salamon, M.D.G. Rock Mechanics of Underground Excavations. IN: Advances in Rock Mechanics, Proceedings 3rd Congress of International Society for Rock Mechanics, Denver, 1974, National Academy of Sciences, Washington, D.C., 1(B), p. 951-1099.

Keyword(s): rock mechanics

Salamon, M.D.G. Least-Squares Analysis of Ground Displacement Observations. IN: Large Ground Movements and Structures, Proceedings of International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 30-59.

The creation of surface or underground excavations is always accompanied by some deformation of the rock mass. Usually, the most easily observed and the most meaningful manifestation of this deformation is the displacement of points inside or on the surface of the rock mass. Observation of the displacement of the ground is closely akin to the work of land or mine surveyors. However, this similarity is not all-embracing. The traditional aim of surveyors is to determine the permanent location of points. The purpose of the rock mechanics field observer is to determine the change in the position of points and to follow the progress of this change by repeated observations at intervals.

Keyword(s): survey methods, survey data processing

Salamon, M.D.G. The Role of Linear Models in the Estimation of Surface Ground Movements Induced by Mining Tabular Deposits. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 187-208.

This paper gives a brief summary of the principles involved in treating tabular excavations as displacement discontinuities, the outlines of which coincide with the plan of the excavations. More details are given on the application of these principles to the prediction of displacements at the ground surface and to the protection of structures on the surface.

Keyword(s): vertical displacement, horizontal displacement, mine design, prediction, modeling, surface structural damage

Location(s): South Africa

Salamon, M.D.G. Linear Models for Predicting Surface Subsidence. IN: Rock Mechanics for Resource Development, Mining and Civil Engineering, Proceedings 5th Congress of International Society for Rock Mechanics, Melbourne, Australia, 1983, Balkema, Rotterdam, p. E 107-E 114.

The notion of a preliminary screening of models is introduced using critical measures of surface movement. Exact elastic media are then examined with attention focused on the modeling of stratified rock masses using an equivalent medium. The Monte Carlo technique is employed to estimate from the properties of individual layers, which are treated as independent random variables, the moduli of the equivalent transversely isotropic mass. Semi-empirical models are discussed and their application is illustrated by an example.

Keyword(s): modeling, elastic model, phenomenological model, empirical model, prediction, National Coal Board, prediction theories

Location(s): United Kingdom

Salamon, M.D.G. Subsidence Prediction Using a Laminated Linear Model. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 503-510.

If all stratifications are horizontal, the computation of surface deformation induced by coal mining involves the prediction of roof and floor convergence and then the transfer of the effects of this relative displacement to the surface through the use of the appropriate influence functions. A laminated model, in the form of a quasi-continuum, provides a simple means of computing the approximate convergence distribution and leads to the Gaussian distribution as the influence function. This paper presents a subtle but fundamental generalization of the influence function method. It is postulated that the influence of a small area of extraction is proportional to the roof and floor convergence and not to the thickness extracted. This difference in definition removes many conceptual difficulties associated with the influence function method. The surface disturbances induced by the extraction of a parallel sided long panel are derived to demonstrate the utility of the model. Formulas giving subsidence, tilt, horizontal displacement and strain are given.

Keyword(s): prediction, modeling, coal mining, influence function, vertical displacement, horizontal displacement, elastic model, overburden

Location(s): United States

Salamon, M.D.G. Mechanism of Caving in Longwall Coal Mining. IN: Rock Mechanics Contributions and Challenges, W.A. Hustrulid and G.A. Johnson, eds., Proceedings of the 31st U.S. Rock Mechanics Symposium, June 18-20, 1990, Golden, CO, Balkema, Rotterdam, p. 161-168.

Longwall extraction, in conjunction with caving, is one of the most widely practiced underground coal mining methods. Caving and the subsequent reconsolidation of the caved rocks combine to form a mechanism that is kernel to the solution of several important problems.

Keyword(s): coal mining, longwall, overburden

Salamon, M.D.G. Displacements and Stresses Induced by Longwall Mining in Coal. IN: Proceedings International Congress on Rock Mechanics, Aachen, 1991, W. Wittke, ed., v. 2, p. 1199-1202.

A linear laminated model is employed, in conjunction with a non-linear compaction characteristic for the caved rocks, to describe the behavior of the rock mass. The model of the rock mass is characterized by two parameters (Young's modulus and an effective lamination thickness), the caved rubble by an effective "modulus," and the coal seam by an elastic modulus. These four parameters are combined in the model to yield the goaf compaction (convergence), pressure transmitted from the roof to the floor, load transmitted from the panel to surrounding ribsides, and subsidence of the surface. The convergence, pressure, and subsidence distributions illustrated appear to be realistic.

Keyword(s): modeling, longwall, coal mining

Salamon, M.D.G. Partial Extraction to Control Surface Subsidence Due to Coal Mining. IN: Rock Mechanics as a Multidisciplinary Science, Proceedings 32nd U.S. Symposium, The University of Oklahoma, Norman, July 10-12, 1991, J.-C. Roegiers, ed., Balkema, Rotterdam, p. 861-870.

The longwall partial extraction (panel and pillar) mining method has been used successfully to control subsidence in many countries. Extraction ratios up to 60% to 70% have been achieved. The fundamentals of the layout are examined using a simple linear laminated model of stratified coal measures. Cases of a narrow panel, of an infinite train of panels, and edge effects are studied. Suggestions are made concerning underground geometry, panel centre distances, and span to minimise edge effects.

Keyword(s): longwall, partial extraction, modeling, coal mining, mine design, vertical displacement, horizontal displacement

Salamon, M.D.G., G. Yang. The Seam Element Method: Prediction of Subsidence Due to Coal Mining. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 47-55.

The laminated model, in conjunction with the seam element method, is expected to be a powerful predictor of subsidence due to coal mining. The fundamental solutions for the model are presented. Numerical approaches to determine the roof-to-floor convergence and evaluation of ground movement are discussed. Numerical results and comparisons with field observations are given to illustrate the validity and the potential of the model.

Keyword(s): prediction, coal mining, modeling, boundary element

Salas, J. A. J. Two Subsidence Cases in Spain. IN: Proceedings International Society for Rock Mechanics 4th International Congress, Montreux, v. 3, 1979, p. 369-373.

Keyword(s): rock mechanics

Location(s): Spain

Sanda, A. P., S. A. Zaburunov. Is It a Short Longwall, or a Long Shortwall? Coal, December, 1988, p. 39-41.

The "go longwall" maxim is being challenged by a 25-year-old concept just now being proven to be commercially viable and operationally feasible. The shortwall machine was originated in the 1960s, but one coal company in western Pennsylvania calls it the solution to their problem.

Keyword(s): coal mining, shortwall, longwall, National Coal Board
Location(s): Pennsylvania, Appalachian Coal Region, United States

Sanderson, S. A. The Future of Longwall Mining Under SMCRA. An Industry Under Siege: Some Facts About Subsidence, Seminar sponsored by American Mining Congress and Illinois Coal Association, February 15-16, 1990, Mt. Vernon, IL, 12 p.
During the past 2 years, the coal industry has faced many nationwide regulatory initiatives to limit or curtail full-extraction underground coal mining. The increasing political scrutiny and attention to longwall mining is reflected in state legislative measures to restrict longwall mining, court decisions, and rulemaking proposals.
Keyword(s): law, longwall, coal mining, environment, surface structural damage, active mines
Location(s): Rocky Mountain Coal Region, Illinois Coal Basin, Appalachian Coal Region, United States

Sandhu, R. S., E. L. Wilson. Finite-Element Analysis of Land Subsidence. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 89, v. 2, p. 393-400.
Keyword(s): finite element, modeling

Sandhu, R. S. Modeling Land Subsidence. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, S.K. Saxena, ed., Pensacola Beach, FL, January 15-20, 1978. ASCE, New York, 1979, p. 565-579.
The author selectively and briefly reviews the development of land subsidence models in this paper. The purpose is to highlight doubts and to raise questions regarding the validity of some commonly accepted notions. First, some theoretical models are looked at and certain differences of opinion are noted in setting up constitutive relationships. Thereafter, some theoretical as well as numerical schemes are considered. An example is included to illustrate the possibility of error inherent in the use of ad hoc simplifications.
Keyword(s): prediction, modeling, mathematical model, phenomenological model, continuum mechanics

Sandia National Laboratories. A Review of Subsidence Prediction Research Conducted at Sandia National Laboratories. SAND82-0017, Sandia National Laboratories, Albuquerque, NM, April, 1982, 46 p.
Keyword(s): prediction, subsidence research
Location(s): United States

SANGORM, International Society for Rock Mechanics, South African National Group. The Effect of Underground Mining on Surface. Proceedings SANGORM Symposium, October 21, 1986, Sandton, South Africa.
The proceedings contains 18 papers related to the effects of underground mining on the surface.
Keyword(s): coal mining, metal mining, nonmetal mining, rock mechanics, law, surface structural damage, monitoring methods, survey methods, room-and-pillar, longwall, influence function, computer, modeling, empirical model, prediction, subsurface water, mine design
Location(s): South Africa

Sann, B. Considerations on Precalculating Ground Subsidences Due to Coal Mining. Bergbau-Rundschau, 1949, p. 163-168 (in German).
Keyword(s): prediction, coal mining, modeling, empirical model, influence function

Santy, W. P., W. F. Eichfeld, R. J. McKelvey. Methods of Characterization of Subsidence Due to Longwall Mining in the Illinois Coal Basin. IN: Proceedings 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 247-259.
This paper describes the monitoring systems conducted in conjunction with the rock mechanics study undertaken with the longwall demonstration project at Old Ben No. 24 Mine from 1975 to 1979. Two subsidence monitoring systems were employed for monitoring subsidence. The reasons for using two systems were to show the feasibility of using a concentrated system for characterizing subsidence and to compare the results obtained from more traditional monitoring techniques.
Keyword(s): coal mining, longwall, monitoring methods, monitoring equipment, monitoring design, survey equipment, survey methods, vertical displacement, horizontal displacement
Location(s): Illinois, Illinois Coal Basin, United States

Sargand, S. M., G. A. Hazen. Highway Damage Due to Subsidence. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, 1988, p. 18-31.

In this study, subsidence profiles were obtained over three longwall panels that were mined beneath state highways in southeastern Ohio. Immediate and short-term subsidences were recorded. A video camera probe was lowered into two core holes before and after longwall mining took place, and visual inspections were performed to examine the nature of cracking. A laboratory investigation was conducted to determine the strength and elastic properties of rock strata above the mine.

Keyword(s): longwall, coal mining, roads, survey methods, lab testing, rock mechanics, profile function, horizontal displacement, prediction, structural mitigation

Location(s): Ohio, United States

Saric, J. A. The Hydrogeological Effects of Abandoned Underground Coal Mines, Muddy, Illinois. M.S. Thesis, Northern Illinois University, De Kalb, May, 1987, 106 p.

The long-term hydrogeologic effects of underground mining and mine-induced fracturing and subsidence were studied at the town of Muddy, Illinois, which is underlain by two abandoned mines. The Pennsylvanian rocks include several minor sandstone aquifers and are overlain by glacial lake deposits, some water-bearing. The Cottage Grove Fault separates the mines. It is generally thought that the strata fracturing associated with subsidence can increase permeability and create interaquifer connections. In this study, subsidence features were located and water levels in wells were measured in 1985 and 1986. Although the water table, like the topography, is almost flat, the bedrock piezometric surface shows anomalies due to the mine. Possibly, mine-induced fractures connected aquifers and allowed groundwater to enter the mine conduit. However, transmissivities estimated from pumping tests showed no relation to subsidence features. It is suggested that the mine is absorbing the regional upward discharge of groundwater, creating a depression in the piezometric surface. Mixing zones between glacial and bedrock aquifers were seen to occur as leakage occurred through mine-induced fractures and through leaky well casings. Water samples were analyzed for major ions; indirect evidence was found for the upwelling of mineralized water. Mixing is shown to occur between glacial and bedrock wells in relation to mine-induced fracturing and subsidence.

Keyword(s): subsurface water, coal mining, abandoned mines, hydrology, overburden, geologic features, inflow

Location(s): Illinois, Illinois Coal Basin, United States

Sauck, W. A. Geophysical Studies Near Subsidence Fissures in Central Arizona. Transactions American Geophysical Union, EOS, v. 56, 1975, p. 984-985.

Keyword(s): fluid extraction, geophysical

Location(s): Arizona, United States

Sauer, A. Die Einfluesse Von Durchbauungsgrad, Abbaukonzentration Und Abbaugeschwindigkeit Auf Die Vorausberechnung (Influence of Previous Workings, Concentration, and Advance Rate of Mining Exploitation on the Precalculation of Ground Deformations). Glueckauf-Forschungshefte, v. 36, no. 1, February 1975, p. 16-26.

Keyword(s): prediction, multiple-seam extraction

Saul, H. The Working of Coal Seams in Close Proximity. Transactions Institute of Mining Engineers, v. 113, no. 1089, April, 1954.

Keyword(s): backfilling, multiple-seam extraction, coal mining

Saustowicz, A. New Conceptions as to the Phenomena of Stress and Strain in Rocks Around Mining Excavations. IN: Proceedings International Strata Control Congress, Leipzig, October 14-16, 1958, p. 1-13 and III-IV.

One of the first problems studied was the determination of the magnitude of pressure effected by rocks on supports in roads and tunnels. The subject of this paper is the role played by time in strata control phenomena.

Keyword(s): ground control, time factor, rock mechanics, modeling, lab testing

Location(s): Poland

Savage, W. Z. Prediction of Vertical Displacements in a Subsiding Elastic Layer--A Model for Subsidence in Karst Terrains. U.S. Geological Survey OFR 79-1094, 1979, 13 p.

This paper details a model in which a subsiding region is modeled as an infinitely long elastic layer resting on a rigid base and deforming under its own weight into an opening at its lower edge. An approximate solution for vertical displacements on the ground surface and over the opening is found for the case when the layer thickness is much greater than the width of the opening.

Keyword(s): modeling, vertical displacement, geologic features
Location(s): United States

Savage, W. Z. Prediction of Vertical Displacements in a Subsiding Elastic Layer. Geophysical Research Letters, v. 8, no. 3, 1981, p. 195-198.

The author quantitatively discusses a method of modeling subsidence over an underground cavity. The subsiding region is assumed to be an infinitely long elastic layer that rests on a rigid base and deforms under its own weight into an opening under its lower surface. An approximate analytic solution based on Fourier transform methods is found for vertical displacements of the ground surface and the roof of the opening when the layer thickness is much greater than the width of the opening.

Keyword(s): vertical displacement, modeling, geologic features, geophysical

Savkov, L. V. Ground Movement Induced by Open Cut and Underground Mining. Soviet Mining Science, v. 2, no. 6, November/December 1966, p. 557-583.

Keyword(s): surface subsidence damage
Location(s): Soviet Union

Saxena, N. C., S. Samanta, K. P. Mukherjee, B. Singh. Strata Control Investigations at Caved Longwall Faces with Special Reference to the Faces of Moonidih Project. Journal of Mines, Metals, and Fuels, March, 1978, p. 109-130.

Keyword(s): ground control, longwall, roof stability
Location(s): India

Saxena, N. C., B. Singh. Investigations into the Safety of the Railway Line Against Ground Movement Due to Extraction of Two Thick Seams in India. IN: Rock Mechanics: A State of the Art, Proceedings 21st U.S. Rock Mechanics Symposium, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 345-355.

A railway line was subsided 385 mm, without affecting its normal operations.

Keyword(s): railroads, coal mining, multiple-seam extraction
Location(s): India

Saxena, N. C., B. Singh. Subsidence Behaviour of Coal Measures Above Bord and Pillar Workings. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York.

The angle of draw in Indian coalfields is positive and varies between 4 and 31 degrees. The non-effective width varies between 0.3 and 1.0 times the depth. It has not been possible to establish general relationships in the proportion of sandstone from 64% to 95% in the Coal Measures Succession, and its nature, is a contributing factor in the variation of subsidence behaviour. Safe limits of surface slope and strains for various categories of surface features and structures are proposed.

Keyword(s): prediction, surface subsidence damage, mine design, multiple-seam extraction, room-and-pillar, longwall, surface structural damage, surface water, coal mining, overburden, inflow
Location(s): India

Saxena, N. C., B. Singh. Subsidence Research in India. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., IAHS Publication No. 151, 1986, p. 661-667.

Due to lack of knowledge of subsidence behavior of Indian Coal Measures, seams underneath surface properties have mostly remained unexploited. Recent research has made it possible to partially develop subsidence indices and also to extract more than 6 million tons of coal underneath surface properties.

Keyword(s): coal mining, geologic features, hydraulic backfilling, pneumatic backfilling, room-and-pillar, surface structural damage, roads, railroads, subsidence research, angle of draw, surface water
Location(s): India

Saxena, N. C., B. Singh. Subsidence in Indian Coalfields. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 344-350.

Subsidence investigations in Indian coalfields have led to development of relationships between subsidence movement parameters and defining safe limits of subsidence movements for surface properties. The maximum subsidence over caved workings was generally not more than 60% of extraction thickness underground. In the case of hydraulically stowed sand stowed workings, it was generally not more than 5%. The relationships have been useful in extraction of more than 7 million tons of coal from underneath and in the vicinity of surface properties.

Keyword(s): coal mining, hydraulic backfilling, surface structural damage, room-and-pillar, longwall, active mines, railroads, geologic features

Location(s): India

Saxena, N. C., B. Singh. Extraction of Coal Seams Underneath a Main Railway Line at Sudamdih in Jharia Coalfield. IN: Proceedings, International Symposium on Underground Engineering, New Delhi, India, April 14-17, 1988, B. Singh, ed., Balkema, Rotterdam, p. 389-393.

About 3 million tons of coking coal have been extracted from three thick coal seams by ascending slicing with hydraulic sand stowing at depths ranging from 35 to 400 meters underneath and in the vicinity of a main railway line. The railway line has been made to gradually subside by a maximum of 621.8 mm. The railway tracks have also been subjected to a maximum strain of 3 mm/m, which was taken as the safe limit for jointed construction railway lines. It has not been necessary to adjust the railway track or stop its operation so far.

Keyword(s): hydraulic backfilling, horizontal displacement, longwall, coal mining, railroads, multiple-seam extraction

Location(s): India

Saxena, S. K. A Review of the Methods Used in Investigation of Subsidence. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 214-244.

This paper concentrates on examining the available methods for evaluating subsidence due to fluid flow. The problem of fluid flow through a geologic media is a hydrogeomechanical problem and the solutions are based on the conservation principle of classical physics.

Keyword(s): fluid extraction, oil extraction, modeling

Saxena, S. K. A Review of the Theories Used in Investigation of Subsidence. Indian Geotechnical Journal, Delhi, v. 11, no. 1, 1981, p. 75-91.

Keyword(s): prediction theories

Location(s): India

Saxena, S. K., ed. Evaluation and Prediction of Subsidence. Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, American Society of Civil Engineers, New York, 1979, 594 p.

Subsidence due to withdrawal of ground fluids has been observed in Venezuela, Thailand, Mexico, Italy, Netherlands, and several states in the United States. In the last decade, there has been a significant development in theory and evaluation of methods to predict subsidence. This conference brought together experts in groundwater hydrology, geotechnology, and geologists from various parts of the world. The evaluation of subsidence is a geomechanical problem and requires a synthesis of knowledge from many fields.

Keyword(s): prediction, engineering, modeling, fluid extraction, coal mining, surface structural damage

Schaffer, J. F. Roof Fall Prediction at an Illinois Underground Mine. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 55-63.

Roof fall prediction in coal mines is complicated by the many interacting geological factors contributing to the occurrence of a fall. Empirical methods are typically best suited to characterize the nature of conditions that result in roof falls at a given mine. In this mine in the Springfield seam, clay dikes are the primary cause of roof falls. Collection and analysis of pertinent geological data from 96 falls led to the development of the "Roof Failure Rating System" for predicting the occurrence of roof falls with a reasonable degree of accuracy.

Keyword(s): roof stability, coal mining, partial extraction, mine safety, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Schaller, S. Stability of Chain Pillars and Gate Roads at South Bulli 'B' Mine Longwalls. Australian Coal Industry Research Labs., Ltd., North Ryde, Australia, October 1983, 80 p.

Keyword(s): pillar strength, longwall, coal mining

Location(s): Australia

Schilizzi, P., M. Karmis, A. Jarosz. Development of Subsidence Prediction Technology from an Extensive Monitoring Program. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 31-43.

A detailed subsidence and strain monitoring program was initiated above a number of active mines, located in three major coal-producing counties of Virginia. The aim of this program was to enhance the database with accurate and complete measurements of surface movements and to allow, therefore, the evaluation and refinement of prediction techniques.

Keyword(s): empirical model, prediction theories, prediction, horizontal displacement, coal mining, law, government, profile function, influence function, monitoring methods, survey equipment, survey methods

Location(s): Virginia, Appalachian Coal Region, United States

Schmechel, F. W., W. F. Eichfeld, W. P. Santy. Automated Data Acquisition for Subsidence Characterization. Presented at SME-AIME Fall Meeting, New Orleans, LA, February 18-22, 1979, SME-AIME preprint 79-132, 12 p.

This paper reviews the design and installation of an automatic data-acquisition system over a coal mine in Illinois to monitor and record ground deformations associated with underground mining operations.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey equipment, computer, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Schmidt, B. Settlements and Ground Movements Associated with Tunnelling in Soil. Ph.D. Thesis, 1969, University of Illinois, Urbana-Champaign.

Keyword(s): soils, tunnelling

Schmidt, B. State of Predictive Art in Subsidence Engineering. Discussion ASCE Journal Soil Mechanics & Foundations Division, v. 96, no. SM5, 1970, p. 1841-1843.

Keyword(s): prediction, soil mechanics

Schmidt, B. Prediction of Settlements Due to Tunneling in Soil: Three Case Histories. IN: Proceedings Rapid Excavation and Tunneling Conference, v. 2, 1974, p. 1179-1199.

Keyword(s): prediction, tunnelling

Schmidt, R. D. Fracture Zone Dewatering to Control Ground Water Inflow in Underground Coal Mines. U.S. Bureau of Mines RI 8981, 1985, 84 p.

This investigation focuses on the identification and control of groundwater inflow problems that occur in the active sections of underground Appalachian coal mines. A fracture inflow survey of eight underground mines was conducted. Three types of mine fracture intercepts typical of wet section mining conditions were identified. A mine in Preston County, West Virginia, was selected as the site for a fracture zone dewatering experiment. This investigation indicates that fracture zones are responsible for the sudden release of stored groundwater, which often occurs as mining sections advance beneath fracture valley topography. It is concluded, therefore, that dewatering operations designed to intercept the component of groundwater stored in fracture zones will be most effective in controlling infiltration to active mine sections.

Keyword(s): subsurface water, coal mining, geologic features, hydrology, inflow

Location(s): West Virginia, Appalachian Coal Region, United States

Schmidt, R. D., W. F. Ebaugh. Some Considerations Regarding the Steady-State Response of Shallow Aquifers to Underground Mining. IN: Proceedings, Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Lexington, KY, December 9-13, 1985, p. 1-7.

The effect of underground room-and-pillar mine development (first mining only) on shallow ground water aquifers is often difficult to predict. A hydrogeologic context that includes not only the underlying mine void, but also multiple aquifer-aquitard layers, and zones of rock fracturing is important to understanding the hydrologic effects of underground mining in eastern coal regions. Nested piezometers were installed at various depths above a mine void in western Pennsylvania. Piezometer measurements indicate a downward gradient in head in the rock units overlying the mine that is highly variable, depending on piezometer depth in relation to fractures and shale aquitard layers.

Keyword(s): coal mining, room-and-pillar, hydrology, subsurface water, overburden, monitoring methods

Location(s): Pennsylvania, Appalachian Coal Region, United States

Schmidt, R. D. Factors Affecting Residential Water Well Yield in the Vicinity of Room and Pillar Mines. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 244-252.

The USBM is conducting an investigation to develop remediation techniques for residential water wells whose yield has been affected in the long term by underground mining. Initial work related to this project was conducted from 1984 to 1987 at a room-and-pillar mine in Indiana County in Pennsylvania.

Keyword(s): hydrology, subsurface water, room-and-pillar, coal mining, longwall, mitigation, geologic features

Location(s): Pennsylvania, Appalachian Coal Region, United States

Schonfeldt, H. V., F. D. Wright, K. F. Unrug. Subsidence and its Effect on Longwall Mine Design. Session papers American Mining Congress, St. Louis, MO, May 20-23, 1979, v. 6, 12 p. (NTIS Accession No. 80-06126)

Keyword(s): longwall, mine design, geologic features

Location(s): United States

Schoonbeck, J. B. Land Subsidence as a Result of Natural Gas Extraction in the Province of Groningen. Society of Petroleum Engineers of AIME, SPE Paper 5751 presented to SPE--European Spring Meeting, 1976, Amsterdam, The Netherlands.

Keyword(s): fluid extraction, oil extraction

Location(s): Netherlands

Schoonbeek, J. B. Land Subsidence as a Result of Gas Extraction in Groningen, The Netherlands. International Association Hydrological Sciences Publication 212, 1977, p. 267-284.

Keyword(s): oil extraction, fluid extraction

Location(s): Netherlands

Schothorst, C. J. Subsidence of Low Moor Peat Soils in the Western Netherlands. Geoderma, v. 17, 1977, p. 265-291.

Keyword(s): fluid extraction, soils

Location(s): Netherlands

Schubert, J. P. Reducing Water Leakage into Underground Coal Mines by Aquifer Dewatering--A Computer Simulation Study. IN: Proceedings 1st World Congress on Water in Mines and Underground Work, SIAMOS, September 18-22, 1978, R. Fernandez-Rubio, ed., Granada, Spain, p. 911-932.

Stratigraphic, structural, hydrogeologic, and mining data were collected during a study in central Pennsylvania. A two-dimensional, finite-difference computer model was used to simulate groundwater flow in a sandstone unit (0.3-11 m thick) overlying an underground mine, and to evaluate the responses of the flow system and leakage rate into the mine when hypothetical dewatering wells are introduced into the system. Simulation of well dewatering, using 25 wells, showed that negligible reduction in leakage would occur if sandstone permeability was less than 0.30 m/day. When sandstone permeability equalled 3.0 m/day, 25 wells reduced leakage by 2.4%.

Keyword(s): computer, modeling, hydrology, subsurface water, coal mining, mine waste, environment, geologic features

Location(s): Pennsylvania, Appalachian Coal Region, United States

Schubert, J. P. Fracture Flow of Groundwater in Coal-Bearing Strata. IN: Proceedings Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation, Lexington, KY, December 1-5, 1980, D.H. Graves and R.W. DeVore, eds., University of Kentucky, UKY BU123, p. 61-73.

Fractures are of considerable importance to groundwater flow through lithified coal-bearing strata. By studying and understanding more about the structural control of fractures in coal basins, the larger inflows possibly could be avoided. This would reduce pumping and water treatment costs and lessen the depletion of groundwater resources in surrounding areas.

Keyword(s): coal mining, subsurface water, hydrology, overburden, lab testing, in situ testing, inflow

Location(s): Appalachian Coal Region, United States

Schuler, K. W., S. E. Benzley, H. J. Sutherland. A Study of Subsidence Over Longwall Panels Using Numerical and Physical Modeling Techniques. IN: Proceedings 19th Annual Meeting, Society of Engineering Science, University of Missouri-Rolla, October 27-29, 1982, p. 189 (abstract only).

Keyword(s): longwall, modeling, physical model

Schulte, H. F. The Effects of Subsidence on the Strata Immediately Above a Working with Different Types of Packing and in Level Measures. IN: Proceedings European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 188-197.

Various measurements were made to determine the effectiveness of backfilling methods, as well as to determine the effect of subsidence on roof strata.

Keyword(s): backfilling, subsurface subsidence damage, overburden, roof stability

Schumann, E.H.R. Controlled Subsidence of the Blackhill-Greenside Railway Line: Part 1. Chamber of Mines of South Africa, Research Report 8/83, 1983.
Keyword(s): railroads, active mines
Location(s): South Africa

Schumann, E.H.R. Surface Subsidence Due to the Extraction of Moderately Thick Coal Seams at Shallow Depth. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 248-263.
A significant proportion of the increase in South Africa's coal output comes from open cast mines and collieries employing longwall and pillar extraction methods. As a result of the change in mining technology and the scale of operations, damage to the surface and surface structures becomes a critical factor for the South African coal mining industry. For underground mining, the situation is aggravated by the thickness of the seams being extracted and their relatively shallow depth. This paper describes some results of research work carried out in connection with the undermining of surface structures.
Keyword(s): coal mining, surface structural damage, active mines, longwall, pillar extraction, monitoring methods, survey methods, survey equipment
Location(s): South Africa

Schumann, E. H. R. The Monitoring, Computation and Data Analysis of Surface Subsidence. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group.
Surface subsidence monitoring above total extraction coal mine workings was conducted by the 'Radial Precision Survey' method, using a theodolite and an electronic distance meter. The paper concludes that this method meets all of the requirements of modern subsidence monitoring and should therefore replace precise leveling where possible.
Keyword(s): survey methods, survey equipment, survey data processing, monitoring methods, monitoring equipment, profile function, empirical model, horizontal displacement, vertical displacement, coal mining, computer
Location(s): South Africa

Schumann, E. H. R. The Control of Surface Subsidence by Width/Depth Ratio and Chain Pillar Size in the Presence of Competent Coal Measures. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 358-368.
The local stratigraphy and composition of the coal measures, including competent dolerite sill and massive sandstone layers, is shown to have a restricting influence on the development and magnitude of surface subsidence above total extraction panels in South Africa. The critical panel width necessary to induce non-violent failure of a dolerite sill is quantified. Maximum surface subsidence, tilt and ground strain is compared to the National Coal Board model. An exponential subsidence profile curve (SPC) describes a trough half-profile. A parabolic relationship between horizontal displacement and tilt, which has been discovered to exist, can be substituted in the first derivative of the SPC to generate transverse displacement and strain profiles.
Keyword(s): coal mining, active mines, geologic features, overburden, National Coal Board, horizontal displacement, vertical displacement, room-and-pillar, multiple-seam extraction, longwall, pillar extraction
Location(s): South Africa

Schumann, E. H. R. Occurrence of Controlled Coalmining Subsidence in South Africa. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 87-96.
In this paper, an overview is given of results of surface subsidence monitoring above numerous total extraction panels at shallow to moderate depth in various South African coalfields. Statutory restrictions are applied on the undermining of buildings and structures in order to protect them. Modes of surface subsidence are defined in terms of the severity of differential displacements, and the mechanism of caving and the deformation of superincumbent strata is briefly explained.
Keyword(s): surface structural damage, coal mining, active mines, longwall, pillar extraction, vertical displacement, horizontal displacement, survey data processing, National Coal Board, foundations, roads, pipelines, railroads
Location(s): South Africa

Schumann, H. H., J. F. Poland. Land Subsidence, Earth Fissures, and Groundwater Withdrawal in South-Central Arizona, U.S.A. IN: Proceedings Reading Symposium on World Water Balance, Institute of Scientific Hydrology, July, 1970.
Keyword(s): hydrology, subsurface water, fluid extraction
Location(s): Arizona, United States

Schwartz, B., R. Dubois. Effects of the Treatment of the Goaf (Strip Packing or Caving) On the Rock In the Immediate Vicinity. IN: Proceedings European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 152-158.
Keyword(s): backfilling, mine waste

Schwartz, B., R. Buisson, R. DuBois. Application of Statistical Methods to Characterize Support Efficiency and Floor Stability. IN: Proceedings, International Strata Control Congress, Leipzig, October 14-16, 1958, p. 137-156 and LXVI-LXV.
The purpose of these investigations was to determine the data for the strength of the surrounding rock and the behavior of the support in the various panels.
Keyword(s): rock mechanics, floor stability, pillar strength, longwall, coal mining
Location(s): France

Schwartz, B. Movements of the Roof and Floor in Roadways. IN: Proceedings 4th Symposium on Rock Mechanics, Mineral Industries Experiment Station Bulletin 76, The Pennsylvania State University, University Park, 1961, p. 1-10.
This paper includes an approximate mathematical method of forecasting long-term movements in roadways, to facilitate design of roadway supports.
Keyword(s): coal mining, floor stability, roof stability, rock mechanics, mine design, mathematical model
Location(s): United States

Schwarz, S. D., G. McLucas. Detection of Destressed Rock and Potential Collapse Above Old Mine Workings by the Seismic Refraction Method. IN: Proceedings Symposium on the Application of Geophysics to Engineering and Environmental Problems, Society of Engineering and Mineral Exploration Geophysicists, March 28-31, 1988, p. 658-665.
The delineation of existing or potential geologic hazards related to the subsidence, relaxation or weakening of rock above old mine workings is important to public safety and the mitigation of property damage. The detection of areas of destressed rock by conventional exploration methods can be extremely difficult and expensive. A number of sites in coal-mining areas of the western and northwestern United States have been explored using seismic refraction. It has been demonstrated that low velocity zones in bedrock can be diagnostic of destressed zones in bedrock above old mine workings. In areas where no detailed or reliable mine maps are available, low velocity zones in bedrock interpreted from highly detailed seismic velocity profiles can provide a basis for establishing targets for more direct methods of exploration.
Keyword(s): abandoned mines, seismic, geophysical, coal mining, overburden, geologic features
Location(s): Washington, United States

Scotese, T. R. Instrumentation and Monitoring for Pillar Extraction in a Deep, Faulted Uranium Mine. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 513-522.
A rock mechanics instrumentation and monitoring program was implemented during pillar extraction at the deepest uranium mine in the United States. Three types of monitoring were employed: (1) drift convergence around stopes (using a portable tube extensometer), (2) stress changes in pillars (using vibrating wire stressmeters in horizontal boreholes), and (3) load changes in haulageways under stopes (using vibrating load cells in jack stands). The instrumentation and monitoring program provided a warning system against ground control problems and a characterization of ground behavior for future development and extraction of pillars.
Keyword(s): pillar extraction, metal mining, instrumentation, monitoring methods, monitoring equipment
Location(s): New Mexico, United States

Scott, A. C. Locating and Filling Old Mine Workings. Civil Engineering Public Works Review, v. 52, 1957, p. 1007-1011.
Keyword(s): backfilling, abandoned mines

Scott, J. J. Practical Ground Control as it Relates to Productivity, Safety and Costs. IN: 2nd Conference on Ground Control Problems in the Illinois Coal

Basin, May 1985, Southern Illinois University, Carbondale, Y.P. Chugh, ed., (keynote address), p. 1-7.

Rock mechanics theory needs to be applied to solve ground control problems but, in the final analysis, the mining method and equipment used will be those that solve problems in a practical manner. Equipment and its inherent productivity and safety as supplied by "off the shelf" items by manufacturers often dictate the size of mine openings. In this whole process, the costs of mining finally dictates what system will be employed and what equipment will be used.

Keyword(s): ground control, mine safety, rock mechanics, economics, mine operation, geologic features, instrumentation, roof bolting, coal mining, metal mining

Location(s): United States

Scott, R. F. Subsidence--A Review. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 1-25.

In this paper, a brief review is given of surface movement mechanisms, analytical techniques, and a few case histories.

Keyword(s): horizontal displacement, vertical displacement, fluid extraction, geologic features, coal mining, modeling, oil extraction, finite element

Scurfield, R. W. Reconstruction in the North Staffordshire Coalfield. Colliery Guardian, v. 195, no. 5030, July, 1956, p. 95.

Keyword(s): backfilling, coal mining

Location(s): United Kingdom

Segatto, P., W. F. Heinz. Backfilling of Coal Mines. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 237-241.

This paper describes primarily the two types of backfilling operations done in the undermined coalfields in Ermelo. Particular reference has been made to filling under fiery and flooded mine conditions. This successful backfilling operation had to take into account the availability and pumpability of the backfill material in the Ermelo area, while at the same time minimizing the costs to make the exercise economically viable.

Keyword(s): backfilling, coal mining, abandoned mines, hydraulic backfilling

Location(s): South Africa

Seils, D. E., R. G. Darmody, F. W. Simmons. Water Movement on Aeric Ochragualf as Revealed by Dye Tracers. IN: Agronomy Abstracts, American Society of Agronomy/Soil Science Society of America 82nd Annual Meeting, San Antonio, TX, October 21-26, 1990, p. 303.

A solution of dye and tracer was ponded on three pedons to characterize the macroporosity and flow paths of an Aeric Ochraqualf with a weak fragipan, located over a subsiding longwall panel.

Keyword(s): agriculture, soils, longwall, active mines, coal mining, hydrology

Location(s): Illinois, Illinois Coal Basin, United States

Seils, D. E., R. G. Darmody, F. W. Simmons. The Effects of Coal Mine Induced Subsidence on Macropores and Bromide Movement. IN: Agronomy Abstracts, American Society of Agronomy/Soil Science Society of America, October 27-November 1, 1991, Denver, CO, p. 51.

Subsidence is increasing as the coal-mining industry adopts more efficient methods of underground extraction. Subsidence as deep as 2 meters and cracks as wide as 0.3 meters can develop above a mine panel. However, most noticeable cracks close after the mining front moves beyond a given point. Field studies were initiated to determine if subsidence cracks result in greater preferential flow.

Keyword(s): soils, active mines, longwall, agriculture, mitigation, subsurface water

Location(s): Illinois, Illinois Coal Basin, United States

Seils, D. E., R. G. Darmody, F. W. Simmons. The Effects of Coal Mine Subsidence on Soil Macroporosity and Water Flow. IN: Proceedings National Symposium on Prime Farmland Reclamation, 1992, R.E. Dunker, R.I. Barnhisel, and R.G. Darmody, eds., Department of Agronomy, University of Illinois, Urbana, p. 137-145.

A field study using Rhodamine B dye and bromide tracers was conducted to determine whether subsidence fractures remain in the soil and contribute to increased preferential flow. Results indicated that cracks remain in the soil along the mine panel edge 8 months after subsidence. Preferential flow was shown to be enhanced at this site following subsidence. However, evidence of this is lacking for the panel center. Further research is needed to determine if groundwater quality changes occur as a consequence of subsidence cracks along the mine panel edge.

Keyword(s): active mines, soils, longwall, coal mining, agriculture, subsurface water, hydrology
Location(s): Illinois, Illinois Coal Basin, United States

Seils, D. E. Soil-Hydrological Impacts of Coal Mine Subsidence. M.S. Thesis, University of Illinois Department of Agronomy, 1992, 93 p.

A field study was undertaken to determine whether soil cracks resulting from coal mine induced subsidence allowed greater preferential flow of water through soil and also to document the effects of subsidence on near-surface groundwater elevations. A solution of Rhodamine B dye and bromide were applied to characterize changes in soil structure and water movement. Cracks were found to remain in the soil at the mine panel edge eight months after subsidence as revealed by the dye. Dye patterns at the panel center line revealed no subsidence cracks. Groundwater elevations at the site a year after subsidence were approximately the same as before subsidence.

Keyword(s): agriculture, soils, hydrology, coal mining, active mines, longwall, monitoring methods
Location(s): Illinois, Illinois Coal Basin, United States

Seldrenrath, R. Can Coal Measures be Considered as Masses of Loose Structures to Which the Laws of Soil Mechanics May be Applied? IN: International Conference on Rock Pressure and Support in the Workings, Liege, 1951, p. 79-83.

Keyword(s): coal mining, overburden, soil mechanics

Selman, P. H. Coal Mining and Agriculture: A Study in Environmental Impact Assessment. Journal of Environmental Management, 22, 1986, p. 157-186.

Coal mining activities in the United Kingdom are extending into areas of comparatively unspoilt countryside. Despite reductions in the National Coal Board's program of future expansion, it is considered that the scale of impact of new mining activities on agriculture is still likely to be significant. The major impact will be associated with land alienation, but a wide range of other adverse effects will also be encountered. In view of the controversy likely to accompany new mining proposals, it is recommended that methods of environmental impact assessment (EIA) should be adopted. The nature and components of EIA are reviewed, and a framework appropriate to mining-agriculture conflicts is advanced.

Keyword(s): coal mining, agriculture, environment, reclamation, active mines, mine waste, soils, vertical displacement, horizontal displacement
Location(s): United Kingdom

Sendlein, L. V. A., H. Yazicigil, C. L. Carlson, H. K. Russell, eds. Surface Mining, Environmental Monitoring and Reclamation Handbook. Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146. Elsevier, New York, 1983, 750 p.

The process for constructing this handbook was based on the philosophy that experts working in the field could best describe the state of the art of monitoring and planning to meet the requirements of the SMCRA (1977). The book has eight chapters on geology, hydrology, reclamation, air quality, blasting, fish and wildlife, archaeological resources, and subsidence. Each chapter has sections written by various experts on the subject.

Keyword(s): monitoring methods, reclamation, environment, geologic features, hydrology, surface structural damage, wildlife
Location(s): Illinois Coal Basin, Appalachian Coal Region, Rocky Mountain Coal Region, United States

Sendlein, L. V. A., J. S. Dinger, T. D. Fickel. Impact of Underground Coal Mining on the Anvil Rock Aquifer. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, Illinois, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 15-50.

This paper describes the data collection and analysis performed to assess the impact of underground coal mining on groundwater. The coal mine under study is located in western Kentucky in a region that has been mined for the last 50 years. A major aquifer is present in the area and is a stratigraphic unit that occurs in both sheet and channel phases.

Keyword(s): active mines, abandoned mines, room-and-pillar, subsurface water, hydrology, geologic features, coal mining
Location(s): Kentucky, Illinois Coal Basin, United States

Serata, S., B. H. Gardner. Prediction and Design Control of Surface Subsidence by Global Simulation of Mine Behavior Using Finite Element Model. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 44-53.

The Stress Control Method of mine design provides enhanced engineering control over the behavior of underground structures in comparison to conventional mine design methods. A field example is given in this paper to illustrate the application of this method.

Keyword(s): finite element, mine design, computer, modeling, prediction

Serata, S., F. Carr. Stress Control Method Applied to Stabilization of Underground Coal Mine Openings. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 583-590.

Serious floor heave of as much as 2.4 meters in a 2.4-meter-high mine entry was eliminated by applying the stress control method of mining in the Black Warrior coal basin near Birmingham, Alabama. Underground observation of the first three-room entry created using the stress control method is discussed here. The behavior of the test entry, which eliminated the heave problem, is analyzed in relation to studies conducted in a salt mine underground conditions by using finite element analysis.

Keyword(s): finite element, floor stability, coal mining, non-metal mining

Location(s): Alabama, United States

Serata, S., B. Das, K. Shrinivasan, V. J. Hucka. Application of the Stress-Property-Deformation Relation (SPDR) Technology to Underground Mine Design Optimization. IN: Proceedings, International Symposium on Underground Engineering, New Delhi, India, April 14-17, 1988, B. Singh, ed., Balkema, Rotterdam, p. 157-163.

The behavior of complex ground commonly involves a number of behavioral components, including elasticity, viscoelasticity, viscoplasticity, strength deterioration, strain hardening, and brittle ductile movement. A quantitative approach for analyzing and designing earth structures in such complex ground has been synthesized from in situ stress measurement, in situ property measurement, field deformation measurement, and development of an REM (Rheological Element Method) finite element computer program.

Keyword(s): yielding supports, in situ testing, ground control, instrumentation, finite element, computer

Location(s): Pennsylvania, Appalachian Coal Region, United States

Sgambat, J. P., E. A. LaBella, S. Roebuck. Effects of Underground Coal Mining on Ground Water in the Eastern United States. Geraghty & Miller, Annapolis, MD, US EPA-600/7-80-120, Contract No. 68-03-2467, June, 1980, Industrial Environmental Research Laboratory, Office of Research and Development, US EPA, Cinncinnati, 183 p.

This report addresses the past effects and the possible future effects of underground coal mining activities on groundwater resources in the region east of the 100th meridian. Such effects are highly dependent on the location of the mine with respect to natural flow system. Recharge-discharge relationships in the vicinity of active mines may be altered, and lowered groundwater levels may not recover to pre-mining conditions after closure. Studies indicate that contamination of groundwater exists in many places in the immediate vicinity of coal mines. Many refuse piles and impoundments probably affect the quality of streams and shallow groundwater. However, on a regional basis, there is little evidence from the scanty data on hand of gross groundwater contamination in heavily mined areas.

Keyword(s): coal mining, subsurface water, hydrology, mine waste, inflow, surface water, active mines, bituminous, anthracite, abandoned mines

Location(s): Alabama, Illinois, Indiana, Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, Illinois Coal Basin, Appalachian Coal Region, United States

Shadbolt, C. H., W. J. Mabe. Subsidence Aspects of Mining Development in Some Northern Coalfields. IN: Geological Aspects of Development and Planning in Northern England, P.T. Warren, ed., Yorkshire Geological Society, Leeds, England, 1970, p. 108-123.

This paper discusses three factors pertaining to surface development and exploitation in undermined areas: orthodox ground movements related to the dimensions of mineral extraction, geotechnical conditions, and the tolerance of surface structures to ground movements.

Keyword(s): mine design, mine operation, surface structural damage, structural mitigation, coal mining, land-use planning, geologic features

Location(s): England

Shadbolt, C. H., B. N. Whittaker, D. J. Forrester. Recent Developments in Mining Subsidence Engineering. IN: 64th General Meeting of the Midland County Mineral Division of the Royal Institute of Chartered Surveyors, Nottingham, October 19, 1973.
This paper examines methods of subsidence prediction and engineering and their influence by local geological site conditions. Subsidence aspects of both deep mining and surface mining are dealt with in detail and attention is focused on structural aspects of mining subsidence. The authors describe current forms of instrumentation and field measurement techniques.
Keyword(s): prediction, survey methods, instrumentation, geologic features, surface structural damage
Location(s): United Kingdom

Shadbolt, C. H. Mining Subsidence. IN: Site Investigations in Areas of Mining Subsidence, F.G. Bell, ed. Newnes-Butterworths, 1975, p. 109-124.

Shadbolt, C. H. Mining Subsidence and Protective Measures for Surface Structures. Chartered Surveyor Land Hydrology & Mineral Quarterly, v. 3, no. 2, 1975-76, p. 29-32.
Keyword(s): surface structural damage, engineering

Shadbolt, C. H. Mining Subsidence--Historical Review and State of the Art. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 705-748.
The author discusses various subsidence parameters and their effects as they relate to mine extraction dimensions, and explains various means of reducing subsidence damage. Also included is a historical review of the theories and work by early subsidence investigators.
Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, survey data processing, engineering, historical, prediction theories

Shadbolt, C. H. A Study of the Effects of Geology on Mining Subsidence in the East Pennine Coalfield. Ph.D. Thesis, University of Nottingham, UK, 1987.
Keyword(s): geologic features, coal mining

Shadrin, A. G. Trajectory of a Point at the Surface Near An Advancing Extraction Face. Soviet Mining Science, v. 9, no. 1, January/February 1973, p. 7-10.
Keyword(s): surface subsidence damage
Location(s): Soviet Union

Shadrin, A. G., A. S. Yagunov. Raschet Maksimal Nykh Velichin Sdvizhenii Zemnoi Poverkhnosti Pri Podzemndi Razrabotke Ugol'Nykh Mestorozhdenii (Calculation of Maximum Shifts of the Ground Surface Due to Underground Working of Coal Deposits). Permskii Politehniceskii Institut, U.S.S.R., Izvestiya Vysshikh Uchebnykh Zavedenij, Gornyj Zhurnal, no. 11, 1973, p. 53-58.
Keyword(s): prediction, coal mining
Location(s): Soviet Union

Shea-Albin, V. R. Effects of Longwall Subsidence on Escarpment Stability. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 272-279.
Because sandstone escarpments are an environmental issue, millions of tons of coal reserves that underlie these escarpments risk being classified as unminable by regulatory agencies. At this time, the effect of subsidence on escarpments has not been well documented or characterized. The USBM is using numerical modeling techniques to analyze escarpment response to longwall mining. Two- and three-dimensional models have been constructed for a study area near Price, Utah, where longwall panels were mined near an escarpment.
Keyword(s): coal mining, longwall, geologic features, active mines, environment, wildlife, modeling, finite element, boundary element
Location(s): Utah, Rocky Mountain Coal Region, United States

Shelton, J. W. Role of Contemporaneous Faulting During Basinal Subsidence. Bulletin American Association of Petroleum and Geology, v. 52, no. 3, 1968, p. 399-413.
Keyword(s): fluid extraction, geologic features

Sheng, X. L., S. Y. Jing. The Research on the Mechanical Properties of Hard Roof in Underground Coal Mining. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 579-586.

During the course of mining, when the roof above coal seams is constituted by thick and hard sandstone, sudden roof movements often take place with great force and destruction, which is the biggest danger to safety and production. Such severe movements of the roof directly relate to rock mechanical properties, which are the main factors that influence the regularity of hard roof movement and its destruction form. A significant way to apply rock mechanics into mining engineering is to study the properties of the hard roof; parameters can then be altered that will help to more efficiently control the movement of the hard roof.

Keyword(s): coal mining, roof stability, overburden, rock mechanics, engineering, active mines

Location(s): China

Sheorey, P. R., B. Singh. Strength of Rectangular Pillars in Partial Extraction. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 11, no. 1, January, 1974, p. 41-44.

Model sandstone pillars were used in laboratory compression tests. The concluding theory was that average width rather than least width is important in determining pillar strength.

Keyword(s): room-and-pillar, pillar extraction, pillar strength, rock mechanics, partial extraction, lab testing

Sheorey, P. R., T. N. Singh, B. Singh. Considerations for the Stability of Longwall Chain Pillars and Adjacent Roadway. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, Elsevier, New York, I.W. Farmer, ed., p. 129-133.

The old subject of stability of chain pillars and a roadway protected by them is dealt with using a new approach. The simple method of the theory of beams on elastic support is used to estimate the one-sided pressure distribution over the chain pillars when the goaf is only on one side. It is shown how the mechanical properties involved in the method can be determined measuring roof-seam contact displacements in situ. Even if the pillars per se are stable, the roadway they protect may still show signs of distress, as shown in a case study. A modern rock mass classification has been applied to assess roadway stability.

Keyword(s): longwall, mine design, pillar strength, in situ testing, modeling, coal mining, roof support, rock mechanics

Location(s): India

Sheorey, P. R., M. N. Das, D. Barat, R. K. Prasad, B. Singh. Coal Pillar Strength Estimation from Failed and Stable Cases. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 24, no. 6, December, 1987, p. 347-355.

A new pillar strength equation is proposed for all practical values of width-height ratio based on 23 unstable and 20 stable pillar cases. Strength data of a number of coal seams are used to show that the in situ large-scale strength is more likely to be affected by depth of cover than the laboratory small-specimen strength. The latter is therefore incorporated in the new equation. Performance of some of the better known pillar strength formulas is compared with the new equation against the case studies. It is proposed that the safety factor should be changed with depth of cover and width-height ratio of pillars. Safety factor values are accordingly recommended for stowed and unstowed pillar arrays and chain pillars. An alternative simpler equation is also proposed for slender pillars.

Keyword(s): pillar strength, coal mining, lab testing, in situ testing

Location(s): India

Sheorey, P. R., B. Singh. Case Studies of Depillaring Under Special Strata and Mining Conditions. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 351-357.

Four case studies of special geomining conditions from Indian coalfields are discussed. These cases relate to pillar extraction in two seams simultaneously under a difficult roof, depillaring in an inclined seam resulting in rib instability, depillaring resulting in floor lift and side spalling, and contiguous pillar extraction under hard incavable strata. Solutions to these problems are given based on rock mechanics principles involving stress analysis, classification techniques, past experiences, and engineering judgement.

Keyword(s): pillar extraction, coal mining, multiple-seam extraction, rock mechanics, active mines, floor stability, overburden, geologic features

Location(s): India

Sherman, G. D. Assessment of Subsidence Related Damage to Structures in Louisville and Lafayette, Colorado. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special

Publication 31, Department of Natural Resources, Denver, 1986, p. 87-95.

Many theoretical methods are available to estimate subsidence induced horizontal ground strains. However, no evidence exists as to the magnitude of ground strains developed from collapse or the type and amount of structural damage that can be expected. To quantify the above questions, the author conducted an investigation of structures that are underlain by mine workings but were built prior to mining.

Keyword(s): abandoned mines, surface structural damage, horizontal displacement, foundations, prediction, empirical model, influence function, coal mining, architecture

Location(s): Colorado, Rocky Mountain Coal Region, United States

Sherrey, P., R. Dunham. An Approximate Analysis of Floor Heave Occurring in Roadways Behind Advancing Longwall Faces. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 15, 1978, p. 277-288.

Keyword(s): floor stability, longwall

Shih, S. F., J. W. Mishoe, J. W. Jones, D. L. Myhre. Subsidence Related to Land Use in Everglades Agricultural Area. Transactions, American Society Agricultural Engineers, 22, 1979, 560-568.

Keyword(s): land-use planning, agriculture

Location(s): Florida, United States

Shilang, L. Rational Layout of Roadways in Floor Strata Affected by Longwall Extraction. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 201-206.

Keyword(s): mine design, mine operation, longwall

Shippam, G.K. Numerical Investigation of Elastic Behaviour Around Longwall Excavations. Ph.D. Dissertation, University of Nottingham, 1970.

Keyword(s): longwall, modeling

Location(s): England

Shoemaker, F. D. How and Why Backfill Anthracite Mines. Coal Age, v. 44, May, 1939, p. 68.

A 4.5-foot. seam was successfully extracted beneath an industrial and residential district.

Keyword(s): anthracite, backfilling, room-and-pillar, coal mining, economics

Location(s): Pennsylvania, Appalachian Coal Region, United States

Shoemaker, H. D., S. H. Advani, F. D. Gmeindl, Y. T. Lin. Studies of Thermo-Mechanical Subsidence Associated with Underground Coal Gasification. IN: Evaluation and Prediction of Subsidence, International Conference, Pensacola Beach, FL, ASCE, 1979.

Keyword(s): coal gasification

Location(s): United States

Shoemaker, R. P. A Review of Rock Pressure Problems. American Institute Mining and Metallurgy Engineers Technical Publication 2495, 1948, 14 p.

Keyword(s): mine operation, rock mechanics

Location(s): United States

Shoemaker, R. P., T. J. Thorley. Problems of Ground Subsidence. Journal of the American Water Works Association, v. 47, April, 1955, p. 412-418.

This paper describes subsidence problems associated with oil extraction from the Wilmington oil field in Long Beach, California. Repressurization using gas or water as a means of arresting subsidence is briefly mentioned.

Keyword(s): oil extraction

Location(s): California, United States

Shoemaker, R. R. Protection of Subsiding Waterfront Properties. Journal of the Waterways Division, ASCE, v. 81, Proceedings Paper 805, p. 805-1--805-24, September, 1955.

Subsidence resulted from a reduction of fluid pressure in the Wilmington oil field.

Keyword(s): oil extraction, surface structural damage

Location(s): United States, California

Shoham, D., L. Levin. Subsidence on the Reclaimed Hula Swamp Area of Israel. Israel Journal of Agricultural Research, 18, 1968, p. 15-18.

Keyword(s): fluid extraction, agriculture

Location(s): Israel

Shultz, R. A. Ground-Water Hydrology of Marshall County, West Virginia, with Emphasis on the Effects of Longwall Coal Mining. U.S. Geological Survey Water-Resources Investigations Report 88-4006, in cooperation with Marshall County Commission, Charleston, WV, 1988, 147 p.

This report describes the groundwater hydrology of Marshall County, West Virginia, with emphasis on the effects of longwall coal mining.

Two hundred and eighteen wells and 59 springs were inventoried. A groundwater monitoring network was established whereby water levels in 62 wells and discharges of 13 springs were measured at least monthly. Single-well aquifer tests were made at three sites. The following geophysical logs were run on selected wells: gamma ray--15 wells, caliper--14 wells, and electric resistivity--2 wells. Two observation wells were drilled in July 1985 ahead of an advancing longwall panel to obtain pre- and post-mining data. Water samples from 56 wells and 16 springs were analyzed for major chemical constituents. Additional ground-water data obtained during previous studies by the USGS also are available.

Keyword(s): subsurface water, surface water, hydrology, geologic features, coal mining, longwall, overburden, geophysical, monitoring methods

Location(s): West Virginia, Appalachian Coal Region, United States

Siddle, H. J., M. E. Oliver, P. Ansell. The Effect of Mining Subsidence on Spoil Heap Stability: A Case History. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 264-278.

This paper describes the methods used to assess the possible effects of mining shallow panels of coal by rapid retreat beneath the a tip complex. Critical areas of the tip included tailings lagoons, some of which were capped, and a 45-meter-high face overlooking a road and cottages. The measures recommended to enable completion of the tip are described, together with the results of the monitoring performed during the mining.

Keyword(s): coal mining, active mines, mine waste, geotechnical, monitoring methods, vertical displacement, horizontal displacement

Location(s): United Kingdom

Siekmeier, J. A., K. M. O'Connor, L. R. Powell. Rock Mass Classification Applied to Subsidence Over High Extraction Coal Mines. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 317-325.

The USBM uses a commercially available computer spreadsheet program in combination with a modified version of Bieniawski's Rock Mass Rating system to characterize the geology overlying high extraction coal mines. The results presented in this paper focus on the relationship between the bridging potential of individual beds and the deformation measured using Time Domain Reflectometry. Subsurface displacements measured over seven high-extraction coal mines in southern Illinois were correlated with the bed stiffness and bridging potential profiles.

Keyword(s): instrumentation, monitoring methods, geologic features, coal mining, active mines, monitoring equipment, computer, modeling, rock mechanics, overburden, longwall, high-extraction retreat

Location(s): Illinois, Illinois Coal Basin, United States

Simes, D. J., F. E. Jaggar. Strata Control in Mining Operations in a New Mine at South Bulli Colliery. IN: 5th International Strata Control Conference, London, 1972, Paper 3, 9 p.

Keyword(s): ground control, active mines

Sims, F. A., R. J. Bridle. Bridge Design in Areas of Mining Subsidence. Journal Institute Highway Engineers, v. 13, 1966, p. 19-38.

Keyword(s): surface structural damage, engineering

Sinclair, D., P. B. Bucky. Photoelasticity and its Applications to Mine Pillar and Tunnel Problems. Transactions, AIME, v. 139, 1940, p. 224-252.

Isotropic transparent material was stressed and viewed with polarized light, obtaining an image indicating the magnitude of the stress in color bands of light. This method studies the principal points of maximum stresses in loaded model pillars; it includes the effects of cutting the tops of the pillars or of tunnelling underneath them.

Keyword(s): pillar strength, modeling, tunnelling

Location(s): United States

Sinclair, J. Mining Subsidence in the South Yorkshire Coalfield. Transactions, Institute Mining Engineers, London, v. 110, 1951, p. 365-387.

This paper deals with a method of setting out lines of stations to observe subsidence and accompanying lateral movements; observation techniques and results are described in detail.

Keyword(s): survey design, survey methods, coal mining, vertical displacement, horizontal displacement

Location(s): England

Sinclair, J. Ground Movement and Control at Collieries. Sir Isaac Pitman & Sons Ltd., London, England, 1966, 93 p.

The author discusses methods of roof support for safe and economical extraction of coal. One chapter is devoted to methods of reducing subsidence damage. These methods include measures taken underground in the layout and workings, such as packing and stowing, and precautions to be taken on the surface during construction.

Keyword(s): ground control, roof support, economics, construction, engineering, mine design, stowing, coal mining

Singh, L. N., M. A. Rafigui, B. Singh. Angle of Fracture in Mine Subsidence. Journal of Mines Metals & Fuels, v. 24, 1976, p. 375-385.

Singh, M. M., W. J. Courtney. Application of Pneumatic Stowing in United States Coal Mines. AIME Annual Meeting, Dallas, Texas, February 24-28, 1974.

This paper gives details of methods and equipment used in pneumatic filling and describes various problems involved; it also mentions potential explosion hazards.

Keyword(s): pneumatic backfilling, coal mining

Location(s): United States

Singh, M. M. Experience With Subsidence Due to Mining. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola, Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 92-112.

This paper lists states in the United States with subsidence damage and suggests a dual approach to attack the problem.

Keyword(s): surface subsidence damage, subsurface subsidence damage, environment, prediction

Location(s): United States

Singh, M. M., F. S. Kendorski. Strata Disturbance Prediction for Mining Beneath Surface Water and Waste Impoundments. IN: Proceedings 1st Annual Conference on Ground Control in Mining, July 27-29, 1981, S.S. Peng, ed., West Virginia University, Morgantown, p. 76-89.

The scope of this paper is limited to the exploitation of stratified mineral deposits with overlying surface bodies of water.

Keyword(s): surface water, coal mining, prediction, inflow

Location(s): United States

Singh, M. M. Review of Subsidence Control Measures--Past, Present, and Future. SME-AIME preprint #84-182, SME-AIME Annual Meeting, Los Angeles, CA, February 26-March 1, 1984, 6 p.; also Transactions, AIME, v. 276, 1985, p. 1988-1992.

The author reviews subsidence control measures to meet new regulations, including basic techniques and specific procedures to implement those measures.

Keyword(s): land-use planning, partial extraction, backfilling, room-and-pillar, surface structural damage, law, ground control

Location(s): United States

Singh, M. M., S. Bhattacharya. Proposed Criteria for Assessing Subsidence Damage to Renewable Resource Lands. Preprint No. 84-341, SME-AIME Fall Meeting, 1984, Denver, CO.

This paper attempts to establish relationships of various levels of subsidence damage for aquifers, agricultural lands, and other renewable resource areas.

Keyword(s): hydrology, agriculture, environment, land-use planning, surface subsidence damage, subsurface water, surface water, coal mining

Location(s): United States

Singh, M. M., S. Bhattacharya. Proposed Criteria for Assessing Subsidence Damage to Renewable Resource Lands. Mining Engineering, March, 1987, p. 189-194.

The Surface Mining Control and Reclamation Act of 1977 (SMCRA) requires underground coal mine operations to prevent "material damage" to renewable resource lands caused by subsidence. However, what constitutes material damage is not defined. This paper discusses the applicable criteria for agricultural lands, forests and grazing lands, surface water bodies, and aquifers. Although data on the subject are limited, an attempt is made to present quantitative guidelines to distinguish between moderate and severe damage due to subsidence.

Keyword(s): law, surface subsidence damage, surface water, subsurface water, hydrology, agriculture, environment, land-use planning, coal mining, inflow

Location(s): United States

Singh, M. M., ed. Mine Subsidence. Proceedings of Society of Mining Engineers Fall Meeting, September, 1986, St. Louis, MO, SME, Littleton, CO, 143 p.

This volume contains chapters on the following subjects: modeling and prediction, case histories, regulatory aspects, and subsidence in hardrock mining.

Keyword(s): coal mining, metal mining, nonmetal mining, modeling, prediction, law

Singh, R. N., S. Hibberd, R. J. Fawcett. Numerical Calculation of Groundwater Inflow to Longwall Coal Faces. IN: Mine Water, Proceedings 2nd International Congress, Granada, Spain, September 1985, R. Fernandez-Rubio, ed., v. 1, p. 541-552.

The paper describes numerical calculations of groundwater inflow to longwall coal faces through heterogeneous anisotropic rock strata using the boundary element method. The influence of mining induced changes in conductivity is investigated. The effect of a protective layer of intact rock between damaged strata and water bearing strata is examined. Results are supported by diagrams of Darcy seepage velocities.

Keyword(s): longwall, coal mining, hydrology, subsurface water, modeling, boundary element

Singh, S. P. Ground Control Aspects of Longwall Design. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 123-128.

Recognizing the important role to be played by longwall mining in achieving the projected doubling of coal production in the United States, the author endeavours to outline the basic considerations for longwall design with a special focus on ground control measures. The influence of the geological features, geotechnical considerations, seam characteristics and support system on the longwall design is discussed. The importance of design and stability of gate roadways are considered. Special emphasis is given to the significance of ground control measures in the success of a longwall design.

Keyword(s): longwall, mine design, ground control, coal mining, geologic features, geotechnical, roof stability

Location(s): United States

Singh, T. N., B. Singh. Partial Extraction to Minimize Surface Subsidence. Journal of Mines, Metals, Fuels, v. 12, December 1964, p. 369-379.

Keyword(s): partial extraction, surface subsidence damage

Singh, T. N., R. N. Gupta. Influence of Parameters of Packing on Surface Protection. Journal of Mines, Metals, Fuels, v. 16, February, 1968, p. 37-52.

Subsidence mechanics are briefly outlined, followed by a discussion on the economic aspects of packing. Various packing parameters are defined, including compressibility, consolidation, cementation, packing efficiency, and pack density. The results of previous research are summarized for each parameter; useful information on the angle of draw is included.

Keyword(s): backfilling, economics, angle of draw

Singh, T. N., B. Singh. Angle of Draw in Mine Subsidence. Journal of Mines, Metals, Fuels, v. 16, July 1968, p. 253-258.

This paper analyzes the effect of different natural and operational factors on the magnitude of the angle of draw in mine subsidence with reference to the mechanism of draw. It also discusses the importance of angle of draw in measuring methods.

Keyword(s): vertical displacement, horizontal displacement, backfilling, angle of draw

Singh, T. N., B. Singh. Load and Convergence Measurements in Worked Out Areas in Mines--A Critical Review. Journal of Mines, Metals, and Fuels, January, 1971, p. 7-21.

Singh, T. N., B. Singh. Strata Movement Around Workings in a Massive Formation--Equivalent Material Model Investigation. Journal of Mines, Metals, and Fuels, v. 20, no. 9, September, 1972, p. 267-274.

Keyword(s): modeling

Singh, T. N., B. Singh. Model Studies of Strata Movement Around a Longwall Face. Journal of Mines, Metals, and Fuels, v. 25, no. 2, February, 1977, p. 39-43.

Keyword(s): modeling, longwall

Singh, T. N., B. Singh. Caving of a Coal Seam Under Kamptee Aquifers of India. IN: Symposium on Water in Mining and Underground Works, SIAMOS--78, Granada, Spain, September 18-22, 1978, p. 657-673.

A coal seam of the Chanda-Wardha Valley of Maharashtra is overlain by the Kamptee formation, which is reported to be highly aquiferous. This seam developed on the bord-and-pillar system has rarely been depillared in conjunction with hydraulic stowing with a view of avoiding water hazards. It is proposed to try caving under this condition, which needs anticipation of pumping load at different stages of caving. In the absence of any field experience, the indirect technique of Equivalent Mine Modeling was used. On the basis of the model findings and the available hydrological information, the likely pumping problem during caving is described in this paper.

Keyword(s): subsurface water, hydrology, coal mining, room-and-pillar, pillar extraction, modeling, geologic features

Location(s): India

Sinha, K. M. Hydraulic Stowing--A Solution for Subsidence Due to Underground Mining in the USA. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 827-834.

Hydraulic stowing, which is being practiced in several major coal producing countries to deal with adverse mining conditions, usually permits almost 100% coal recovery from underground mines with minimal and controlled surface subsidence. It can be implemented in coal mines in the United States to reduce the severe effect of land subsidence and at the same time improve the cost of coal production, both of which are major setbacks for the coal industry in the United States.

Keyword(s): coal mining, economics, environment, land-use planning, reclamation, mine waste, hydraulic backfilling, stowing

Location(s): Illinois, Illinois Coal Basin, United States

Siriwardane, H. J., J. Amanat. Prediction of Subsidence in Hilly Ground Terrain Using Finite Element Method. IN: Proceedings 2nd International Conference on Stability in Underground Mining, A.B. Szwilski and C.O. Brawner, eds., 1984, SME-AIME, New York, p. 554-575.

Keyword(s): prediction, finite element, geologic features

Siriwardane, H. J., J. Amanat. Analysis of Subsidence Caused by Underground Mining. International Journal of Mining Engineering, v. 2, no. 4, 1984, p. 271-290.

Some aspects of subsidence caused by longwall coal mining are analysed using the finite element method. Results of the analysis are compared with a true mine panel, where measurements on subsidence were available. Rock deformations in the overburden were modeled using an elasto-plastic constitutive model. The study indicates that the shape of the subsidence profile can be predicted reasonably well using nonlinear finite element analysis.

Keyword(s): coal mining, longwall, modeling, finite element, overburden, elastic model, prediction, empirical model, phenomenological model

Location(s): United States

Siriwardane, H. J. A Numerical Procedure for Prediction of Subsidence Caused by Longwall Mining. IN: Proceedings 5th International Conference on Numerical Methods in Geomechanics, Nagoya, Japan, April 1-5, 1985.

A numerical procedure, based on the nonlinear finite element analysis, was developed for the prediction of subsidence profiles over longwall mine panels. The behavior of the overburden rock was modeled using an elasto-plastic constitutive model.

Keyword(s): finite element, modeling, prediction, longwall, phenomenological model, elastic model, overburden

Location(s): United States

Siriwardane, H. J. Some Aspects of Analysis and Prediction of Subsidence. IN: Rock Masses: Modeling of Underground Openings/Probability of Slope Failure/Fracture of Intact Rock, Proceedings, Symposium sponsored by Geotechnical Engineering Division of ASCE, in conjunction with ASCE Convention, Denver, CO, April 29-30, 1985, p. 2-13.

A procedure, based on the nonlinear finite element analysis, was investigated for the prediction of subsidence caused by longwall mining. This paper presents a case study involving predictions of subsidence at a coal mine panel for which a considerable amount of data was available in the literature. Aspects of the selection of material properties and shape of the subsidence profile are discussed.

Keyword(s): finite element, prediction, longwall, modeling, coal mining

Location(s): United States

Siriwardane, H. J. Numerical Modelling of the Behavior of Overburden Rock Masses Associated with Longwall Mining. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, 1985, p. 171-177.

This paper presents two approaches based on the finite element method for modeling the behavior of overburden rock masses over longwall mine panels for predicting surface subsidence. Results obtained from a case study are presented.

Keyword(s): modeling, prediction, finite element, continuum mechanics, longwall, computer, overburden

Location(s): West Virginia, Appalachian Coal Region, United States

Siriwardane, H. J., H. Ramli, J. Amanat. Comparison of Predictions and Measurements of Subsidence Caused by Underground Mining in Northern Appalachia. IN: Proceedings 7th International Conference on Ground Control in Mining, Morgantown, WV, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, p. 163-173.

This paper presents results from three case studies involving longwall mine panels at which the measured ground movements were compared with the numerical model predictions based on the finite element method. A new approach called the "displacement approach" was used in this study. The general concept of this method is based on the assumption that total roof collapse occurs behind the mine face as it advances. This assumption appears to be true for almost all longwall mining conditions. The prediction based on the numerical model appears to compare well with the measurements.

Keyword(s): longwall, prediction, empirical model, finite element, roof stability, modeling, coal mining, surface subsidence damage, surface structural damage, bituminous, mathematical model, continuum mechanics, National Coal Board, profile function, computer, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

Siriwardane, H. J., J. Amanat. Displacement Based Approach for the Prediction of Subsidence Caused by Longwall Mining Using Numerical Methods. IN: Computer Methods and Advances in Geomechanics, Proceedings 7th International Conference, Cairns QLD Australia, May 6-10, 1991, G. Beer, J.R. Booker, and J.P. Carter, eds., v. 2, Balkema, Rotterdam, p. 1387-1392.

An improved procedure, called the "displacement approach" for predicting the magnitude of subsidence over longwall mine panels was developed. This approach is based on history matching concept using finite element and displacement discontinuity methods. Here, measured ground movements at a number of mine panels were used in developing and verifying the model. The general concept of the method is based on the assumption that roof collapse occurs behind the mine face as it advances. Based on the results of a typical case presented in the paper, as well as the results for a number of other cases, the authors conclude that the predictive capability of maximum subsidence has been significantly improved. However, the predictive capability of the shape of the subsidence profile needs further improvements.

Keyword(s): prediction, computer, longwall, coal mining, finite element, modeling, rock mechanics

Location(s): West Virginia, Appalachian Coal Region, United States

Siska, L. Problems Relating to Coal Extraction in Seams Containing Strong Sandstones in the Overlying Strata. IN: 5th International Strata Control Conference, London, 1972, Paper 24, 12 p.

This paper analyzes specific problems related to mining discontinuous seams with variations in seam height. It indicates that low density supports are needed to operate under thick sandstone roofs.

Keyword(s): mine operation, ground control, overburden, roof support, coal mining

Skelly and Loy, Inc. Guidelines for Mining Near Surface Water. Report to U.S. Bureau of Mines, Contract No. HO252083, 1977, 190 p. (NTIS PB 264728/AS)

Keyword(s): surface water, mine design, mine operation

Location(s): United States

Skelly, W. A., J. Wolgamott, F-D. Wang. Coal Mine Pillar Strength and Deformation Prediction Through Laboratory Sample Testing. IN: Energy Resources and Excavation Technology, Proceedings 18th U.S. Rock Mechanics Symposium, Keystone, CO, June 22-24, 1977, F-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, Golden, p. 2B5-1--2B5-5.

This paper presents results of a study that includes measurement of pillar strength and deformation in situ, as well as laboratory compression tests of small specimens. Field and laboratory data are compared with predictions of pillar strength calculated from several empirical equations suggested for use in pillar design. Field research was conducted in an underground mine in southern West Virginia.

Keyword(s): pillar strength, ground control, prediction, coal mining, lab testing, in situ testing, rock mechanics, instrumentation
Location(s): West Virginia, Appalachian Coal Region, United States

Skempton, A. W., D. H. MacDonald. Allowable Settlements of Buildings. IN: Proceedings, Institution of Civil Engineers, Part III, 1965, v. 5, p. 727.
Keyword(s): surface structural damage, engineering

Skinderowicz, B. Zasady Wyznaczania Filarow Ochronnych Dla Pokladow Nachylonych (Principles of Determination of Surface Protecting Pillars in Exploitation of Steeply Dipping Coal Seams). Przeglad Gorniczy, v. 25, no. 6, 1969, p. 294-297.
Keyword(s): coal mining, pillar strength

Skinderowicz, B. Rownanie Pelnej Nie Ustalonej Niecki Osiadania (Equation of a Full Nonstabilized Subsidence Trough). Przeglad Gorniczy, v. 33, no. 2, 1977, p. 75-79.
Keyword(s): modeling

Skinderowicz, B. Description of Mining Methods for Minimizing the Effect of Mining Work on the Surface. Phase I, Task No. 4. Subsidence Prediction and Control Project No. 14-01-0001-1451, Central Mining Institute, Katowice, Poland, March, 1978, 20 p. Translation, Joint Research Project through the Maria Sklodowska-Curie Joint Fund.
Keyword(s): mine design, mine operation, ground control
Location(s): Poland

Skinderowicz, B. Subsidence Prediction and Control, Phase 1: The State of Knowledge in Poland Concerning the Influence of Mining Exploitation on the Surface. U.S. Department Energy Contract DOE/TIC-11481, Central Mining Institute, Katowice, Poland, Final Report, Phase 1, 1978, 39 p. (NTIS DOE/TIC-11481)
This report examines the geologic and mining conditions and subsidence problems of 12 coal mines located in the Appalachian Region, Illinois Basin, and Rocky Mountain Region. Remarks and suggestions are made on subsidence prediction and control on the basis of the mines inspected.
Keyword(s): vertical displacement, horizontal displacement, subsurface water, mine design, prediction, ground control, coal mining, geologic features
Location(s): Poland, Appalachian Coal Region, Illinois Coal Basin, Rocky Mountain Coal Region, United States

Sladen, J. A., C. S. Bodimeade, V. R. Jobling. Site Investigation and Urban Development Guidelines with Respect to Mining Subsidence Hazards--Two Examples from Alberta, Canada. IN: Mineworkings 84: Proceedings International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1984, M.C. Forde, B.H.V. Topping, H.W. Whittington, eds., Engineering Technics Press, p. 196-220.
Keyword(s): land-use planning, abandoned mines
Location(s): Canada

Slagel, G. E. Key Regulatory Issues--Planned and Controlled Subsidence. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 93-96.
The 1974 surface mining law showed that Congress considered removing all the coal from an area and causing subsidence in a predictable and uniform manner to be equal to or better than leaving support coal and causing no subsidence. While the actual provision in the bills talked of preventing subsidence, a subsequent exception made it clear that the real intent was to control it. The author feels that the original intent of Congress has been changed from one of controlling subsidence to one of minimizing damage. This paper reviews the surface mining law, subsidence aspects, differences between state and federal regulations, and offers suggestions on possible ways for the coal industry to deal with these issues.
Keyword(s): law, environment, coal mining, government, partial extraction, hydrology, subsurface water, longwall, active mines, mine design, mine operation
Location(s): Illinois, Illinois Coal Basin, Pennsylvania, Appalachian Coal Region, United States

Sloan, P., R. C. Warner. A Case Study of Groundwater Impact Caused by Underground Mining. IN: Proceedings, Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Kentucky, Lexington, December 2-7, 1984, p. 113-120.
An investigative methodology is presented to assist mining and regulatory personnel in determining the effect underground mining can have on

local aquifers in the Appalachian coal region. The impact of underground mining on groundwater may be more extensive than first realized. The primary reason for this possible underassessment of deep mining's influence on groundwater is the methods used to calculate groundwater movement. In many cases, groundwater flow times and the corresponding areas of influence are much greater than those assumed because water is rapidly moved through fractured zones that commonly occur throughout Appalachia.

Keyword(s): subsurface water, hydrology, coal mining

Location(s): Kentucky, United States

Small, J. B. Settlement Investigations in the Vicinity of Galveston-Houston, Texas, and San Joaquin Valley, California. Journal of Geophysical Research, v. 64, 1959, p. 1124-1125.

Keyword(s): fluid extraction

Location(s): Texas, California, United States

Smart, B. G. D., A. K. Isaac, P. A. Carr. The Elimination of Rib Pillars Between Adjacent Longwall Coalfaces. IN: Rock Mechanics: A State of the Art, Proceedings 21st Symposium on Rock Mechanics, May 28-30, 1980, D.A. Summers, ed., University of Missouri at Rolla, p. 319-355.

British longwall coal mining has traditionally used a pair of single gateroads to serve each panel, rib pillars being left between adjacent panels. The widths of these pillars are determined with stability as the design criterion either by empirical formula, or local experience, and range from a few meters to tens of meters. Consideration is being given, however, to the elimination of these pillars for reasons of maximizing extraction of reserves, cost savings, and development time saving.

Keyword(s): coal mining, longwall, mine design, economics, instrumentation

Location(s): United Kingdom

Smedley, N. Subsidence Management in the North Derbyshire Area. Mining Engineering, London, v. 136, no. 188, December 1976-January 1977, p. 185-192.

Keyword(s): ground control

Location(s): United Kingdom

Smelser, R. E., O. Richmond, F. C. Schwerer. Interaction of Compaction Near Mine Openings and Drainage of Pore Fluids from Coal Seams. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 21, no. 1, February, 1984, p. 13-20.

The long range transport of gas and water through coal seams is generally thought to occur through a natural fracture network, called cleats, existing in the coal seam. During mining, the overburden load formerly supported by the excavated coal is transferred to the nearby pillars and abutments. This added loading will cause the coal seam to yield, or deform plastically, close to the mine openings. In addition, the stresses acting to deform the coal seam--and consequently, the size of the yield zone--are also influenced by changes in the fluid pressure in the natural fracture network. In the present work, a model of the yielded region is developed that follows the ideas proposed by Dugdale for yielding in metal sheets. The Dugdale model is generalized to include the effects of changes in the pressure (drainage) of fluids in the natural fracture network. Changes in porosity and permeability resulting from additional microfracturing in the yielded zone are calculated based on this model.

Keyword(s): coal mining, hydrology, subsurface water, overburden, modeling, overburden

Smith, A., R. E. Collins. The Extraction of Barrier Pillars Between Adjacent Longwall Panels at the Durban Navigation Collieries (Pty) Ltd. Journal of South African Institute of Mining and Metallurgy, v. 85, no. 4, April, 1985, p. 125-130.

The practice of leaving barrier pillars between adjacent longwall panels at the Durban Navigation Collieries (Durnacol) has resulted in a considerable loss of coal reserves. Durnacol has now modified the layout of its longwall panels to allow the concurrent mining of barrier pillars and the extraction of the longwalls. The implementation of the new panel layout has increased the percentage extraction of reserves and will result in an extension of the life of the mine. The method of extracting barrier pillars between adjacent longwall panels is described in this paper.

Keyword(s): longwall, coal mining, pillar extraction

Location(s): South Africa

Smith, M. Coal Mine Subsidence in Washington State; Inventory of a Geologic Hazard. IN: Geological Society of America Abstracts with Programs, Cordilleran Section, 71st Annual Meeting, Los Angeles, CA, March 25-27, 1975, p. 377. (NTIS Accession No. 77-45431)

Keyword(s): engineering, coal mining, land-use planning
Location(s): Washington, United States

Smith, P. A National Mine Subsidence Engineering Research Program. U.S. Department of Energy Contract W-7405-ENG36, Los Alamos Scientific Laboratory LA-8907-MS, July, 1981, 47 p. (NTIS LA8907-MS)

This report suggests a logical approach to choosing and sequencing research activities to attain a suitable set of techniques for predicting the damaging consequences of mine subsidence. The detail required for damage predictions varies from customers who conduct regional impact assessments to subsidence hazard engineers who are concerned with a particular structure to be undermined. High priority research needs include the following: a National Mine Subsidence Information Management Center, empirical surface and subsurface subsidence damage correlations for practice in the United States, a comprehensive study of influence function subsidence prediction techniques, finite element computer code refinements for full-extraction subsidence prediction and engineering geology approach to assessing the timing of room-and-pillar subsidence, and well-designed field observations in support of all research needs.

Keyword(s): subsidence research, prediction, land-use planning, surface structural damage, influence function, finite element, computer, room-and-pillar, longwall, engineering
Location(s): United States

Smith, R. M. Update on Overburden Characteristics. IN: American Mining Congress Coal Convention Session Papers Set No. 3, Pittsburgh, PA, May 1-4, 1977, 17 p.

The author outlines methods of sampling and characterizing coal mine overburden to aid mining and reclamation plans.

Keyword(s): reclamation, overburden, coal mining, monitoring installation, mine design
Location(s): United States

Smith, W. C. Evaluation of Progressive Rib Failure in Thick Coal Seams. SME Preprint 89-174, for presentation at SME Annual Meeting, Las Vegas, NV, February 27-March 2, 1989, 7 p.

Even with the most conservative mine plan, rib instability can occur unexpectedly and, if not adequately dealt with, can progress from a nuisance to a major safety hazard. This USBM paper examines the mechanisms of progressive rib failure in high mine openings and discusses techniques to control rib slabbing. A field test site in a longwall mine was instrumented to investigate rib behavior during mining. Although data analysis showed minor pillar dilation, sporadic zones of progressive rib instability were detected, which culminated in eventual rib failure. The failure occurred despite conservative pillar dimensions and shallow depth. Physical and computer models were used to demonstrate the mechanisms of rib failure and then evaluate the influence of support and other mine-related parameters on rib behavior.

Keyword(s): coal mining, mine design, longwall, instrumentation, pillar strength, modeling, computer, mine safety
Location(s): Rocky Mountain Coal Region, United States

Smith, W. C. Rib Stability: Practical Considerations to Optimize Rib Design. U.S. Bureau of Mines IC 9323, 1992, 16 p.

The USBM examined previous research on rib stability to develop a practical approach to understanding, characterizing, and controlling weak rib conditions in underground coal mines. Because success in stabilizing ribs depends on a basic knowledge of how weak ribs behave, the report reviews the mechanics of rib failure and the relationship of coal mine geology and pillar constraint to rib instability. Strategies for choosing an effective method of rib support are considered, and various rib support methods are discussed. Finally, the report documents techniques for monitoring ribs and use of models to assess rib stability; such monitoring and modeling can also help determine the most effective method for roof support.

Keyword(s): roof support, coal mining, geologic features, mine safety
Location(s): United States

Sneed, L. A., R. Sumner. Longwall Mining Beneath A State Highway - Case History. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, Pittsburgh, PA, C.D. Elifrits, ed., p. 269-270.

In July 1988, Old Ben Coal Company undermined and subsided Illinois State Highway 149 by use of the longwall mining method. This was the first time in the State of Illinois that such planned subsidence mining was done beneath a state highway. This paper outlines the steps followed in planning, monitoring and effecting repairs.

Keyword(s): roads, active mines, coal mining, longwall, monitoring methods, mitigation
Location(s): Illinois, Illinois Coal Basin, United States

Snodgrass, J. J., D. A. Newman. An In Situ Technique for the Assessment of Failure in Coal Pillars. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 1181-1188.

A coal pillar comprises two distinct zones, a solid elastic core enclosed and confined by an exterior of failed or yielded coal. Initially the elastic core-yield zone boundary is located immediately adjacent to the pillar edge. As the pillar load increases, the boundary migrates towards the center of the pillar, ultimately culminating in pillar failure. The ability to delineate the elastic core-yield zone boundary in the field is therefore of fundamental importance. A dry-hole sonic velocity logging probe was used to define the boundary on the basis of sonic velocity profiles.

Keyword(s): pillar strength, monitoring equipment, monitoring methods, room-and-pillar, longwall, in situ testing
Location(s): Utah, Rocky Mountain Coal Region, West Virginia, Appalachian Coal Region, United States

Snow, R. E. Estimation and Control of Ground Water Inflow and Discharge from Underground Mines. SME Preprint 90-117, for presentation at SME Annual Meeting, Salt Lake City, February 26-March 1, 1990, 9 p.

The objective of this paper is to discuss the practical applications of mine inflow and discharge analysis, describe the typical flow components, outline the procedures necessary to perform the analysis, and illustrate the modeling procedures and potential results of mine inflow and discharge predictions.

Keyword(s): subsurface water, hydrology, modeling, environment, coal mining, inflow
Location(s): United States

Snowden, J. O., W. B. Simmons, E. B. Traughber, R. W. Stephens. Differential Subsidence of Marshland Peat as a Geologic Hazard in the Greater New Orleans Area, Louisiana. Transactions, Gulf Coast Association Geological Society, 27, 1977, p. 169-179.

Keyword(s): fluid extraction, geologic features, soils
Location(s): Louisiana, United States

Snowden, J. O. Drainage-Induced Land Subsidence in Metropolitan New Orleans, Louisiana, USA. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association Hydrological Sciences Publication No. 151, 1986, p. 507-527.

Now that the relationship between drainage and land subsidence is relatively well understood in the New Orleans region, it is possible to predict areas that have the potential for future hazardous subsidence. Present drainage systems should be modified and future systems designed to keep subsidence-prone sediments and soils as wet as possible. Water table levels should be kept as high as possible. Thorough geological and geotechnical surveys should be done prior to further drainage projects within the Mississippi River delta plain.

Keyword(s): fluid extraction, soils
Location(s): Louisiana, United States

Soil Testing Services, Inc. HUD - Mine Subsidence Evaluation Manual. June 30, 1976, 45 p.

Under ordinary circumstances, the intent of the design of foundations has the primary goals of providing a reasonable factor of safety against failure and of limiting or minimizing damage movements. However, many well located sites on which intense mining activity has occurred in the past, and in which time-related mechanisms of subsurface deformation and deterioration are now operating, are expected to exhibit future subsidence and horizontal displacements. Housing development on such sites should be done with the realization that the potential for damaging movements definitely exists.

Keyword(s): coal mining, time factor, horizontal displacement, pillar strength, foundations, construction, land-use planning, surface structural damage
Location(s): United States

Sopworth, A. Discussions of Subsidence Due to Coal Workings. Institution of Civil Engineers, Minutes of Proceedings, v. 135, 1898, p. 165-167.

Keyword(s): historical, coal mining
Location(s): England

Sorenson, W. K., W. G. Pariseau. Statistical Analysis of Laboratory Compressive Strength and Young's Modulus Data for the Design of Production

Pillars in Coal Mines. IN: Proceedings 19th U.S. Symposium on Rock Mechanics, Stateline, NV, May 1-3, 1978, Y.S. Kim, ed., University of Nevada-Reno, p. 30-37.

Sample statistics (mean, standard deviation, coefficient of variation, regression line slope and intercept, correlation coefficient) obtained from statistical analyses of a total of 371 tests for unconfined compressive strength and Young's modulus performed on test cylinders having nominal diameters of 1, 2, 4, 6, 8, and 12 inches, and height-to-diameter ratios of 1/2, 1, 1-1/2, and 2 are presented. The paper discusses some of the possible implications of such data for "size effects" and the design of production pillars in coal mines.

Keyword(s): rock mechanics, pillar strength, mine design, lab testing, coal mining

Location(s): United States

Sossong, A. T. Subsidence Experience of Bethlehem Mines Corporation in Central Pennsylvania. IN: Proceedings, 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Paper 5, Australasian Institute of Mining and Metallurgy, Illawarra Branch, p. 5-1--5-5.

Although mining was conducted in the Cambria County area of Central Pennsylvania for more than 75 years, surface subsidence was not given serious consideration until 1966. At that time, the state drafted legislation making the coal operators responsible for any damage caused as a result of mining to any private dwelling or public building. At about the same time, Bethlehem Mines Corporation was introducing the first successful longwall mining system in Pennsylvania. With conventional mining, the pillar line was from 300 to 400 feet. With longwall, this figure became 600 feet wide. Subsidence surveys of third order were conducted over both longwall and conventional sections. Minimal pillar design changes have been attempted to control subsidence because poor roof conditions and thick overburden mandate wide pillar lines to mine economically. Support pillars are necessary in heavily populated areas, under wide concrete interstate highways, and under breasts of water reservoirs.

Keyword(s): mine operation, coal mining, active mines, longwall, surface water, roads, law, survey methods, bituminous, mine design

Location(s): Pennsylvania, Appalachian Coal Region, United States

Souder, W. E., E. R. Palowitch. The Growth of Longwall Technologies in the United States. IN: SME-AIME Mini Symposium Series 79-05, 1979, p. 7-16.

Keyword(s): mine design, mine operation, longwall

Location(s): United States

South African Mining and Engineering Journal. Problems Associated with Building on Undermined Ground. v. 82, no. 4048, 1970, p. 769-741.

Keyword(s): engineering, construction, surface structural damage, abandoned mines

Location(s): South Africa

South Wales Institute of Engineering. The Pneumatic Stowing of Longwall Faces in South Wales. IN: Proceedings, v. 63, no. 2, 1947, p. 30.

This paper describes the use of pneumatic backfilling as an alternative to hand packing for roof control in longwall coal mines.

Keyword(s): pneumatic backfilling, longwall, coal mining, roof support

Location(s): Wales

Southwestern Illinois Metropolitan and Regional Planning Commission. Mine Subsidence: A Guidebook for Local Officials. Illinois Department of Mines and Minerals, and Abandoned Mined Lands Reclamation Council, June 1983, R.S. Pocreva and R.K. Thompson, assistants, 148 p.

This booklet was designed for Illinois community officials to detail the characteristics of subsidence. It examines a series of options available to local government to deal with subsidence, including the Illinois Mine Subsidence Insurance Fund, a subsidence preparedness plan, public facility construction policies, land development ordinances, and underground mine permit processes.

Keyword(s): vertical displacement, horizontal displacement, law, land-use planning, government, insurance, construction, mine operation, land values, surface structural damage, abandoned mines, roads, utilities, bituminous, coal mining, metal mining, non-metal mining

Location(s): Illinois, Illinois Coal Basin, United States

Sovinc, I., N. Hass, M. Ribicic. Prediction and Evaluation of Subsidence Above a Thick Coal Seam. IN: Proceedings International Symposium on Numerical Models in Geomechanics, Zurich, September 1982, p. 814-819.

Keyword(s): prediction, coal mining

Sowers, G. F. Mechanisms of Subsidence Due to Underground Openings. IN: Subsidence Over Mines and Caverns, Moisture and Frost Actions, and Classification, Transportation Research Record 612, Part 1, Transportation Research Board, Washington, D.C., 1976, p. 2-8. (NTIS PB 272 844)

Subsidence from underground defects is an increasing problem, and effective preventive or corrective measures depend on knowing the mechanism causing the failure. Too often, however, the mechanism is ignored or diagnosed from the appearance of the ground surface, leading to routine indiscriminate treatment such as filling the depression or draining any water, which can be successful, ineffective, or harmful, depending on the mechanism involved. This paper briefly discusses subsidence caused by several types of mechanisms.

Keyword(s): roads, surface structural damage, geologic features, utilities, structural mitigation, reclamation, coal mining, non-metal mining, metal mining, tunnelling, subsurface water, hydrology, railroads

Location(s): Florida, United States

Sowry, C. G., K. Tubb. The Investigation of Strata Movements When Mining Three Thick Coal Seams in One Area. South African Institute of Mining and Metallurgy Journal, v. 65, 1964, p. 143-170.

This paper describes instruments and methods used to measure strata movements and pillar contraction when mining superimposed coal seams 60 to 170 feet below the surface.

Keyword(s): monitoring equipment, monitoring methods, multiple-seam extraction, coal mining, pillar strength

Location(s): South Africa

Spalding, J. Theory and Practice of Ground Control (the Kolar Gold Field). Transactions, Institution of Mining and Metallurgy, v. 47, 1937-38, p. 71-110.

Keyword(s): ground control, metal mining

Spande, E. D. Effects of Longwall-Induced Subsidence on Hydraulic Properties at a Site in Jefferson County, Illinois. M.S. Thesis, Department of Geology, Northern Illinois University, 1990, 245 p.

Longwall mine subsidence potentially alters aquifer and aquitard hydraulic properties, potentiometric surfaces, and pore-water geochemistries as a result of subsidence-induced fracturing. Changes in these three areas were measured through monitoring the water levels in domestic wells and drift and bedrock piezometers, conducting hydraulic tests, and analyzing water chemistry.

Keyword(s): hydrology, subsurface water, longwall, active mines, coal mining, monitoring methods, overburden, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Spanovich, M. Construction Over Shallow Mines: Two Case Histories. ASCE Structural Engineering Division Meeting, Pittsburgh, PA, September 30-Oct. 4, 1968. ASCE Preprint 703, New York, 10 p.

This paper describes groutcase and caissons to support structures over subsidence-prone areas; it includes costs for methods employed.

Keyword(s): engineering, construction, economics, roof support

Location(s): United States

Spark, H. G. Subsidence in Coal Mines. B.E. Thesis, University of Sydney, Australia, 1968, 90 p.

Keyword(s): coal mining

Speck, R. C. A Comparative Analysis of Geologic Factors Influencing Floor Stability in Two Illinois Coal Mines. Thesis, University of Missouri-Rolla, 1979, 265 p.

Keyword(s): floor stability, geologic features, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Speck, R. C. The Influence of Certain Geologic and Geotechnical Factors on Coal Mine Floor Stability--A Case Study. IN: Proceedings 1st Annual Conference on Ground Control in Mining, July 27-29, 1981, S.S. Peng, ed., West Virginia University, Morgantown, p. 44-49.

This paper describes the floor heave problem as it was manifested at two room-and-pillar coal mines in Illinois. The objective of the study was to develop one or more simple procedures to allow detection of a potential floor heave problem during the exploration phase of mine design--before initiation of production mining.

Keyword(s): floor stability, ground control, geotechnical, coal mining, geologic features, in situ testing, lab testing

Location(s): Illinois, Illinois Coal Basin, United States

Speck, R. C., R. W. Bruhn, R. E. Gray. Instrumentation Plan for Monitoring Ground Movements Associated With Pillar Extraction Mining

at the Kitt No. 1 Mine in Northern West Virginia. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 231-236.

This paper discusses the design and installation of surface, subsurface, and mine-level instrumentation to monitor ground movements associated with pillar-extraction mining.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, instrumentation, room-and-pillar, pillar extraction

Location(s): West Virginia, Appalachian Coal Region, United States

Speck, R. C., R. W. Bruhn. The Appalachian Field: A Surface Monitoring Program Over Pillar-Extraction Mine Panels. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., 1983, Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, p. 647-656.

Pillar extraction is a mining technique whereby the coal within the mine area is almost totally removed. It is often used in areas where, for reasons of economy, geologic setting, mine space or timing, longwall total-extraction mining is not appropriate. The authors monitored the ground movements associated with pillar-extraction mining at a coal mine in northern West Virginia.

Keyword(s): monitoring methods, pillar extraction, coal mining, vertical displacement, horizontal displacement, survey methods, monitoring installation, monitoring equipment, survey equipment, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

Speck, R. C., R. W. Bruhn. Prediction of Mine Subsidence Ground Movements and Resulting Surface-Structure Damage - Complicating Factors. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 79-88.

Empirical methods have shown some promise in improving the capability of engineers to predict ground-surface movements and damage to surface structures associated with underground mining, particularly in yielding estimates of ground movements. Departures from prediction behavior are common and can be related to mining, geology, and surface structures. Ground movements normally unassociated with mine subsidence may take place concurrently with a subsidence event.

Keyword(s): empirical model, prediction, surface structural damage, geologic features, soils, abandoned mines, active mines, longwall, room-and-pillar, overburden

Location(s): United Kingdom, United States

Spencer, L. H. Subsidence Research Carried Out in the Bestwood Area of Nottinghamshire. Transactions, Institute of Mining Engineers, London, v. 120, no. 3, December, 1960, p. 201-210.

Keyword(s): subsidence research

Location(s): England

Spickernagel, H. Der Einfluss Der Abbautechnik Auf Die Senkungsbewegungen An Der Erdoberflaeche (Influence of the Mining Method on the Subsidence Movements of the Earth's Surface). Glueckauf-Forschungshefte, v. 34, no. 5, October, 1973, p. 168-174.

Keyword(s): mine operation, mine design, surface subsidence damage

Location(s): Germany

Spickernagel, H. Hebungen Des Gebirges Als Folgen Des Bergbaus Unter Tage (Rock Lifting Caused by Underground Mining Operations). Glueckauf-Forschungshefte, v. 36, no. 4, August, 1975, p. 170-176.

Keyword(s): subsurface subsidence damage

Spokes, E. M., C. R. Christiansen, eds. Proceedings of the 6th Symposium on Rock Mechanics. University of Missouri at Rolla, October, 1964.

Keyword(s): rock mechanics, instrumentation, roof support, mine design, modeling, pillar strength, time factor, metal mining, backfilling, room-and-pillar

Spokes, E. M., J. J. Scott. Rock Mechanics in Coal Mining. Mining Congress Journal, 1967, v. 53, p. 44-48.

Keyword(s): rock mechanics, coal mining

Sprouls, M. W. Rend Lake Banks on Longwalls. Coal, April, 1989, v. 27, no. 4, p. 88-90.

Consolidation Coal successfully switches an Illinois mine from pulling pillars to developing longwall panels.

Keyword(s): longwall, coal mining, mine design, mine operation
Location(s): Illinois, Illinois Coal Basin, United States

St. John, C. M., M. P. Hardy. Geotechnical Models and Their Application in Mine Design. IN: Proceedings, Mini Symposium on Application of Geotechnical Data to Underground Mine Design, SME-AIME Fall Meeting, September, 1978, Mini Symposium Series no. 78-1.
Keyword(s): modeling, mine design, geotechnical

Stacey, T. R. Three-Dimensional Finite Element Stress Analysis Applied to Two Problems in Rock Mechanics. South African Institute of Mining and Metallurgy Journal, v. 72, 1972, p. 251-256.
Keyword(s): finite element, rock mechanics, modeling
Location(s): South Africa

Stacey, T. R. Interaction of Underground Mining and Surface Development in a Central City Environment. Transactions, Institute of Mining and Metallurgy, 95A, 1986, p. 176-180.
Keyword(s): land-use planning

Stacey, T. R., D. Bakker. The Erection or Construction of Buildings and Other Structures on Undermined Ground. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 282-288.
The Mines and Works Regulations stipulate that permission is required from the Government Mining Engineer when buildings or other structures are to be erected or constructed over undermined ground. These guidelines have been reviewed recently and considerations given to revising them. This paper contains some of the background to the review, and some suggestions regarding new guidelines are made.
Keyword(s): law, government, surface structural damage, roads, railroads, metal mining, geologic features, coal mining, time factor, utilities, pipelines, horizontal displacement, vertical displacement
Location(s): South Africa

Stache, J. E. Database Analysis in Mine Subsidence Research. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 326-331.
Commercial software programs are used to create and maintain a mine subsidence database in conjunction with USBM research on mine subsidence in Illinois. A 3-year survey net of monitored structures in an Illinois subdivision was incorporated into the database design.
Keyword(s): computer, survey data processing, abandoned mines, coal mining, surface structural damage, vertical displacement
Location(s): Illinois, Illinois Coal Basin, United States

Stahl, R. L. Guide to Geologic Features Affecting Coal Mine Roof. MSHA Information Report 1101, 1979, 18 p.
Keyword(s): roof stability, geologic features, coal mining
Location(s): United States

Stahl, R. W. Extracting Final Stump in Pillars and Pillar Lifts with Continuous Miners. U.S. Bureau of Mines RI 5631, 1960.
Keyword(s): room-and-pillar, pillar extraction
Location(s): United States

Stahl, R. W. Survey of Practices in Controlling Roof at Intersections and Junctions in Underground Coal Mines. U.S. Bureau of Mines IC 8113, 1962, 13 p.
Keyword(s): roof support, coal mining, ground control
Location(s): United States

Stall, F. J. The Ports of the Rhine-Herne Canal Subject to the Effects of Mining Operations. Bulletin Permanent International Associated Navigation Congress, v. 1-2, no. 19/20, 1966, p. 87-123.
Keyword(s): surface subsidence damage, surface structural damage, surface water
Location(s): Europe

Starfield, A. M., C. Fairhurst. How High-Speed Computers Advance Design of Practical Mine Pillar Systems. Engineering and Mining Journal, May, 1968, p. 78-84.
Computer programs are used to solve structural problems found in determining stress on pillars of various sizes.
Keyword(s): pillar strength, computer, mine design

Starfield, A. M., W. R. Wawersik. Pillars as Structural Components in Room and Pillar Design.

IN: Basic and Applied Rock Mechanics, Proceedings, 10th Symposium on Rock Mechanics, University of Texas, Austin, 1972, p. 793-809.

Pillar stability is presented in a computer model as the interaction between the pillars and the surrounding rock. Qualitative behavior of pillars is obtained using compression tests.

Keyword(s): pillar strength, computer, room-and-pillar, modeling, rock mechanics, lab testing

Starfield, A. M., S. L. Crouch. Elastic Analysis of Single Seam Extraction. IN: Proceedings, 14th Symposium on Rock Mechanics, Pennsylvania State University, 1972.

This paper describes a digital computer method for computing stresses and displacements due to a dislocation in an otherwise continuous linearly elastic, infinite rock mass.

Keyword(s): rock mechanics, phenomenological model, elastic model, computer, modeling

Location(s): United States

Stark, J. F. Report of the Subsidence Committee. Submitted to the Joint State Government Commission of the General Assembly of PA, Harrisburg, PA, February 20, 1957, 54 p.

Keyword(s): government, law

Location(s): Pennsylvania, Appalachian Coal Region, United States

Starkey, D. L. Removal of a Shaft Pillar at Depth, Simmer and Jack Ltd. Associated Mine Managers South Africa, Papers and Discussions, 1962/63, p. 723-745.

Keyword(s): room-and-pillar, pillar extraction

Location(s): South Africa

Stassen, P., H. Duyse. Harmful Influences of Faces on the Roadways in a Colliery Layout, and Methods of Reducing Them. IN: 5th International Strata Control Conference, London, 1972, Paper 19, 8 p.

This paper discusses the importance of planning the behavior of main roadways of a mine and shows the harmful effect of a pillar of abandoned coal in a seam on roadways situated in this pillar or immediately above or below it.

Keyword(s): mine design, pillar strength, coal mining

Stateham, R. M. Field Studies on an Unsupported Roof, York Canyon Coal Mine, Raton, New Mexico. U.S. Bureau of Mines RI 7886, 1974, 18 p. (NTIS PB 231 122)

Infrared and displacement studies were made of an unsupported roof in Kaiser Steel Corporation's York Canyon coal mine, Raton, New Mexico. Monitoring of the roof continued until the roof over the area was caved. Loose slabs in the roof were detected by means of associated thermal anomalies using remote-sensing infrared instruments. Displacement measurements taken during the study indicate that roof movement was cyclic in nature, and the cycles appear to be related to the mine work cycle (work days to idle days).

Keyword(s): roof support, roof stability, coal mining, remote sensing

Location(s): New Mexico, Rocky Mountain Coal Region, United States

Stateham, R. M., D. E. Radcliffe. Humidity: A Cyclic Effect in Coal Mine Roof Stability. U.S. Bureau of Mines RI 8291, 1978, 19 p.

Climatic conditions are compared with roof fall occurrence. These comparisons indicate that humidity has a strong influence on roof fall occurrence rates. Cubic regression techniques are used to develop best fit curves. Statistical analysis of these curves indicate that both are sinusoidal and exhibit positive correlation with each other. The sine waves have a period of 1 year with maximum and minimum inflection points in August and February.

Keyword(s): roof stability, coal mining, mine design

Location(s): United States

Statham, I., C. Golightly, G. Treharne. Thematic Mapping of the Abandoned Mining Hazard: A Pilot Study for the South Wales Coalfield. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference of the Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 255-268.

A desk study was conducted to look into the feasibility of producing thematic maps of the mining subsidence risk for planners.

Keyword(s): abandoned mines, coal mining, land-use planning, engineering

Location(s): Wales, United Kingdom

Statham, I. C. F. Subsidence and Shaft Pillars. Colliery Guardian, v. 125, 1923, p. 325-327, 387-388, 449.

This article reviews and compares various formulas for calculating the size of a shaft pillar.

Keyword(s): bumps, overburden, angle of draw, room-and-pillar, roof stability, pillar strength

Statham, I. C. F. Coal Mining. English University Press, Ltd., 1951, 564 p.
Keyword(s): coal mining

Stearn, E. W. Can Coal Live With Subsidence Laws? Coal Mining & Processing, v. 3, no. 11, 1966, p. 31-34.
Keyword(s): law, coal mining, government, mine operation

Steart, F. A. Strength and Stability of Pillars in Coal Mines. Transactions, Chemical, Metallurgical, and Mining Society of South Africa, v. 54, 1953-54, p. 309-325.
This paper describes bord-and-pillar or pillar-and-stall method of mining as practiced in South Africa. The author discusses pressure exerted on pillars and various means of estimating this pressure and the strength of coal within the pillars. The results of laboratory tests are described in relation to actual conditions within active mines.
Keyword(s): coal mining, pillar strength, room-and-pillar, lab testing, active mines
Location(s): South Africa

Steart, F. A. Mining Subsidence with Particular Reference to the Coalfields of South Africa. Coal and Base Minerals, Part 1, December 1955, p. 42-46; Part 2, January 1956, p. 30-38; Part 3, February 1956, p. 28-56.
Keyword(s): coal mining
Location(s): South Africa

Steed, C., W. F. Bawden, A. M. Coode, P. Mottahed. Subsidence Prediction for Saskatchewan Potash Mines. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, 1985, p. 163-170.
This paper describes the use of an empirical subsidence prediction method applied to Saskatchewan potash mines. Subsidence data were collected from five producing mines. A review of existing subsidence prediction methods was made and applicability of the methods was considered. The data indicate that subsidence tends to be time dependent. The plastic nature and low strength of the evaporites cause subsidence to occur in two stages.
Keyword(s): empirical model, modeling, prediction, time factor, zone area, influence function, computer, non-metal mining, active mines
Location(s): Canada, Saskatchewan

Stefanko, R. Subsidence and Ground Movement. SME Mining Engineering Handbook, v. 1, A.B. Cummins and I.A. Givens, eds., 1973, SME-AIME, New York, p. 13-2--13-9.
This treatment of subsidence and ground movement is confined to subsidence control for limiting surface damage by assessing the significant parameters affecting ground movements during mining to optimize mining techniques.
Keyword(s): coal mining, angle of draw, overburden, longwall, room-and-pillar, mine design
Location(s): United States, Europe

Stemple, D. T. A Study of Problems Encountered in Multiple Seam Coal Mining in the Eastern United States. Virginia Polytechnic Institute Bulletin, v. 49, no. 5, March, 1956, 64 p.
The author discusses several factors that have been shown to have an influence on the presence and amount of disturbance in multi-seam operations. These include proximity of the seams to each other, method of mining, and the amount of overburden above the uppermost bed.
Keyword(s): backfilling, multiple-seam extraction, pillar strength, room-and-pillar, mine design, mine operation, coal mining, overburden, roof stability
Location(s): Appalachian Coal Region, United States

Stephens, J. C. Subsidence of Organic Soils in the Florida Everglades. IN: Proceedings, Soil Science Society of America, v. 20, 1956, p. 77-80.
Keyword(s): fluid extraction, soils
Location(s): Florida, United States

Stephens, J. C. Subsidence of Organic Soils in the Florida Everglades--A Review and Update. Memoirs, Miami Geological Society, 2, 1974, p. 352-361.
Keyword(s): soils, fluid extraction
Location(s): Florida, United States

Stephens, J. C., L. H. Allen, Jr., E. Chen. Organic Soil Subsidence. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, T.L. Holzer, ed., The Geological Society of America, 1984, p. 107-122.
Organic soil subsidence occurs mainly with drainage and development of peat for agriculture.

Subsidence occurs either from densification or from actual loss of mass. Densification usually occurs soon after drainage is established. Slow, continuous loss of mass is due mainly to biological oxidation. Subsidence rates are determined mainly by type of peat, depth to water table, and temperature.

Keyword(s): soils, fluid extraction, modeling, remote sensing

Location(s): Florida

Stephenson, R. W., N. B. Aughenbaugh. Analysis and Prediction of Ground Subsidence Due to Coal Mine Entry Collapse. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 100-118.

This paper discusses the field investigation and analysis used to determine the cause of movements of an elementary school and to establish the probable magnitude of future movements of the structure.

Keyword(s): surface structural damage, coal mining, abandoned mines

Location(s): Illinois, Illinois Coal Basin, United States

Stephenson, R. W. Ground Surface Subsidence Due to Coal Mine Collapse. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 113-128.

This paper discusses subsidence, structural damage, and monitoring at the Washington Elementary School in Johnston City, Illinois.

Keyword(s): abandoned mines, surface structural damage, surface subsidence damage, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Sterling, R.L. Roof Design for Underground Openings in Near-Surface Bedded Rock Formations. Ph.D. Thesis, University of Minnesota, 1977.

Keyword(s): roof stability, roof support, mine design

Location(s): United States

Stewart, C. L. Subsurface Rock Mechanics Instrumentation Program for Demonstration of Shield-Type Longwall Supports at York Canyon, Raton, New Mexico. IN: Energy Resources and Excavation Technology, Proceedings 18th U.S. Symposium on Rock Mechanics, Keystone, CO, June 22-24, 1977, F-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, Golden, p. 1C2-1 - 1C2-13.

A rock mechanics instrumentation program, designed to determine the rock mass response due to longwall mining a thick coal seam using shield-type supports, was instituted at the York Canyon Mine near Raton, New Mexico. This report summarizes the information obtained from the subsurface instrumentation program during mining of the initial longwall panel. The data collected during this study are unique in that they represent the results from mining a super-critical longwall panel in a known geologic environment with cross- and along-panel topographic variations.

Keyword(s): geologic features, active mines, coal mining, longwall, roof support, rock mechanics, instrumentation

Location(s): New Mexico, Rocky Mountain Coal Region, United States

Stewart, C. L., J. E. Shoemaker. Subsidence Monitoring Program at Cyprus Coal's Colorado Operations. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 254-262.

This paper summarizes the results of a subsidence monitoring program above two longwall panels at the Foidel Creek Mine located in northwest Colorado. The monitoring area is characterized by overburden ranging from 1,000 to 1,100 feet in thickness. The surface slope parallels the dip of the bedding at approximately 5 degrees. Average mining height is 9 feet. Smax averaged 3.4 feet. Draw angles averaged 15 degrees for up-dip ribsides and 19 degrees for down-dip ribsides. A site-specific profile function is developed from the data.

Keyword(s): monitoring methods, survey methods, overburden, longwall, coal mining, angle of draw, profile function, vertical displacement

Location(s): Colorado, Rocky Mountain Coal Region, United States

Stewart, J. E. Mining a 100 Million Tonne Orebody Without Subsidence. IN: Proceedings, New Zealand Conference, University of Auckland, May 19-23, 1980, Australasian Institute Mining & Metallurgy, p. 111-123.

Keyword(s): mine design, ground control

Stier, K. H. Measurement of Ground Movements in Shafts With the Help of a New Method. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 159-166.
Keyword(s): instrumentation, monitoring methods

Stimpson, B., G. Walton. Clay Mylonites in English Coal Measures: Their Significance in Open-Cast Slope Stability. IN: Proceedings, 1st International Congress Association of Engineering Geologists, Paris, 1970, v. 3, p. 1388-1393.
Keyword(s): coal mining, floor stability
Location(s): England

Stingelin, R. W., E. T. Baker, S. B. Cousin. Overview of Subsidence Potential in Pennsylvania Coal Fields. Appalachian Regional Commission Report ARC73-111-2552, June, 1975, 220 p. (NTIS PB 272 682)

This study is part of a comprehensive program on mining activities, the associated surface subsidence effects, and their correlation with post-hurricane Agnes reconstruction projects in Pennsylvania. The objective was to develop a methodology that would permit the classification of land areas within the Anthracite Region in terms of their potential for mine-incurred subsidence.
Keyword(s): coal mining, surface structural damage, land-use planning, anthracite, bituminous, prediction
Location(s): Pennsylvania, Appalachian Coal Region, United States

Stingelin, R. W., P. O. MacDonald, J. P. Sparks, E. T. Baker. The Impact of Overmining and Undermining on the Eastern Underground Coal Reserve Base. User's Manual for the Coal Loss Calculation Model Computer Program. Contract JO357129, HRB-Singer, Inc. U.S. Bureau of Mines OFR 6(2)-77, 1976, 78 p. (NTIS PB 262 519)
Keyword(s): computer, multiple-seam extraction, modeling, coal mining
Location(s): Appalachian Coal Region, United States

Stingelin, R. W., P. O. MacDonald, J. P. Sparks, E. T. Baker. The Impact of Overmining and Undermining on the Eastern Underground Coal Reserve Base. Final Report July 1975-September 1976. U.S. Bureau of Mines OFR 6-77-Vol. 1, HRB-Singer Inc., State College, PA, HRB-4967-F, September, 1976, 286 p. (NTIS PB-262 518)

This study developed and implemented of a methodology for estimating the impact of coal seam interaction on the eastern bituminous underground reserve base as published in USBM IC 8655. The effects of previous mining in multiple coal seam areas on currently mined and reserve seams are predicted as a percentage of coal loss by an engineering assessment model called the Coal Loss Calculation Model. The model was developed and tested using data from four coal mines in western Pennsylvania and southern West Virginia.
Keyword(s): coal mining, active mines, bituminous, multiple-seam extraction, modeling, mathematical model, rock mechanics
Location(s): Pennsylvania, West Virginia, Appalachian Coal Region, United States

Stone, K. J. L., R. J. Jewell. Modelling Surface and Subsurface Subsidence Over Coal Mines. IN: Proceedings 6th Australia-New Zealand Conference on Geomechanics, Christchurch, February 3-7, 1992, New Zealand Geomechanics Society, p. 269-273.

Many modern mining methods make surface subsidence unavoidable. Subsidence prediction has generally been by empirical methods. Both longwalling and Wongawilli extraction have been simulated in tests in a geotechnical centrifuge to enable greater understanding of the phenomenon. Scaling laws, the trapdoor system to replicate mining, and data acquisition are discussed. Initial results are illustrated, with crack patterns on model faces and model surfaces shown. Work suggests that centrifuge testing will prove a valuable tool in understanding and predicting subsidence.
Keyword(s): modeling, prediction, longwall, high-extraction retreat
Location(s): Australia

Stoner, J. D. Probable Hydrologic Effects of Subsurface Mining. Ground Water Monitoring Review, v. 3, no. 1, 1983, p. 128-137.
Keyword(s): hydrology, subsurface water

Stout, K. The Law of Subsidence and Support as Applied to Mines. IN: SME Mining Engineering Handbook, v. 1, 1973, A.B. Cummins and I.A. Givens, eds., SME-AIME, New York, p. 13-180 - 13-193.

This chapter discusses what a landowner can expect in terms of lateral and subjacent support. Lateral support is given by land lying adjacent; subjacent support is support by underlying land.
Keyword(s): law

Stringfield, V. T., J. R. Rapp. Land Subsidence Resulting from Withdrawal of Groundwater in Carbonate Rocks. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 447-452.

Keyword(s): fluid extraction

Stritzel, D. L. Observations in Mines Which are Indicative of Ground Control Problems in the Illinois Basin. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 53-58.

Actual case studies are presented that depict serious ground control problems in the Illinois Basin to understand the theoretical concepts of roof control more clearly. Many concepts of rock mechanics can be applied in the daily routine of practical observations. Complex situations often have simple solutions. If the basics of what causes ground control problems are understood, experience can be used in conjunction with theory to prevent such occurrences, thereby providing safer and more efficiently operated coal mines.

Keyword(s): coal mining, ground control, roof stability, rock mechanics, mine safety

Location(s): Illinois, Illinois Coal Basin, United States

Strzalkowski, P. Evaluation of the Parameters for Use with Statistic-Integral Theories of Predicting the Influence of Mining Extraction Based on Zych's Method. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 255-265.

The application of Zych's (1987) method (which provides a great improvement on the statistic-integral theories presented so far) considerably increases the quality of a prediction. Therefore, in this work, the discussion of the selection of proper values of parameters for carrying out calculations is presented on the basis of Zych's method.

Keyword(s): prediction, modeling, horizontal displacement, vertical displacement

Location(s): Poland

Stull, R. T., R. K. Hursh. Tests on Clay Materials Available in Illinois Coal Mines. Illinois State Geological Survey, Mining Investigation Bulletin 18, 1917, 130 p.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Stump, D. E. Underground Coal Mine Subsidence Impacts on Surface Water. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 253 (abstract only).

Subsidence from underground coal mining alters surface water discharge and availability. The magnitude and areal extent of these impacts are dependent on many factors, including the amount of subsidence, topography, geology, climate, interactions between surface water and groundwater interactions, and fractures in the overburden. These alterations may have positive and/or negative impacts. One of the most significant surface water impacts occurred in July 1957 near West Pittston, Pennsylvania. Subsidence in the Knox Mine under the Coxton Yards of the Lehigh Valley Railroad allowed part of the discharge in the Susquehanna River to flow into the mine and create a crater 200 feet in diameter and 300 feet deep.

Keyword(s): surface water, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Sturges, F. C., J. H. Clark. Fly Ash--The Answer to Mine Subsidence Protection? Coal Mining and Processing, v. 7, no. 4, 1970, p. 69-73, 88-89.

This paper discusses several applications and procedures for using fly ash to minimize mine subsidence damage.

Keyword(s): backfilling, abandoned mines, coal mining

Stutzer, O. Geology of Coal. The University of Chicago Press, Chicago, IL, original 1923, translation 1940, p. 416-426.

One section covers disturbances of coal beds, including subsidence. The author describes surface cracks, overburden characteristics, subsidence prediction, groundwater withdrawal, and house and bridge damages.

Keyword(s): floor stability, coal mining, geologic features, surface structural damage, hydrology, subsurface water

Location(s): Germany

Styler, A. N. Strata Deformation Above Longwall Faces. Department of Mining Engineering, University of Newcastle-Upon-Tyne, England, 1979, 11 p. (Available for consultation at the USBM Denver Research Center.)

Keyword(s): longwall, subsurface subsidence damage

Location(s): United Kingdom

Styler, A. N., R. K. Dunham. Strata Deformation Above Longwall Faces. IN: Rock Mechanics: A State of the Art, Proceedings 21st U.S. Symposium on Rock Mechanics, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 308-318.

The mechanics of strata deformation above longwall faces has attracted the attention of many investigators over the past 20 years. Because of access difficulties, very few of these investigations have included detailed measurement of inter-strata deformations at levels above the seam. This paper presents the final results from two investigations to monitor strata deformation above shallow undersea longwalls. Results are compared with those of similar studies and with predicted values of ground movement obtained from the National Coal Board Subsidence Engineers Handbook.

Keyword(s): longwall, coal mining, active mines, monitoring methods, overburden, instrumentation, surface water

Location(s): United Kingdom

Styler, N. Prediction of Inter-Strata Movements Above Longwall Faces. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 651-658.

This paper presents an analysis of measurements of inter-burden deformations above six longwall faces. An attempt is made to demonstrate some correlation between the movements at the various sites and to examine their importance with respect to predicting caving height, disruption of overlying seams, and disruption of aquifers. This analysis demonstrates some significant differences between predicted surface subsidence and inter-burden deformation. In addition, it is shown that the caving height above a longwall face is equal to 8 to 12 times the extraction height, with a zone of fractured rock extending to approximately 50 times the extraction height above the seam.

Keyword(s): longwall, overburden, subsurface water, prediction, multiple-seam extraction, prediction

Location(s): United Kingdom, United States

Su, D. W. H., G. J. Hasenfus. Field Measurements of Overburden and Chain Pillar Response to Longwall Mining. IN: Proceedings, 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., West Virginia University, Morgantown, p. 296-311.

This paper presents the results of an extensive geomechanical testing and monitoring program conducted at a longwall panel. The field program included the monitoring of roof caving sequence and mechanism, surface subsidence, change of pillar stress, roof displacement and entry convergence, and strength characterization of the overburden rocks. The response of eight headgate pillars and the adjacent entries was monitored as the longwall face approached and passed the instrumented locations. Overburden response to longwall mining was monitored using TDR; the height of the highly fractured zone above the gob was determined by postmining drilling. Good correlation was found between the height of the highly fractured zone and the TDR, subsidence, and pillar stress data. The results provide a detailed picture of the response of overburden strata and chain pillars to longwall mining.

Keyword(s): longwall, monitoring methods, overburden, monitoring equipment, modeling, coal mining, rock mechanics, instrumentation, pillar strength, survey equipment, survey methods, survey data processing

Location(s): Appalachian Coal Region, United States

Su, D. W. H. Finite Element Modeling of Subsidence Induced by Underground Coal Mining: The Influence of Material Nonlinearity and Shearing Along Existing Planes of Weakness. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 287-300.

Surface subsidence induced by multiple-panel coal extraction was calculated with finite element stress analysis. The use of nonlinear material behavior and GAP elements, which provide a realistic representation of shearing along existing planes of weakness, allows the finite element program to accurately reproduce observed subsidence profiles.

Keyword(s): finite element, modeling, coal mining, prediction, mathematical model

Location(s): Appalachian Coal Region, United States

Su, D. W. H. Finite Element Modeling of Surface Subsidence Induced by Underground Coal Mining. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 32-46.

The finite element model described and evaluated in this paper is based on 5 years of underground and surface observations and evolutionary development of modeling techniques and attributes. The model can be used to calculate post-mining stress and strain conditions at any horizon between the mine and the ground surface.

Keyword(s): finite element, modeling, coal mining, prediction, longwall, rock mechanics

Location(s): Appalachian Coal Region, United States

Su, W. H., S. M. Hsiung, S. S. Peng. Optimum Mining Plan for Multiple Seam Mining. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 591-602.

Multiple seam mining and its associated problems are very serious in southern West Virginia where poor planning or lack of knowledge in seam interaction often results in complete loss of coal properties. Several measures have been proposed to alleviate the interaction problems under various multiple seam conditions, but few of them are specific in terms of mining plan. Two parallel approaches are adopted for this paper.

Keyword(s): coal mining, multiple-seam extraction, active mines, finite element

Location(s): West Virginia, Appalachian Coal Region, United States

Subsidence Compensation Review Committee. The Repair and Compensation System for Coal Mining Subsidence Damage. Department of Energy, London, 1984, 98 p.

Keyword(s): surface structural damage, coal mining

Location(s): United Kingdom

Sugawara, K., Y. Obara, H. Okamura. Pre-Calculation of Surface Subsidence Due to Coal Mining. IN: Proceedings 5th International Conference on Numerical Methods in Geomechanics, Nagoya, Japan, April 1-5, 1985.

A finite element procedure is applied for the prediction of surface subsidence. It features improvements, such as use of joint elements for bedding planes and considerations of the scale effect on the stiffness of discontinuity and the transverse anisotropic behavior of rock related to the tensile fracture, and permits the simulation of thin seam extraction.

Keyword(s): prediction, finite element, longwall, overburden, modeling, coal mining, geologic features

Sullivan, A. M. Satellite Photos Trace Unstable Mine Roof. Coal Age, v. 83, no. 9, 1978, p. 60-69.

Keyword(s): photography, coal mining, roof stability, remote sensing

Sullivan, P. J., C. F. Hutchinson, J. Makihara, J. Evensizer. Methodology for the Environmental Assessment of Advanced Coal Extraction Systems. Jet Propulsion Laboratory, Pasadena, CA, June 15, 1980, 205 p. (NTIS JPL-PUB-79-82)

Keyword(s): environment, coal mining, land-use planning

Location(s): United States

Summers, D. A., ed. Rock Mechanics: A State of the Art. Proceedings 21st U.S. Symposium on Rock Mechanics, May 28-30, 1980, University of Missouri at Rolla, 835 p.

Keyword(s): rock mechanics, finite element, longwall, modeling, ground control, room-and-pillar, surface structural damage, railroads, pillar extraction, mine design, lab testing

Summers, J. W., R. I. Jeffery. Numerical Prediction of Strata Deformation Associated with Longwall Mining. Transactions Institution of Mining and Metallurgy, Jan-Apr, v. 101, 1992.

Keyword(s): prediction, longwall

Sutherland, H. J., R. A. Schmidt, K. W. Schuler, E. S. Benzley. Physical Simulation of Subsidence by Centrifuge Techniques. Report on Department of Energy Contract No. DE-AC04-76DP00789, 1979, 18 p. (NTIS SAND-78-2272C)

Keyword(s): modeling, physical model

Location(s): United States

Sutherland, H. J., R. A. Schmidt, K. W. Schuler, S. E. Benzley. Physical Simulations of Subsidence by Centrifuge Techniques. IN: Proceedings, 20th U.S. Symposium on Rock Mechanics, Austin, TX, June 4-6, 1979, p. 279-286.

The subsidence of linearly elastic strata above shallow mine drifts is studied by using centrifuge simulation techniques and finite-element

calculational techniques. The centrifuge simulations, conducted on a 6-foot-radius machine, examined six configurations in jointed and unjointed structures of foundry stone and ashfall tuff. Two of these configurations are analyzed numerically.
Keyword(s): finite element, modeling, physical model

Sutherland, H. J., K. W. Schuler, S. E. Benzley. Observations and Analytic Calculations of Strata Movement Above Idealized Mine Structures. IN: Proceedings, 7th Annual Underground Coal Conversion Symposium, Fallen Leaf Lake, CA, September 8-11, 1981, p. 290-302.
Keyword(s): mine design, modeling, overburden, coal mining

Sutherland, H. J., D. E. Munson. Complementary Influence Functions for Predicting Subsidence Caused by Mining. IN: Issues in Rock Mechanics, Proceedings 23rd U.S. Symposium on Rock Mechanics, R.E. Goodman and F.E. Heuze, eds., SME, New York, 1982, p. 1115-1121.
Surface subsidence caused by underground mining is described through complementary influence functions. The complementary functions developed here differ from the simple functions previously used in that the surface displacement is the result of the combined contributions of the mined and unmined zones. This eliminates computational difficulties experienced with the simple functions in determining the deflections above the rib side and in the eventual application of influence functions to complex room-and-pillar configurations. Although the analysis framework presented is intended for predicting subsidence over complex mine configurations, use of the complementary functions is illustrated adequately by application to a longwall panel of the Old Ben No. 24 coal mine.
Keyword(s): influence function, prediction, empirical model, rock mechanics, longwall, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Sutherland, H. J. Centrifuge Simulations of the Subsidence Over Coal Mines and the Stability of Tailings Dams. IN: High Gravity Simulation for Research in Rock Mechanics, G.B. Clark, ed., Colorado School of Mines, May 13-14, 1982, p. 71-98.
Keyword(s): modeling, coal mining
Location(s): United States

Sutherland, H. J., K. W. Schuler. A Review of Subsidence Prediction Research Conducted at Sandia National Laboratories. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, Morgantown, 1982, p. 1-14.
This paper highlights results of the subsidence research program at Sandia National Laboratories: the application of empirical methods to subsidence above longwall panels; the use of the "rubble model" to describe the behavior of broken strata as it distends when it falls to the mine floor and then is compacted by overlying strata; and the application of physical modeling techniques (centrifuge simulations) and numerical techniques to study failure mechanisms in highly structured stratigraphy.
Keyword(s): vertical displacement, longwall, prediction, modeling, geologic features, subsidence research
Location(s): Illinois, Illinois Coal Basin, West Virginia, Appalachian Coal Region, United States

Sutherland, H. J., K. W. Schuler. A Review of Subsidence Prediction Research Conducted at Sandia National Laboratories. Sandia National Laboratories, Report SAND82-0017, Albuquerque, NM, April, 1982, 46 p.
This paper reviews the results of the subsidence research program at Sandia National Laboratories. The manuscript highlights the following: the application of empirical methods (profile functions) to the subsidence above longwall panels in the United States; the use of the "rubble model" to describe the behavior of broken strata as it distends when it falls to the mine floor (or top of the rubble pile) and then is subsequently compacted as it is loaded by overlying elements of strata; and the application of physical modeling techniques (centrifuge simulations) and numerical techniques to study the failure mechanisms in highly structured stratigraphy. The capabilities of the latter two are illustrated by comparing their predictions to the results of a field case that has complicated stratigraphy.
Keyword(s): empirical model, profile function, modeling, geologic features, longwall
Location(s): United States

Sutherland, H. J., K. W. Schuler, S. E. Benzley. Numerical and Physical Simulations of Strata Movements Above Idealized Mine Structures. In Situ, v. 7, no. 1, 1983, p. 87-113.
Keyword(s): modeling, physical model

Sutherland, H. J., P. J. Hommert, L. M. Taylor, S. E. Benzley. Subsidence Prediction for the Forthcoming TONO UCG Project. IN: Proceedings 9th Annual Underground Coal Gasification Symposium, DOE/METC/84-7 (DE84003052), December, 1983, p. 99-108.
Keyword(s): prediction, coal gasification
Location(s): United States

Sutherland, H. J., P. J. Hommert, L. M. Taylor, S. E. Benzley. Subsidence Modeling. IN: Process and Technology Development Activities for In Situ Coal Gasification-FY83, R.E. Glass, ed., Sandia National Laboratories, Albuquerque, NM, SAND83-2041, October, 1983, p. 33-49.
Keyword(s): modeling, coal gasification

Sutherland, H. J., D. E. Munson. Subsidence Prediction for High Extraction Mining Using Complementary Influence Functions. Sandia National Laboratories Report, SAND82-2949, U.S. DOE contract DE-AC04-76DP00789, Albuquerque, NM, February, 1983, 31 p. (NTIS SAND82-2949)
A new approach has been developed for the use of influence functions in the prediction of mine subsidence. In this approach, complementary influence functions are developed for the response of both mined and unmined elements. The surface displacement is then determined by integrating (appropriately summing) the response for each unit element over its area of influence. Both elements contribute significantly to the subsidence prediction. Development of complementary influence functions represents a significant advancement in the subsidence analysis of complicated room-and-pillar mines using empirical techniques. Comparisons between field data and predictions for two longwall panels and a room-and-pillar panel illustrate the capabilities of this technique.
Keyword(s): vertical displacement, prediction, influence function, empirical model, modeling, room-and-pillar, longwall, yielding supports
Location(s): Illinois, Illinois Coal Basin, West Virginia, Pennsylvania, Appalachian Coal Region, United States

Sutherland, H. J., A. A. Heckes, L. M. Taylor. Physical and Numerical Simulations of Subsidence Above High Extraction Coal Mines. Preprint, Sandia National Laboratories, Albuquerque, NM, for the U.S. Department of Energy, SAND83-1191C, March, 1984, 8 p.
Modeling the failure and settlement of strata above mine openings requires a knowledge of several different geomechanical processes such as the failure of the rock mass above the opening, the fall of this mass into the opening, the associated bulking of the rock rubble, and the recompaction of the rubble under subsequent loading. These processes are studied in this paper using physical models and analytical models. The former are based on centrifuge simulation techniques and the latter on numerical techniques.
Keyword(s): modeling, coal mining, overburden, physical model
Location(s): United States

Sutherland, H. J., D. E. Munson. Prediction of Mine Subsidence Using Complementary Influence Functions. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 21, no. 4, August, 1984, p. 195-202.
Surface subsidence caused by high-extraction underground mining is described through complementary influence functions. This concept differs from other proposed concepts in that the surface displacement is the result of the combined contributions of mined and unmined zones. The approach eliminates computational difficulties experienced with the conventional influence functions in determining the deflections above the rib side, and in the application of influence functions to complex room-and-pillar configurations. The general analytical framework for complementary influence functions is reported here. The technique is illustrated with analyses of several case histories which include both longwall and room-and-pillar mine plans.
Keyword(s): prediction, influence function, rock mechanics, empirical model, longwall, room-and-pillar
Location(s): Illinois, Illinois Coal Basin, Pennsylvania, West Virginia, Appalachian Coal Region, United States

Sutherland, H. J., P. J. Hommert, L. M. Taylor, S. E. Benzley. Subsidence Prediction for Two UCG Projects. In Situ, v. 8, no. 4, 1984, p. 347-367.
Keyword(s): prediction

Sutherland, H. J. The Use of Centrifuge Simulation Techniques in U.S. Rock Mechanics. IN: 1984 Annual Review of U.S. Progress in Rock Mechanics: Rock Dynamics, F.E. Henze, ed.
Keyword(s): rock mechanics, modeling
Location(s): United States

Sutherland, H. J., A. A. Heckes, L. M. Taylor. Physical and Numerical Simulations of Subsidence Above High Extraction Coal Mines. IN: Proceedings, International Society for Rock Mechanics Symposium on Design and Performance of Underground Excavations, Cambridge, England, September, 1984, E.T. Brown and J.A. Hudson, eds., British Geotechnical Society, London, p. 65-72.
Keyword(s): coal mining, modeling, physical model

Sutherland, H. J., L. M. Taylor, S. E. Benzley. Physical and Numerical Simulations of Subsidence in Fractured Shale Strata. IN: Proceedings, 10th Annual Underground Coal Gasification Symposium, DOE/METC-85/5 (DE85001956), December, 1984, E. Burwell, L. Docktor, and J.W. Martin, eds., p. 388-399.
Keyword(s): prediction, modeling, physical model, overburden, coal gasification, roof stability

Sutherland, H. J. Roof Stability Prediction for the TONO UCG Site. Underground Coal Gasification Program FY84 Annual Report, C.E. Tyner, ed., SAND85-0101, Sandia National Laboratories, Albuquerque, NM, March, 1985, p. 39-41.
Keyword(s): roof stability, prediction, coal gasification
Location(s): United States

Sutherland, H. J. Subsidence and Roof Stability Analyses for the Extraction and In Situ Processing of Fossil Fuels. Sandia National Laboratories, Albuquerque, NM, Report SAND85-2077, for U.S. Department of Energy, (DE86007552), December, 1985, 95 p. (NTIS 624751747 F)
In the late 1970s, a coal mine subsidence research and development program was initiated at Sandia National Laboratories for the U.S. Department of Energy. The program objective was to develop the capability to predict surface subsidence above coal mines as a function of the mine plan and the geologic setting. As this research progressed, its scope was expanded to encompass strata motions associated with in situ extraction of fossil fuels. A comprehensive bibliography of the publications produced by this program and synergistic studies at Sandia is included.
Keyword(s): prediction, coal mining, mine design, geologic features, longwall, modeling, roof stability, room-and-pillar, empirical model, influence function, finite element, literature search
Location(s): United States, England, Wyoming, Illinois, New Mexico, Washington, Pennsylvania

Suzuki, K. Stress Variation in Coal-Seam Near Longwall Workings Underground. Journal Mining & Metallurgy Institute, Japan, v. 74, 1958, p. 996-1000.
Keyword(s): longwall, coal mining

Swain, H. Successful Design for Mining Subsidence. Architecture Journal, v. 143, May, 1974, p. 1047-1054.
The author describes a building construction system (CLASP) designed for articulated structures located over undermined areas. Rather than depending on strength, the buildings are designed to depend on lightness and flexibility to withstand the effects of subsidence. The key component, diagonal spring-loaded wind brace, permits the buildings to resist wind forces but compress to allow the building frame to adjust to subsidence.
Keyword(s): surface structural damage, ground control, construction, engineering, architecture

Swallow, F. C. Caving Chambers. Colliery Guardian, v. 157, 1938, p. 1079 and 1159; v. 158, 1939, p. 392.
Caving the roof in certain areas lessened the stress and strengthened the roof over areas adjacent to the caved area.
Keyword(s): roof stability

Swart, L. The Extraction of a Shaft Pillar at Shallow Depth. Association Mine Managers Transvaal, Papers and Discussions, 1952/53, p. 93-103.
Keyword(s): pillar extraction, room-and-pillar
Location(s): South Africa

Sweet, A. L. Validity of a Stochastic Model for Predicting Subsidence. IN: ASCE Journal Engineering Mechanics Division, v. 91, no. EM6, Proceedings Paper 4573, 1965, p. 111-128.
Experiments using sand and glass spheres as media investigated the small subsidence of media between two parallel plates of glass resulting from the medium escaping through a narrow opening at the lower edges of the plates.
Keyword(s): prediction, stochastic model, modeling, empirical model
Location(s): United States

Sweet, A. L., J. L. Bogdanoff. Stochastic Model for Predicting Subsidence. ASCE Journal Engineering Mechanics Division, v. 91, no. EM2, 1965, p. 21-45.

A stochastic model for predicting subsidence of a granular medium is presented; it yields a Markov chain for which a solution is not found. Time is eliminated as a variable by examining the subsidence only after motion has ceased.

Keyword(s): prediction, stochastic model, modeling, empirical model

Symons, M. V. Sources of Information for Preliminary Site Investigation in Old Coal Mining Areas. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 119-135. (NTIS Accession No. 79-22617)

All known sources of information relating to past coal mining activities were consulted for an area where coal extraction from the productive Upper Coal Measures took place between the 16th and mid-20th centuries. The occurrence of shafts, adits, and shallow workings obtained from this study were compared with that obtained by the normal procedure of referring to the abandonment plans held by the National Coal Board, to Ordnance and Geological Survey plans, to Geological Memoirs, and to aerial photographs. The benefits to be gained from this more extensive form of preliminary investigation are assessed and the feasibility of adopting it as standard procedure is discussed. Recommendations are made in relation to site investigations in old coal mining areas.

Keyword(s): coal mining, abandoned mines, surface structural damage, engineering, land-use planning, National Coal Board

Location(s): United Kingdom

Symons, M. V. Preliminary Site Investigation in Old Coal Mining Areas -Problems of Correlating Coal Seam Names. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 211-237.

This paper examines the problems involved in correlating old coal seam names with present known seams in an area where coal was mined between the 16th and mid-20th centuries. The practical benefits to be gained from this correlation are assessed.

Keyword(s): coal mining, historical, land-use planning, engineering

Location(s): United Kingdom

Symons, M. V. Site Investigation in Old Coal Mining Areas--Recommended Procedure for the Desk Study. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 173-187.

Details are provided of a good practice procedure for carrying out the Desk Study for a site investigation in an old coal mining area. Step-by-step instructions are given, in both written and flow chart form, with all information sources listed and the feasibility of consulting them discussed.

Keyword(s): abandoned mines, literature search, coal mining, land-use planning, National Coal Board

Location(s): United Kingdom

Systems Planning Corporation. Evaluation of Mine Subsidence, Neighborhood Development Program, Webster-Elba and Roberts-Devilliers Project Action Areas. Report for the Urban Redevelopment Authority, Pittsburgh, PA, 1973.

This paper covers subsidence of mines operated prior to 1900 at depths of less than 100 feet. Possible subsidence prevention measures included overexcavation, deep foundations, loose filling, grout columns, and bulk grouting.

Keyword(s): grouting, historical, abandoned mines, structural mitigation, land-use planning

Location(s): Pennsylvania, Appalachian Coal Region, United States

Szpetkowski, S. Obliczanie Wielkosci Deformacji Powierzchni Na Terenachgorniczych (Calculating the Extent of Surface Deformation Resulting from Mining Exploitation). Przeglad Gorniczy, v. 27, no. 4, 1971, p. 170-174.

Keyword(s): prediction

Szpetkowski, S. Wyznaczanie Deformach Powierzchni Przy Eksploateji Prostokatnych Pol Pokladow Poziomych (Determination of Surface Deformation in Excavation of Rightangled Fields of Horizontal Seams). Archiwum Gornictwa, v. 21, no. 3, 1976, p. 205-222.

Keyword(s): prediction

Szpetkowski, S. Prognozowanie Wplywow Na Powierzchni Terenu Nie Zlozach Pokladowych (Forecasting Mining Effects on the Land Surface of Ungotten Solid Coal and Roadside Packs in Sedimentary Deposits). Przeglad Gorniczy, v. 35, no. 7-8, 1979, p. 292-294.
Keyword(s): prediction

Szpetkowski, S. Determination of Surface Subsidence While Extracting Several Coal Seams at Medium and Great Depth with Caving. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 19, no. 3, June, 1982, 8 p.
Keyword(s): surface subsidence damage, prediction, mine design, multiple-seam extraction, coal mining

Szpetkowski, S. Extended Range of Determination of the Predicted Effect of Underground Mining for the Purpose of Surface Protection. Archivum Gornictwa (Mining Archive), v. 27, 1982, no. 1-2 (in English).
Keyword(s): prediction

Szumierz, W. Wplyw Poziomych Deformacji Gorniczych Podloza Na Prace Budowli Liniowych (Influence of Horizontal Deformations on the Subsidence of Linear Structures). Archiwum Inzynierii Ladowej, v. 22, no. 4, 1976, p. 647-663.
Keyword(s): horizontal displacement, surface structural damage

Szwilski, A. B., B. N. Whittaker. Control of Strata Movement Around Face-Ends. Mining Engineering, v. 174, 1975, p. 515-525.
Keyword(s): mine design, longwall, ground control

Szwilski, A. B. Stability of Coal Seam Strata Undermined by Room and Pillar Operations. IN: Proceedings 20th U.S. Symposium on Rock Mechanics, June 4-6, 1979, University of Texas, Austin, p. 59-65.

Mining interaction in multiple seam coal mines is an ever increasing problem. Interaction is a significant mining feature that demands effective planning. Analysis of the mining situation can alleviate the risks of interaction, enhance profitability and the development of reserves. Subsequently systematic mining should be practiced. A concept of anticipating the effect of undermining coal seams by room-and-pillar operations has been developed based on an actual case study. A parallel is made to that of an advancing/retreating longwall panel. Conclusions are drawn as to the best mining method of exploiting the disturbed coal seam that has been undermined, based on the specific geological conditions.
Keyword(s): multiple-seam extraction, coal mining, mine design, room-and-pillar, geologic features
Location(s): Rocky Mountain Coal Region, United States

Szwilski, T. B. Influence of Coal Rib Pillar Width on the Stability of Strata Around the Face-End and Gateroad in Longwall Mining. IN: Rock Mechanics: A State of the Art, Proceedings 21st Symposium on Rock Mechanics, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 285-298.

The efficiency of operation and life of an advancing longwall coal face depends, to a great extent, on the face-end roof strata conditions and the stability of the gateroads. The factors that influence the rate of closure of gateroads are examined, in particular, the gateside pack and the coal rib (crush) pillars. The performance of mechanized packing systems is briefly discussed. Gateroad deformation surveys were carried out at two coal mines to determine the influence of the rib pillar width on the gateroad stability.
Keyword(s): coal mining, longwall, rock mechanics, ground control, mine design
Location(s): E

Tadolini, S. C., K. Y. Haramy. Gateroads with Yield Pillars for Stress Control. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 179-194.

Ground control problems associated with deep coal mines have increased interest in the design of longwall gateroads using yielding pillars. This paper presents a discussion of the yield pillar theory and assesses the stability of gateroads with yield pillar configurations. Case studies were conducted in two underground longwall mines using two- and three-entry yielding chain pillar configurations.

Keyword(s): ground control, coal mining, active mines, yielding supports, longwall, pillar strength, mine design, instrumentation, geologic features

Location(s): Utah, Colorado, Rocky Mountain Coal Region, United States

Tandanand, S., L. R. Powell. Consideration of Overburden Lithology for Subsidence Prediction. IN: Proceedings Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 17-29.

Geological differences among various coalfields restrain the applicability of subsidence prediction using existing European methods. To modify these methods for domestic conditions, the USBM developed a method of assessment to evaluate the lithological effects on subsidence in the Northern Appalachian basin by examining data collected from 16 longwall panels in the coalfield. Results to date showed that the ratio of maximum subsidence to extraction thickness, known as the subsidence factor, can be expressed in terms of the width-to-depth ratio by a simple exponential equation that has a coefficient tentatively considered as the subsidence index. This index varies with the lithology of a particular site and can be expressed in terms of the percent distribution of weak and strong rocks in the overburden.

Keyword(s): prediction, overburden, prediction, longwall, coal mining, geologic features

Location(s): Appalachian Coal Region, United States

Tandanand, S., L. R. Powell. Assessment of Subsidence Data from the Northern Appalachian Basin for Subsidence Prediction. U.S. Bureau of Mines RI 8630, 1982, 14 p.

The authors investigated data collected from 16 longwall panels in the northern Appalachian basin, paying particular attention to the effects of rock lithology, excavation width, and panel depth on the subsidence factor. Based on these data, the subsidence factor is expressed in terms of the width-to-depth ratio by an exponential equation.

Keyword(s): vertical displacement, longwall, prediction, survey data processing, geologic features, coal mining

Location(s): Appalachian Coal Region, United States

Tandanand, S., L. R. Powell. Influence of Lithology on Longwall Mining Subsidence. Mining Engineering, December, 1984, p. 1666-1671.

Data were collected from 13 mines in the Northern Appalachian Coal Basin to assess the geological effects on the ratio of maximum subsidence and extraction thickness, known as the subsidence factor, to develop a simple subsidence prediction method.

Keyword(s): survey data processing, prediction, longwall, geologic features, coal mining

Location(s): Pennsylvania, Ohio, West Virginia, Maryland, Appalachian Coal Region, United States

Tandanand, S. Moisture Adsorption Rate and Strength Degradation of Illinois Shales. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 591-600.

This paper presents a USBM study on the time-dependent behavior of coal measure rocks. The change in weight of Illinois shales due to moisture adsorption was examined. The relationships between moisture adsorption and strength degradation under isothermal conditions were developed.

Keyword(s): roof stability, prediction, overburden, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Tandanand, S., T. Triplett. New Approach for Determining Ground Tilt and Strain Due to Subsidence. IN: Proceedings, National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, Springfield, IL, December 7-11, 1987, Office of Engineering Services, College of Engineering, University of Kentucky, p. 217-222.

Tilt, horizontal displacement, and ground strain due to mining-induced subsidence create severe effects on continuous and discrete surface structures. At present, field measurement of these parameters for subsidence precautions is laborious and time consuming. Empirical implications that the horizontal displacement at a particular point is proportional to the tilt and that the strain is proportional to the curvature have been used in conjunction with subsidence predictions in Europe. As part of developing a new technique to facilitate subsidence monitoring, the USBM has examined these relationships and determined that the proportionality factor is related to the depth of the neutral stratum and has a stationary value if the ratio of maximum horizontal displacement to full subsidence is constant.

Keyword(s): prediction, active mines, coal mining, subsidence research, horizontal displacement, surface structural damage, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Tandanand, S., L. R. Powell. Determining Horizontal Displacement and Strains Due to Subsidence. U.S. Bureau of Mines RI 9358, 1991, 9 p.

Horizontal displacements and ground strains induced by mine subsidence are significant information needed for calculating damage and developing precautions against subsidence effects on surface structures. To devise a simple method for determining the surface horizontal displacements and strains simultaneously with the subsidence prediction, the USBM examined the significance of the tilt number, which is the proportionality constant in the relationship between the horizontal displacement and the slope of the subsidence profile. The ratio of the tilt number to the critical radius of the subsidence trough is identical to the ratio of the maximum possible horizontal displacement to the full subsidence, which is found to be constant in most European coalfields. If this ratio is known for a particular minesite in the United States, then horizontal displacement and ground strains can be readily obtained from the primary subsidence data.

Keyword(s): horizontal displacement, surface structural damage, prediction, active mines, overburden

Tang, D. H., S. S. Peng. Mine Pillar Stability Analysis Using FEM Methods--Two Case Studies. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 88-98.

Massive pillar failures were observed at two underground coal mines. The results of stability analysis using traditional pillar design formulas did not agree with the underground observations. Finite element models were used to analyze the causes and mechanisms of the pillar failures. The results were confirmed by the underground observations. Finally, the improved mine plan for each case was derived to ensure the stability of the underground structure.

Keyword(s): finite element, coal mining, pillar strength, modeling, room-and-pillar, pillar extraction, floor stability

Location(s): West Virginia, Appalachian Coal Region, United States

Tang, D. H. Y., S. S. Peng. Structural Analysis of Mine Pillars Using Finite Element Method--A Case Study. SME-AIME Preprint 87-81, for presentation at the SME-AIME Annual Meeting, Denver, CO, February 24-27, 1987.

Three-dimensional finite element modeling was performed to analyze the safety factors of stump pillars using the Modified Drucker-Prager theory. Results showed they were safe, which was substantiated by underground observations, but the safety factors predicted by three commonly used pillar design formulas showed otherwise. This paper analyzes the differences between these pillar design methods.

Keyword(s): finite element, pillar strength, computer, coal mining, modeling, mine design

Location(s): West Virginia, Appalachian Coal Region, United States

Tang, D. H. Y., S. S. Peng. Structural Analysis of Mine Pillars Using Finite Element Method--A Case Study. Mining Engineering, September, 1988, p. 893-897.

Three-dimensional finite element modeling (3-D FEM) was performed to analyze the safety factors of stump pillars (5.5 x 5.5 m under a cover of 63 m) using the Modified Drucker-Prager theory. The results showed that they were safe. This was substantiated by underground observations, but the safety factors predicted by three commonly used pillar design formulas showed otherwise. This paper discusses the modeling details and analyzes the difference between the 3-D FEM method and traditional pillar design formulas.

Keyword(s): pillar strength, finite element, coal mining, rock mechanics, room-and-pillar, surface structural damage, subsurface water, ground control, lab testing, modeling, computer, roof stability, floor stability, mine design
Location(s): West Virginia, Appalachian Coal Region, United States

Tanious, N. S. Mining Subsidence. M.S. Thesis, University of Minnesota, Minneapolis, July, 1975, 127 p. (NTIS PB 252 455)
The author details the method of analysis and procedures used for formulating a digital computer numerical method for predicting subsidence over flat-lying, seam-type deposits. Existing approaches to subsidence prediction are reviewed.
Keyword(s): vertical displacement, computer, prediction, prediction theories

Tanious, N. S. Investigation of a Large-Scale Coal Pillar Failure. SME Preprint 89-152, for presentation at SME Annual Meeting, Las Vegas, NV, February 27-March 2, 1989, 5 p.
Keyword(s): pillar strength, coal mining, monitoring methods, monitoring equipment, mine design, mine safety
Location(s): Kentucky, United States

Taylor, R. K. Site Investigations in Coalfields: The Problem of Shallow Mine Workings. Quarterly Journal Engineering Geology, v. 1, no. 2, 1968, p. 115-133.
This article gives a general discussion of voids resulting from early mining of coal, clay, and ironstone.
Keyword(s): backfilling, historical, coal mining, non-metal mining, abandoned mines

Taylor, R. K. Characteristics of Shallow Coal-Mine Workings and Their Implications in Urban Redevelopment Areas. IN: Site Investigations in Areas of Mining Subsidence, F.G. Bell, ed., Newnes-Butterworths, 1975, p. 125-148. (Also thesis, University of Minnesota, Minneapolis, July 1975, 127 p.)
Keyword(s): land-use planning, engineering, abandoned mines, coal mining

Taylor, R. K. Development of Resources. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference of the Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 341-346.
This review compares opencast coal mining, dolomite quarrying, and an open-pit tungsten proposal with the planning impacts that affect new underground coal mines. Mine subsidence is commonly the major detractor to underground coal mining.
Keyword(s): coal mining, land-use planning
Location(s): United Kingdom

Tennessee Department of Conservation. Tennessee Coal Surface Mining Law of 1980. Title 59, ch. 8, 1980, p. 29-32.
Section 59-8-312 details the rules and regulations pertaining to surface effects of underground coal mining operations in Tennessee.
Keyword(s): law, government, coal mining
Location(s): Tennessee, United States

Terzaghi, K. Earth Slips and Subsidence for Underground Erosion. Engineering News Record, v. 107, 1931, p. 90-92.
Keyword(s): subsurface subsidence damage

Terzaghi, R. D. Brine Field Subsidence at Windsor, Ontario. IN: Proceedings 3rd Symposium on Salt, Cleveland, OH, 1969, J.L. Rau and L.F. Dellwig, eds., v. 2, p. 298-307.
Keyword(s): non-metal mining
Location(s): Canada

Thakin, D. N. Mechanism of Floor Heaving in Underground Roadways and Measures for its Control. Rock Mechanics Theory and Practice, Mining & Metallurgy Division, Institute of Engineers, Dhanbad, India, 1972, p. 258-277.
Keyword(s): mine operation, mine design, floor stability

Thill, R. E. Acoustical Methods for Monitoring Failure in Rock. IN: Proceedings 14th Symposium on Rock Mechanics, Pennsylvania State University, June, 1972, p. 649-688.
Keyword(s): ground control, bumps, monitoring methods
Location(s): United States

Thom, W. T., Jr. Subsidence and Earth Movements Caused by Oil Extraction, or by Drilling Oil and Gas Wells. Transactions AIME, v. 75, 1927, p.734-742.
The author states that subsidence due to oil and gas removal is probably limited to oil fields in relatively young formations where the oil comes from loosely cemented sands or from oil-soaked clays.

Keyword(s): oil extraction, geologic features
Location(s): Texas, United States

Thomaes, T. L. M., C. J. Vos, J. Boerhave. Viaductbouw In Een Mijnverzakkingsgebied (Construction of a Viaduct in a Coal Mining Subsidence Area). Ingenieur, The Hague, v. 81, no. 40M, October, 1969, p. BT 73-84.
Keyword(s): engineering, construction, surface structural damage

Thomas, J. L. An Introduction to Mining--Exploration, Feasibility, Extraction, Rock Mechanics. Holstead Press, New York, 1978.
Keyword(s): rock mechanics, mine design
Location(s): United States

Thomas, L. J. The Effects of Adjacent Seams and Method of Working on Roadway Closure in the Main Bright Seam at Hucknell Colliery. NCB-MRE Report No. 2330, June, 1968.
Keyword(s): mine operation, multiple-seam extraction, National Coal Board, coal mining
Location(s): England

Thomas, L. J. Effect of Adjacent Seams and Methods of Working in the Main Bright Seam at Hucknall Colliery. Colliery Guardian, v. 218, no. 4, 1970, p. 186-195.
Keyword(s): mine operation, multiple-seam extraction, National Coal Board, coal mining
Location(s): England

Thompson, T. W., J. J. Menezes, K. E. Gray. Roof Stability and Subsidence in In Situ Gasification of Coal. IN: Energy Resources and Excavation Technology, Proceedings 18th Symposium on Rock Mechanics, Keystone, CO, June 22-24, 1977, F-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, Golden, p. 2B1-1--2B1-5.
In situ gasification may well be limited by the ability to predict and control roof behavior and subsidence. This is particularly true in Texas where lignite seams are overlain by weak rock and often with overlying producing aquifers.
Keyword(s): coal gasification, roof stability, overburden, subsurface water, hydrology, geologic features, coal mining, engineering
Location(s): Texas, United States

Thorburn, S., W. M. Reid. Incipient Failure and Demolition of Two-Story Dwellings Due to Large Ground Movements. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 87-99.
This paper discusses the investigation and monitoring of a housing development damaged by subsidence of abandoned room-and-pillar workings. The homes were eventually destroyed because they became unsafe.
Keyword(s): surface structural damage, abandoned mines, coal mining, geologic features

Thorneycroft, W. The Effect on Buildings of Ground Movement and Subsidence Caused by Longwall Mining. Transactions AIME, v. 94, 1931, p. 51-68.
This paper deals with advancing longwall mining and its effects on a residence. A slight upward wave was indicated by the surveys ahead of the subsidence, which appeared to be due to a tilting over of the massive sandstone stratum in the roof measures near the surface, the edge of the coal face acting as the fulcrum.
Keyword(s): longwall, surface structural damage, monitoring methods, survey methods, coal mining, angle of draw
Location(s): Scotland, United Kingdom

Thurman, A. G., V. Straskraba, R. D. Ellison. Development of a Ground Water Hazard Map for an Underground Coal Mine. IN: Proceedings, Symposium on Water in Mining and Underground Works, SIAMOS--78, Granada, Spain, 1978, p. 273-291.
Groundwater conditions affecting underground coal mine planning, development, and operations at an undeveloped property were investigated. Three minable seams and adjacent sandstone members, separated by shaly confining beds, act as aquifers. As a result of formation dip, head varies from zero to more than 300 meters. Faulting probably connects the aquifers in localized areas. Field and laboratory data were used to establish a groundwater hazard map ranking the property by five levels of hydrogeologic complexity. It was possible, using the map with the mining plan, established with appropriate consideration of mining efficiency, safety, and coal recovery, to estimate the water inflow during development of entries, initial longwall mining and sustained longwall mining for the entire period of operation.
Keyword(s): subsurface water, coal mining, hydrology, geologic features, mine design, longwall, geophysical, monitoring methods, lab testing, geotechnical

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Tieman, G. E. Study of Dewatering Effects at Two Underground Longwall Mine Sites in the Pittsburgh Coal Seam of the Northern Appalachian Coal Field. M.S. Thesis, Department of Geology and Geography, West Virginia University, Morgantown, 1986, 147 p.

Keyword(s): surface water, subsurface water, coal mining, longwall, active mines, hydrology

Location(s): West Virginia, Appalachian Coal Region, United States

Tieman, G. E., H. W. Rauch. Study of Dewatering Effects at an Underground Longwall Mine Site in the Pittsburgh Seam of the Northern Appalachian Coalfield. Eastern Coal Mine Geomechanics, U.S. Bureau of Mines IC 9137, 1986, p. 72-89.

Dewatering effects from longwall mining were studied for a mine site in southwestern Pennsylvania. The mine showed evidence of dewatered streams and groundwater supplies. Water sources located much above base level (major stream level) and over or adjacent to recently mined longwall panels were partly to completely dewatered, probably because of downward leakage along subsidence fractures. These lost waters did not migrate to the deep mine because of its thick overburden (at least 500 feet), but instead flowed laterally over confining strata to discharge at nearby streams. Many affected water supplies recovered partially, and all streams recovered fully within 1 to 3 years following longwall mining. Spring and well recovery occurred most frequently near local stream level where newly formed springs were also common.

Keyword(s): hydrology, subsurface water, longwall, coal mining, overburden

Location(s): Pennsylvania, West Virginia, Appalachian Coal Region, United States

Tieman, G. E., H. W. Rauch, L. S. Carver. Study of Dewatering Effects at a Longwall Mine in Northern West Virginia. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 214-221.

Hydrologic impacts of longwall mining were studied in 1986 after mining had occurred at a mine in northern West Virginia. Five springs and one dug well were reportedly dewatered by mining. All such supplies are above nearby streams in elevation, and at least 800 feet above the subsided mine. Three of these six supplies showed partial recovery within 1 year. Only supplies within 50 feet in elevation of a nearby stream showed apparent partial recovery. Measured perennial streams showed notable depletion in streamflow over mined longwall panels that were less than 2 years old. Normal stream discharge was measured over panels more than 2 years old. Most apparent hydrologic dewatering impacts appear to be temporary, and the most vulnerable areas for these impacts are hill sides.

Keyword(s): hydrology, subsurface water, longwall, coal mining, active mines, surface water, monitoring methods

Location(s): West Virginia, Appalachian Coal Region, United States

Tilton, J. G. The Effect of Subsidence on Pipelines. Presented at SME-AIME Annual Meeting, New York, NY, February 27-March 3, 1966, SME-AIME preprint 66FM41, 34 p.

This paper details the damaging effects of subsidence on pipelines and suggests remedial measures to minimize this damage. The author states that subsidence rarely causes failure of pipelines with welded joints but may disrupt other types of connections. Major disruptions occur near the edge of the extraction area except where subsidence induces significant lateral movement outside of the extraction area. The text is supplemented with both plans for subsidence-resistant pipeline designs and photographs detailing the types of damage that may be encountered in a subsidence prone area.

Keyword(s): pipelines, utilities, angle of draw

Location(s): Pennsylvania, Appalachian Coal Region, United States

Tincelin, E., P. Sinou. Observation Made in the Lorraine Iron Ore Mines. IN: Proceedings European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 128-140.

Keyword(s): metal mining

Location(s): Europe

Tincelin, E., P. Sinou. Summary of the Results Obtained from Eight Years Research in Strata Control. IN: Proceedings, International Strata Control Congress, Leipzig, October 14-16, 1958, p. 282-304 and CXXVII-CXXXVI.

This paper summarized results obtained in strata control research conducted in the Lorraine iron ore mines. Direct observations and measurements were used, consisting of the following: (1) determining the rate of rock deformations either at the face or in the interior of the boreholes, (2) determining the load totally acting upon a working front by measuring the velocity of sound for long distances, (3) determining the distribution of load in the interior of a rock massif, (4) laboratory testing of mechanical properties of the rocks, (5) measuring surface subsidences, and (6) measuring the forces and stresses subjected to the roof bolts.

Keyword(s): ground control, metal mining, room-and-pillar, rock mechanics, roof bolting, lab testing, in situ testing

Location(s): France

Tincelin, R., P. Sinou. Spontaneous Collapse in the Lorraine Iron Mines. IN: 4th International Conference on Strata Control and Rock Mechanics, Paris, 1964, p. 56-60.

The subject mine used room-and-pillar methods, followed by pillar extraction, and where required, provided surface protection by leaving pillars. The resulting extraction rate was 50% to 65%. Many spontaneous multiple pillar failures resulted in surface damage and fatalities underground. The failures occurred only at depths of approximately 140 meters and appeared to be related to frequent rock bursts within the area.

Keyword(s): pillar extraction, room-and-pillar, metal mining, pillar strength, surface subsidence damage, mine safety, rock mechanics, ground control

Location(s): Europe

Toenges, A. L. Longwall Mining Methods in Some Mines of the Middle Western States. U.S. Bureau of Mines IC 6893, 1936, 62 p.

This circular deals primarily with the methods of longwall mining used in some mines in certain districts of middle western states. In some instances underground methods were considered comprehensively, and in others only the actual methods of mining and face advance were noted.

Keyword(s): longwall, coal mining, historical, mine operation

Location(s): Illinois, Illinois Coal Basin, United States

Toepfer, P. H. Filling with Unclassified Tailings in Modified Cut and Fill Stopes. U.S. Bureau of Mines IC 7649, 1952, 14 p.

This report describes the substitution of hydraulically emplaced unclassified tailings for previous dry filling techniques for more efficient stope filling.

Keyword(s): hydraulic backfilling

Location(s): United States

Tousell, J., C. Rich, Jr. Documentation and an Analysis of a Massive Rock Failure at the Bautsch Mine, Galena, Ill. U.S. Bureau of Mines RI 8453, 1980, 49 p.

A lead-zinc mine in Paleozoic dolomites experienced a massive rock failure involving 3 to 5 million tons. Analysis of the rock mechanics and mode of failure revealed that failure at the Bautsch mine was the result of the interrelationship of many factors, both internal and external to the mining environment.

Keyword(s): metal mining, rock mechanics, geologic features

Location(s): Illinois, United States

Townsend, J. M., W. C. Jennings, C. Haycocks, G. M. Neall, L. P. Johnson. A Relationship Between the Ultimate Compressive Strength of Cubes and Cylinders for Coal Specimens. IN: Energy Resources and Excavation Technology, Proceedings 18th U.S. Symposium on Rock Mechanics, Keystone, CO, June 22-24, 1977, F-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, Golden, p. 4A6-1--4A6-6.

Most equations being used in the United States for determining the strength of coal pillars require the testing of cubical specimens. In a virgin coal field or the interior of a large mining property, the specimens usually available for strength determination prior to mining are obtained from exploration boreholes. The diameter of the core recovered from diamond boreholes is generally insufficient to prepare cubical specimens and, therefore, cylindrical specimens are tested. The research presented in this paper determines the validity of the assumption that specimens of equal loading area have the same ultimate compressive strength when relating the strengths of cubical and cylindrical specimens.

Keyword(s): rock mechanics, pillar strength, lab testing, coal mining

Location(s): United States

Transportation Research Board, Washington D.C. Subsidence Over Mines and Caverns, Moisture and Frost Actions, and Classification. Transportation Research Record 612, Report Nos. TRB/TRR-612 and ISBN-0-309-02588-5, 1976, 90 p. (NTIS PB-272 844)

This report contains 12 papers on the following subjects: mechanisms of subsidence due to

underground openings; induced and natural sinkholes in Alabama; subsidence control for structures above abandoned coal mines; and ground subsidence associated with dewatering of a depressed highway section.

Keyword(s): roads, soils, subsurface water, hydrology, soil mechanics, coal mining, abandoned mines, surface structural damage, geologic features, monitoring methods, modeling, mathematical model

Location(s): Alabama, Missouri, Hawaii, United States

Traughber, E. B., J. O. Snowden, W. B. Simmons. Differential Subsidence on Reclaimed Marshland Peat in Metropolitan New Orleans, Louisiana. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 479-499.

This paper is a discussion of the history, origin, and utilization of the marshland in the New Orleans area, and the difficulties and hazards that resulted from its development.

Keyword(s): land-use planning, prediction, fluid extraction, foundations

Location(s): Louisiana, United States

Trent, B. C. A Computerized Subsidence Model. Presented at SME Annual Meeting, New Orleans, LA, February 18-22, 1979, SME-AIME preprint 79-86, 11 p.

This paper details a two-dimensional computer code that couples near- and far-field response to model subsidence caused by underground openings.

Keyword(s): vertical displacement, horizontal displacement, computer, modeling

Location(s): United States

Trent, B. C. Empirical Continuum and Block Caving Computer Models for Surface Subsidence. IN: Proceedings Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 142-146.

The economics of today's mining industry prohibit the costly trial-and-error approach that may have been practical at one time. What is clearly needed is an inexpensive, site-specific, general computational model that will allow an engineer to modify certain design parameters in a way that minimizes the hazard of surface subsidence.

Keyword(s): computer, empirical model, modeling, coal mining

Location(s): United States

Trent, B. C., R. T. Langland. Subsidence Modelling for Underground Coal Gasification. In Situ, 1983, v. 7, no. 1, p. 53-85.

Keyword(s): modeling, coal gasification

Trevits, M. A., R. L. King, B. V. Johnson. Overview of the USBM Subsidence Research Program. IN: Proceedings 88th Annual General Meeting Canadian Institute of Mining & Metallurgy, Montreal, Canada, May 11-15, 1986, Paper 86, 14 p.

Keyword(s): subsidence research

Location(s): United States

Trevits, M. A., R. L. King, B. V. Johnson. The Bureau of Mines Subsidence Research Program. IN: Eastern Coal Mine Geomechanics, Proceedings, Bureau of Mines Technology Transfer Seminar, November 19, 1986, U.S. Bureau of Mines IC 9137, p. 57-64.

The USBM, through its Subsidence Research Program, is focusing on providing the mine operator with the ability to predict surface movements and effects on groundwater as a function of mining method and geologic context. The program is designed for coal basins where high mining activity may impact land use requirements. In the long term, all coal basins and mining methods will be addressed. Data sets from several subsidence monitoring sites have been or are being collected. Data sets are now available from the Eastern, Interior, and Rocky Mountain Coal Provinces for full-extraction mining methods. At select sites, shallow-aquifer monitoring wells have also been installed to observe the effects of subsidence on the groundwater system. To date, an empirical model for subsidence prediction has been generated for the Northern Appalachian Coal Region.

Keyword(s): subsidence research, prediction, active mines, land-use planning, monitoring methods, survey methods, hydrology, subsurface water, coal mining, modeling, survey equipment, longwall, high-extraction retreat

Location(s): Appalachian Coal Region, Illinois Coal Basin, Rocky Mountain Coal Region, United States

Trevits, M. A., J. S. Walker. An Accurate, User-Friendly Subsidence Prediction Model for Personal Computers. IN: Proceedings National Symposium on Mining, Hydrology, Sedimentology, and

Reclamation, December 7-11, 1987, Springfield, IL, University of Kentucky, p. 229-233.

The USBM is conducting a comprehensive program of research to identify the mechanisms of mining-induced ground movement. One goal of this effort is to provide the mining industry with a tool to quantify surface movement in advance of mine development, as mine operators are required to predict the magnitude, extent, and duration of surface deformations as part of the mine permitting process. European prediction models generally yield unacceptable results because they have been developed for the conditions in Europe. A model has been developed that is tailored to geologic and mining conditions in teh United States. The basis of the model is the novel application of a variable subsidence coefficient.

Keyword(s): modeling, computer, coal mining, prediction, surface structural damage, agriculture, land-use planning, vertical displacement, horizontal displacement, overburden

Location(s): Appalachian Coal Region, United States

Trevorrow, G. C. Occurrence and Effects of Subsidence in an Operating Mine in the Sewickley Coal Bed of Green County, PA. Thesis, The Pennsylvania State University, 1936.

Keyword(s): coal mining, active mines, surface subsidence damage

Location(s): Pennsylvania, United States, Appalachian Coal Region

Treworgy, C. G., C. A. Hindman, L. Pan, J. W. Baxter. Evaluation of the Potential for Damage from Subsidence of Underground Mines in Illinois. Final Report to Illinois Mine Subsidence Insurance Fund, Contract 1-5-37891, September 1989, Illinois State Geological Survey, Champaign.

This study provides statistics on the proximity of underground-mined areas to urban development. These statistics provide the most detailed view to date of the exposure of structures to the risk of mine subsidence. Prior to this study, maps of non-coal underground mines had never been compiled into a single map database, and the proximity of underground-mined areas (both coal and non-coal) to urban development had never been examined. The project was divided into two tasks: (1) to compile a map database of non-coal underground mines, and (2) to provide data on the proximity of both coal and non-coal underground mines to urban development.

Keyword(s): coal mining, metal mining, non-metal mining, land-use planning, abandoned mines, insurance, surface structural damage, law, computer

Location(s): Illinois, Illinois Coal Basin, United States

Treworgy, C. G., C. A. Hindman. The Proximity of Underground Mines to Residential and Other Built-Up Areas in Illinois. Illinois State Geological Survey, Environmental Geology 138, 1991, 18 p.

The greatest potential for mine subsidence damage to structures occurs where active or abandoned mines lie under or adjacent to cities, towns, and rural subdivisions. In this study we calculated the acreage of four categories of undermined land in Illinois: (1) residential, (2) other urban, (3) urban buffer, and (4) non-urban. We also estimated the number of housing units close to underground mines. Because the oldest mining operations in the state were generally located in and around populated areas, urban areas often have disproportionately higher percentages of undermined land than do adjacent rural areas.

Keyword(s): surface structural damage, abandoned mines, land-use planning, land values, coal mining, metal mining, non-metal mining, insurance

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T., G. Lin, W. Kane, R. M. Bennett. The Effects of Undermining on Various Types of Linear Foundations. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May, 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 99-106.

This work shows that the inclusion of a reasonable intensity function into the influence function technique can produce an accurate prediction for mining conditions in southern Illinois, and that the characteristics of the ground deformation predicted by the method can be related to structural damage. Field data from case studies in southern Illinois were used to determine the two functions employed in the prediction technique.

Keyword(s): influence function, prediction, active mines, coal mining, foundations, surface structural damage, active mines, longwall, horizontal displacement, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T., G. Lin, W. Kane, R. M. Bennett. Prediction of Coal Mine Subsidence and Implications for Structural Damage. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 76-82.

Twelve linear foundations were constructed above a longwall mine to assess the value of various subsidence mitigation techniques. The structures were monitored during and after undermining and footing curvatures at the time of cracking were compared with predicted values. An unreinforced concrete footing sustained substantial damage. Other footings received varying degrees of damage, with inclusion of a sand layer significantly affecting performance. A post-tensioned concrete foundation suffered minimal cracking. A technique developed by the USBM is also presented for determining the subsidence, slope, curvature, and strain of the ground surface.

Keyword(s): foundations, longwall, structural mitigation, active mines, monitoring methods, surface structural damage, vertical displacement, horizontal displacement, influence function, prediction, coal mining, mathematical model

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T. L., A. Drescher. Analysis of Pillar Punching Into Soft Claystone in Southern Illinois. IN: Key Questions in Rock Mechanics, Proceedings of the 29th U.S. Symposium, Minneapolis, MN, June 13-15, 1988, P.A. Cundall, R.L. Sterling, and A.M. Starfield, eds., Balkema, Rotterdam, p. 59-65.

Subsidence can be caused by mine level failures that occur in the roof, pillars, or floor and that allow displacements to propagate to the surface. However, in Illinois, plastic failure of weak claystone floor dominates the failure process. The objective of this USBM research is to define the failure mechanisms and resultant upper bounds to the limit loads given by the limit analysis method for both square and rectangular pillars punching into plastically behaving floor of both finite and infinite thickness. This paper describes the assumptions, techniques and preliminary results of a laboratory program designed to define the three-dimensional failure mechanisms in an infinitely thick, frictionless, perfectly plastic material beneath a square punch.

Keyword(s): floor stability, pillar strength, lab testing, modeling, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T. L., D. W. Yurchak. Inclusion of an Intensity Function for Subsidence Prediction in Illinois. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990,Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 276-284.

This paper presents USBM research on modifying the influence function method to predict mining subsidence in Illinois. According to theory, this technique must incorporate an intensity function to represent the relative significance of extractions at mine level. This paper shows that the inclusion of a reasonable intensity function increases the accuracy of the technique, then introduces a method for finding the required functions for a case study in Illinois. The slopes and curvatures of the subsidence trough are also shown to be given by derivatives of the influence function.

Keyword(s): prediction, influence function, coal mining, active mines, empirical model, longwall, modeling

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T. L., D. W. Yurchak. Determination of an Intensity Function for Subsidence Prediction. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 169-175.

The objective of this research, conducted by the USBM, is to review and modify the influence function method to predict mining subsidence in Illinois. If subsidence on the surface is considered the effect, and an extraction at mine level is considered a cause of certain intensity, this work has determined that the technique must incorporate an intensity field to represent the magnitudes of these causes. This paper shows that the inclusion of a reasonable intensity field increases the accuracy of the technique.

Keyword(s): prediction, coal mining, modeling, influence function

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T. L., D. W. Yurchak. Predicting the Effects of Subsidence from High Extraction Mining in Illinois. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 71-75.

This paper presents research on modifying the influence function method to predict mining subsidence and the resultant strain in Illinois.

Keyword(s): prediction, influence function, coal mining, horizontal displacement, active mines, modeling, vertical displacement, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T. L., D. W. Yurchak. The Practical Application of Subsidence Prediction in the Illinois Coal Basin. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 315-327.

This paper presents research on modifying the influence function method to predict subsidence of the ground surface. The application of the technique is then demonstrated for the prediction of pre-subsidence and post-subsidence shoreline contours around Rend Lake, Illinois, the prediction of induced slopes as it relates to crop or power line damage, and the prediction of curvature for the estimation of structural damage.

Keyword(s): prediction, influence function, coal mining, vertical displacement, horizontal displacement, longwall, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T. L., D. W. Yurchak. Illustrations of the Value of Subsidence Prediction in the Illinois Coal Basin. IN: Proceedings, Illinois Mining Institute, Centennial Year, 1992, p. 26-38.

This paper presents research on modifying the influence function method to predict subsidence of the ground surface. The required functions have been determined for two case studies above longwall coal panels in Illinois. However, the goal of subsidence engineering is not to predict subsidence, but to predict and mitigate subsidence damage. Therefore, the technique has been enhanced to calculate slope and curvature, and a method has been developed to predict strain using these curvatures and a simply measured site constant. The application of the technique is then demonstrated for the prediction of pre-subsidence and post-subsidence shoreline contours around Rend Lake, Illinois, the prediction of induced slopes as it relates to crop or power line damage, and the prediction of curvature for the estimation of potential structural damage.

Keyword(s): prediction, influence function, coal mining, longwall, horizontal displacement, vertical displacement

Location(s): Illinois, Illinois Coal Basin, United States

Trischka, C. Subsidence Following Extraction of Ore from Limestone Replacement Deposits, Warren Mining District, Bisbee, Arizona. Transactions, AIME, v. 109, 1934, p. 173-180.

Keyword(s): non-metal mining

Location(s): Arizona, United States

Trojanowski, K. Analityczne Sposoby Wyznaczania Wektorow Przesuniec Poziomych Punktow Terenow Gorniczych Przy Wykorzystaniu Metod Malej Triangulacji (Vectors of Points on Undermined Surface by Application of "Small Triangulation" Technique). Przeglad Gorniczy, v. 27, no. 2, 1971, p. 65-70.

Keyword(s): modeling

Trojanowski, K. Application of the Segment Network of Even Effects for Calculation of Subsidence According to K. Kochmanski Theory. 1974, 39 p. (NTIS TT74-54015)

This paper details the application of the K. Kochmanski theory of a network nomogram to the calculation of subsidence over a horizontally extending coal seam. The text is translated from Polish to English.

Keyword(s): vertical displacement, horizontal displacement, prediction theories, prediction, modeling, empirical model, influence function, coal mining

Tsang, P., S. S. Peng, S. M. Hsiung. Yield Pillar Application Under Strong Roof and Strong Floor Condition--A Case Study. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 411-418.

The mechanisms and functions of yield pillars are analyzed by employing a finite element method that takes time dependent and plastic failure of rock into consideration. The design criteria for different geological conditions are discussed. The results provide further evidence that yield pillar design will improve floor or roof conditions, especially when the floor and/or roof strata are weaker than the coal. Based on this study, the yield pillar size is determined for one coal mine located in southern West Virginia.

Keyword(s): yielding supports, finite element, time factor, geologic features, coal mining, roof stability, floor stability, mine design, pillar strength, ground control
Location(s): West Virginia, Appalachian Coal Region, United States

Tsur-Lavie, Y., S. Denekamp. A Boundary Element Method for the Analysis of Subsidence Associated with Longwall Mining. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 65-74.

A boundary element method for the evaluation of ground subsidence associated with longwall coal mining is presented. The method is based on a fundamental solution of stresses and deformation around a single rectangular indentation at the boundary of an infinite elastic half plane.

Keyword(s): boundary element, mathematical model, modeling, longwall, coal mining, vertical displacement

Tsur-Lavie, Y., S. A. Denekamp, G. Fainstein. Geometry of Subsidence Associated with Longwall Mining. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 324-337.

A comparison between a theoretical boundary element model and National Coal Board data is presented. This paper discusses three aspects of the model, including maximum subsidence, surface configuration, and applicability of two-dimensional models to three-dimensional cases.

Keyword(s): boundary element, modeling, National Coal Board, longwall, coal mining

Tsur-Lavie, Y., S. A. Denekamp, G. Fainstein. Surface Subsidence Associated with Longwall Mining--Two and Three Dimensional Boundary Element Model. IN: Proceedings 23rd Annual Conference of the Engineering Group of the Geological Society, Engineering Geology of Underground Movements, University of Nottingham, September 13-17, 1987.

Measured surface displacements are compared to the predictions of the model presented, with attention paid to maximum subsidence, surface profile, and the applicability of the two-dimensional model to the three-dimensional case. For deep and shallow mines, respectively, it is necessary to adopt low and high values of Poisson's ratio to obtain close agreement between measurement and calculation because at depth most of the overlying rock is intact, while for shallow mines, the failure zone reaches the surface.

Keyword(s): modeling, boundary element, longwall, prediction, overburden

Tsur-Lavie, Y., S. A. Denekamp, G. Fainstein. Surface Subsidence Associated with Longwall Mining: Two and Three Dimensional Boundary Element Model. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 225-231.

Systematic measurements of surface displacements associated with longwall mining made by British Coal are compared with National Coal Board results calculated in the present study. Three aspects of subsidence are considered: maximum subsidence, surface configuration, and applicability of two-dimensional models to three-dimensional cases. The model presented in this paper is based on elementary solution for stresses and displacements in an infinite homogeneous elastic halfplane or halfspace, subjected at its boundary by a discontinuous uniform displacement. Two- and three-dimensional models were developed using those solutions. The model was used for an analysis of ground subsidence as a function of the span and height of the mined openings, assuming various Poisson's ratios. Results of two-dimensional models, representing openings of infinite length were compared with measurements (compiled by the NCB) that correspond to longwall mines.

Keyword(s): modeling, boundary element, prediction, longwall, coal mining, National Coal Board, mathematical model
Location(s): United Kingdom

Tubby, J. E., I. W. Farmer. Stability of Undersea Workings at Lynemouth and Ellington Collieries. The Mining Engineer, London, v. 141, August, 1981, p. 87-96.

Keyword(s): surface water, coal mining
Location(s): United Kingdom

Turka, R. J., R. E. Gray, F. B. Newman. Use of Concrete for Stabilization of Abandoned Coal Mines. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 177-181.

The applicability of using concrete for stabilization of abandoned coal mines is illustrated by a case history.

Keyword(s): coal mining, abandoned mines, grouting, room-and-pillar, pillar extraction

Location(s): Appalachian Coal Region, United States

Turnbull, D., E. L. J. Potts. Surface and Underground Subsidence Correlation. Colliery Engineering, v. 35, no. 2, February, 1958, p. 65-72.

This paper describes a series of leveling stations at the surface and in five underlying coal seams, which were to be used as a framework for more detailed leveling operations.

Keyword(s): surface subsidence damage, survey design, coal mining, survey methods, multiple-seam extraction

Turney, J. E. Colorado Geological Survey's Role and Responsibility - Abandoned Mine Subsidence Hazards. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 19-23.

The Colorado Geological Survey's responsibilities regarding inactive mine subsidence hazards are mandated by state statutes that created the present Survey in 1967 and Colorado land use laws enacted between 1972 and 1974. These laws set the stage for the Survey's review of subsidence investigations, the development of a subsidence information library that includes reports of subsidence investigations, extent of mining maps, and publications.

Keyword(s): law, abandoned mines, land-use planning, reclamation, literature search

Location(s): Colorado, Rocky Mountain Coal Region, United States

U.S. Army Engineer District (Baltimore, MD) Northeast Flood Study, Susquehanna River Basin Flood Control and Mine Subsidence in Wyoming Valley, Pennsylvania. 1971, 35 p. (NTIS PB 207 567-D)
Keyword(s): surface water
Location(s): Pennsylvania, Appalachian Coal Region, United States

U.S. Bureau of Mines. Rock Mechanics Instrumentation for Mine Design. U.S. Bureau of Mines IC 8585, 1973, 76 p.
Keyword(s): ground control, instrumentation, rock mechanics, mine design
Location(s): United States

U.S. Bureau of Mines. Investigation of Subsidence in Farmington, Marion County, West Virginia. U.S. Bureau of Mines Mineral Resources and Environmental Development, February, 1974.
Keyword(s): surface subsidence damage
Location(s): West Virginia, Appalachian Coal Region, United States

U.S. Bureau of Mines. Ground Control Aspects of Coal Mine Design. Proceedings, U.S. Bureau of Mines Technology Transfer Seminar, Lexington, KY, 1973, U.S. Bureau of Mines IC 8630, 1974, 138 p.
This report includes an overview of the USBM approach to mine design. It includes three papers on problems associated with the design of panels, five papers on coal mine roof problems, three papers on longwall problems, and comments by the participants on the USBM-industry panel discussion. Seminar attendance consisted of representatives from the coal-mining industry, universities, mining consultants, instrument manufacturers, and local, state, and federal government agencies.
Keyword(s): mine design, ground control, coal mining, roof stability, longwall
Location(s): United States

U.S. Bureau of Mines. Pumped-Slurry Backfilling of Inaccessible Mine Workings for Subsidence Control. U.S. Bureau of Mines IC 8667, 1975.
Keyword(s): hydraulic backfilling, abandoned mines, ground control
Location(s): United States

U.S. Bureau of Mines. Surface Subsidence Control in Mining Regions. Final Environmental Statement, FES 76-58, November 5, 1976, 90 p., appendices A and B.
The most significant environmental impact of conducting subsidence control projects is the protection provided to heavily populated surface areas that have been undermined by coal or mineral extraction.
Keyword(s): hydraulic backfilling, abandoned mines, surface structural damage, mine waste, environment, surface water, subsurface water
Location(s): Wyoming, Pennsylvania, Appalachian Coal Region, United States

U.S. Bureau of Mines. Mine Ground Control U.S. Bureau of Mines IC 8973, Proceedings, Bureau of Mines Technology Transfer Seminars, Pittsburgh PA, December 6-7, 1983, and Denver CO, December 8-9, 1983, published 1984, 155 p.
The basic goal of the USBM Ground Control research program is to provide the mining industry with technology that will lead to the reduction of accidents due to falls of ground. The problems of ground control are the inability to "see" geologic anomalies ahead of the mine workings, the difficulty in predicting ground movements induced by excavation, and the need to provide efficient ground control over the widely varying and frequently unexpected conditions encountered from one place to another.
Keyword(s): ground control, mine safety, geologic features, mine design, instrumentation, monitoring equipment, roof support
Location(s): United States

U.S. Bureau of Mines. Subsidence Prediction Model. Technology News No. 256, August, 1986, U.S. Bureau of Mines, Washington, D.C., 2 p.
The objective of this model is to provide the mining industry with an easy-to-use means of accurately predicting surface subsidence caused by longwall mining in the northern Appalachian Coal Basin.
Keyword(s): coal mining, longwall, prediction, active mines, overburden
Location(s): Appalachian Coal Region, United States

U.S. Bureau of Mines. Monitoring Foundation Response to Subsidence Using a Tiltmeter. Technology News No. 313, September 1988, Bureau of Mines, Washington D.C., 2 p.
The objective is to determine how subsidence resulting from underground coal mining affects surface structures, and evaluate the usefulness of the tiltmeter for monitoring foundation movement. The USBM is studying foundation response to mine

subsidence to determine how subsidence-induced ground movements affect foundations in place directly above the mine. A computer software package was developed to aid in the reduction and analysis of the tiltmeter data.

Keyword(s): foundations, coal mining, monitoring equipment, monitoring methods, monitoring design, surface structural damage, computer, vertical displacement, horizontal displacement

Location(s): Illinois, Illinois Coal Basin, United States

U.S. Bureau of Mines. Structural Uses and Placement Techniques for Lightweight Concrete in Underground Mining. U.S. Bureau of Mines Technology News 354, January 1990.

The objective of this project is to investigate the use and placement of lightweight concrete to improve ground control technology in deep mines where deformation occurs under heavy ground conditions and where there is danger of rock bursts.

Keyword(s): ground control, mine design

Location(s): United States

U.S. Bureau of Mines. Simple Extensometer Measures Underground Backfill Displacements. U.S. Bureau of Mines Technology News 355, February 1990.

The objective of this project is to measure settling in cemented backfill when installation of borehole extensometers is not feasible.

Keyword(s): monitoring equipment, instrumentation, backfilling

Location(s): Washington, United States

U.S. Bureau of Mines. Abandoned Mine Lands Program TN No. 1 Subsidence Abatement Investigation Laboratory (SAIL). Technology News 380, April, 1991, Office of Technology Transfer, U.S. Bureau of Mines, Washington, D.C., 2 p.

The objective of this program is to provide a full-scale test facility where the effectiveness of all types of subsidence-abatement techniques can be evaluated under controlled conditions.

Keyword(s): abandoned mines, hydraulic backfilling, pneumatic backfilling, grouting

Location(s): United States

U.S. Bureau of Mines. Computer-Assisted Ground Control Management System. Technology News 381, May 1991, Office of Technology Transfer, U.S. Bureau of Mines, Washington, D.C., 2 p.

The objective of this system is to apply state-of-the-art monitoring and computer systems technology to remotely monitor geostructural data and evaluate ground conditions in near real-time.

Keyword(s): coal mining, longwall, ground control, computer

Location(s): Rocky Mountain Coal Region, United States

U.S. Bureau of Mines. Analysis of Longwall Pillar Stability (ALPS) Method for Sizing Longwall Pillars. Technology News 382, June 1991, 2 p.

The objective of this project is to improve ground control in longwall gate entries by developing a practical method for evaluating longwall pillar designs.

Keyword(s): ground control, longwall, pillar strength, coal mining, active mines

Location(s): United States

U.S. Bureau of Mines. Abandoned Mine Lands Program TN No. 3: Foaming Mud Cement Controls Underground Coal Mine Fires and Subsidence. Technology News No. 387, July 1991, Office of Technology Transfer, U.S. Bureau of Mines, Washington, D.C., 2 p.

The objective of this project was to develop a cost-effective, flexible method for extinguishing underground coal mine fires that can be readily used in fire conditions encountered in both abandoned mines and coal outcrops. A secondary objective was to prevent subsidence by filling the voids with a material having sufficient compressive strength to minimize subsidence.

Keyword(s): mine fires, abandoned mines, coal mining, mine waste, hydraulic backfilling

Location(s): Arizona, Utah, Montana, West Virginia, Rocky Mountain Coal Region, Appalachian Coal Region, United States

U.S. Bureau of Mines. Abandoned Mine Lands Program TN No. 4: Repairing Stream Channels to Reduce Water Loss into Underground Mines. Technology News 388, July 1991, Office of Technology Transfer, U.S. Bureau of Mines, Washington, D.C., 2 p.

The objective of this project was to control stream loss by identifying and selectively sealing water loss zones in stream channels overlying underground mines.

Keyword(s): subsurface water, abandoned mines, active mines, longwall, overburden

Location(s): Maryland, West Virginia, Appalachian Coal Region, United States

U.S. Bureau of Mines. Computer Program for Unsaturated Flow Analysis. Technology News 390, September 1991, 2 p.

The objective of this project was to analyze variably saturated flow in mining and other environmentally sensitive settings through the use of software for personal computers. New and innovative computer models are necessary to assess more accurately the potential impact of mining activities on groundwater resources and the environment.

Keyword(s): subsurface water, hydrology, environment, computer, modeling, finite element

Location(s): United States

U.S. Bureau of Mines. Abandoned Mine Lands TN No. 5. Abandoned Mine Detection Using Integrated Geophysical Methods. Technology News 391, September 1991, Office of Technology Transfer, U.S. Bureau of Mines, Washington, D.C., 2 p.

The objective of this project is to detect hazards associated with abandoned mine openings through the use of integrated geophysical technology.

Keyword(s): geophysical, abandoned mines, backfilling

Location(s): Colorado, Rocky Mountain Coal Region, United States

U.S. Bureau of Mines. Abandoned Mine Lands Program TN No. 9. Subsidence Monitoring Using Seismic Activity. Technology News 404, August 1992, Office of Technology Transfer, U.S. Bureau of Mines, Washington, D.C., 2 p.

The objective of this program is to validate the premise that there is measurable seismic activity associated with abandoned mine lands and that this activity can be used to determine the stability of the abandoned mine openings, failure cycle of these openings, and susceptibility of the area to surface subsidence.

Keyword(s): seismic, abandoned mines, monitoring methods

Location(s): Colorado, Pennsylvania, Rocky Mountain Coal Region, Appalachian Coal Region, United States

U.S. Bureau of Mines. Abandoned Mine Lands TN No. 13. GIS Data Base for Colorado Springs AML Study Area. Technology News 408, October 1992, Office of Technology Transfer, Bureau of Mines, Washington, D.C., 2 p.

The objective of this project is to determine the extent to which remote-sensing techniques, particularly lineament analysis, can be used to identify geologic structures that may affect the location and migration of subsidence over abandoned underground coal mines in the Colorado Springs area. Data are compiled using a geographic information system (GIS) to allow efficient and reproducible comparisons and analyses.

Keyword(s): remote sensing, abandoned mines, coal mining, computer

Location(s): Colorado, Rocky Mountain Coal Region, United States

U.S. Bureau of Mines Staff. Mine Subsidence Control. Proceedings, U.S. Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, September 19, 1985, U.S. Bureau of Mines IC 9042, 56 p.

Four papers are included. Topics are effects of subsidence on water table levels, development of subsidence precalculation methodology suitable for use with the specific lithological conditions of the Pittsburgh coalbed, an engineering comparison of technologies used in surveying for longwall mine subsidence, and a comparison of the process of subsidence over two different longwall panels. The USBM conducted research to develop accurate techniques of subsidence prediction tailored to geologic conditions specific to the United States.

Keyword(s): prediction, engineering, longwall, monitoring equipment, monitoring design, monitoring methods, survey methods, survey equipment, survey design, subsurface water, hydrology, geologic features

Location(s): Pennsylvania, Appalachian Coal Region, United States

U.S. Code of Federal Regulations. Title 30--Mineral Resources; Chapter VII--Office of Surface Mining Reclamation and Enforcement, Department of the Interior; Subchapter K--Permanent Program Performance Standards; Part 817--Underground Mining Activities. July 1, 1984.

Keyword(s): government, law

Location(s): United States

U.S. Code of Federal Regulations. Title 30--Mineral Resources; Chapter VII--Office of Surface Mining Reclamation and Enforcement, Department of the Interior; Subchapter G--Permanent Program Performance Standards; Part 783--Underground Mining Permit Applications--Minimum Requirements for Information on Environmental Resources. July 1, 1984.

Keyword(s): mine operation, law, environment, government
Location(s): United States

U.S. Congress. Surface Mining Control and Reclamation Act of 1977. Public Law 95-87, August 3, 1977, 91 Stat. 4; 30 U.S.C. 1201, et seq.
This law authorized federal regulations for reclaiming and revegetating surface areas of underground and surface coal mines.
Keyword(s): reclamation, mine operation, law, government, coal mining
Location(s): United States

U.S. Department of the Interior. Surface Mining Citizen's Complaint. Office of Hearings and Appeals, Hearings Division, Arlington, VA, January 29, 1990.
This case concerns a Surface Mining Citizen's Complaint alleging that Clinchfield Coal Company's underground mining activities had caused a well to run dry, as well as having damaged a residence.
Keyword(s): law, surface structural damage, coal mining, subsurface water, hydrology, angle of draw, pillar extraction
Location(s): Virginia, Appalachian Coal Region, United States

U.S. Department of the Interior, Bureau of Mines. Demonstration--Hydraulic Backfilling of Mine Voids, Scranton, Pennsylvania. Final Environmental Statement, FES 72-11, U.S. Bureau of Mines, May 15, 1972, 63 p.
The USBM proposes to conduct a demonstration project to test the economic feasibility of the Dowell hydraulic slurry injection process for blind backfill of dry and flooded underground mine voids to stabilize remaining coal pillars and roof rock, thereby preventing surface subsidence. If successfully completed, the project will backfill mine voids in the Clark and New County coalbeds beneath a 20-acre section of the Green Ridge residential area of Scranton, Pennsylvania, with approximately 300,000 cubic yards of crushed coal refuse from the adjacent Eureka culm bank.
Keyword(s): hydraulic backfilling, coal mining, abandoned mines, mine waste, anthracite
Location(s): Pennsylvania, Appalachian Coal Region, United States

U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement. Permanent Regulatory Program Implementing Section 501 (b) of the Surface Mining Control and Reclamation Act of 1977. Final Environmental Statement, OSM EIS-1, January, 1979.
For the purpose of analyzing environmental impacts, the United States was divided into three regions: the eastern coal region, consisting primarily of the Appalachian coal province; the midwestern region or Interior coal province; and the western region, composed of the Northern Great Plains and Rocky Mountain coal provinces.
Keyword(s): government, law, environment, active mines, active mines, coal mining
Location(s): United States

U.S. General Accounting Office. Alternatives to Protect Property Owners from Damages Caused by Mine Subsidence. Report CED-79-25, February 14, 1979, 50 p. (NTIS PB 290 869)
This report presents an overview of experience with subsidence and its economic and social effects in the Untied States. Legislation at the federal, state, and local levels is briefly discussed, as is the relationship between partial- and total-extraction mining methods and resulting surface subsidence. Five possible alternatives for protecting property owners from financial hardship due to mine subsidence are examined.
Keyword(s): surface structural damage, mine design, law, government, insurance, backfilling, structural mitigation, partial extraction, longwall, economics, land-use planning, abandoned mines, active mines, construction, coal mining, metal mining, non-metal mining, utilities, roads, pipelines, bituminous, anthracite, economics
Location(s): Pennsylvania, Illinois, Ohio, West Virginia, New Jersey, Kansas, Missouri, Oklahoma, Kentucky, Colorado, Wyoming, Montana, Arkansas, Indiana, Washington, Maryland, Nevada, Illinois Coal Basin, Appalachian Coal Region, Rocky Mountain Coal Region, United States

University of Illinois, Urbana, IL. Mine Subsidence and Building Damage. Energy Report, Office of Energy Research, University of Illinois at Urbana-Champaign, June, 1982, 2 p.
Analysis of mine subsidence incidents in Illinois indicates that subsidence will continue to occur as the ground over abandoned coal mines collapses or settles. Subsidence is a cause for concern in Illinois because more than 750,000 acres of land have been undermined for coal. A rapid response to emergency problems caused by mine subsidence and the use of certain building techniques can minimize damage to structures. These are among

the conclusions researchers at the University of Illinois at Urbana-Champaign have reached after a detailed investigation of mine subsidence cases.

Keyword(s): surface structural damage, abandoned mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

University of Wyoming, Mining Engineering. Specifications and Recommendations for Residential Construction Subject to Ground Movements Related to Mine Subsidence. Report on Contract 5/38781, Department of Environmental Quality, Land Quality Division, 1988, 68 p.

The purpose of this document is to provide specifications and recommendations to mitigate damage to buildings in areas with a potential for mine subsidence related ground movements.

Keyword(s): structural mitigation, abandoned mines, coal mining, insurance, construction, architecture, foundations, utilities, engineering

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Unrug, K. F. Longwall Support Requirements. Journal of Mines, Metals & Fuels, September, 1983, Special Number on Update on Longwall Mining--Evolving Trends, p. 334-344.

Planning of the longwall operation should take into account many factors such as seam thickness, dip, depth, roof and floor conditions, fractures pattern, etc.

Keyword(s): longwall, roof stability, roof support, mine operation, geologic features, coal mining

Location(s): United States

Unrug, K. F., C. A. Johnson. Subsidence Potential in the Eastern Kentucky Coal Field. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 41-50.

The major subsidence areas in the Eastern Kentucky Coal Field were identified to distinguish the subsidence phenomena on the basis of geographical location. Further, this identification process was based upon selected critical geological, topographical, and mining features in the coal fields. The proposed identification of the regions was derived from a comparison of the subsidence potential in a particular area. The most likely severe subsidence areas were compared to those with the probable low subsidence severity. The combination of certain geological and mining parameters involved allowed for the derivation of a classification of the subsidence potential.

Keyword(s): coal mining, geologic features, land-use planning, multiple-seam extraction

Location(s): Kentucky, United States

Unrug, K. F., S. K. Nandy. Finite Element Analysis and Comparison of Shaly Mine Roof Support Systems. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 629-636.

In the paper a numerical modeling method is used for evaluation of a roof support system, which is commonly used in the coal industry in the United States. The effectiveness of mechanical roof bolting with or without header boards and steel straps are compared. This analysis takes into account the response of a shaly roof to changing environmental conditions in mines related to the seasonal changes in temperature and humidity of the intake air.

Keyword(s): finite element, roof support, modeling, coal mining, roof bolting

Location(s): United States

Unrug, K. F., S. Nandy. Improvement in Stability of Shaly Roofs in Coal Mines. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 125-142.

Maintaining the integrity of shaly roofs in coal mines requires costly, periodic rehabilitation of the support. The design parameters of a roof structure exist only over a limited period of time after excavation. Consequently, in long-term openings like mains and sub-mains, the deterioration of the conditions alters the design parameters to a point where the roof rock becomes a completely different material. Therefore, the criteria for design of roof support in long- and short-term openings should be different.

Keyword(s): roof stability, coal mining, roof support, geologic features, roof bolting, lab testing

Location(s): United States

Urban, D. W. Damage Suits: Blasting, Subsidence, and Reclamation. Ch. 10 in Mineral Law, Sprague, Sprague & Ysursa, Belleville, IL, 1982, p. 10-1-10-76.

The purpose of this chapter is to provide the attorney engaged in civil litigation with an insight into the subject of blasting and subsidence damage litigation. Although it is rare for a law firm to

receive many cases pertaining to blasting damages, virtually every law firm in Illinois could possibly be faced with litigation concerning subsidence damage. This chapter is therefore designed to provide a basic understanding of the various civil and administrative remedies available to the client. It is also designed to provide a basic understanding of the principles of physics and engineering so that the attorney can properly conduct discovery and locate expert witnesses. Finally, while the attorney engaged in general civil litigation could conduct a trial based upon Illinois common law, this chapter is designed to introduce the attorney to the maze of administrative remedies created by the Surface Mining Control and Reclamation Act of 1977 and to provide an understanding of the complex regulations which accompany the Act.

Keyword(s): law, government, coal mining, abandoned mines, active mines, surface structural damage, partial extraction, longwall, insurance

Location(s): Illinois, Illinois Coal Basin, United States

Urban Redevelopment Authority, Pittsburgh, PA. Evaluation of Mine Subsidence, Neighborhood Development Program, Webster-Elba and Roberts-Devilliers Project Action Areas. March, 1973, 23 p.

Keyword(s): surface structural damage

Location(s): Pennsylvania, Appalachian Coal Region, United States

Urbanik, W., V. J. Osborne. Monitoring and Predictive Modeling of Subsidence in the West Moreton Coalfield. IN: Proceedings, Symposium on Ground Movement and Control Related to Coal Mining, Illawarra, Australia, August, 1986, N.I. Aziz, ed., Australasian Institute of Mining and Metallurgy, p. 324-333.

A subsidence monitoring network was established at a room-and-pillar colliery in southeast Queensland, Australia. A computer model, based on the theory of Kowalczyk (1972) was developed to predict subsidence, and will be used with the field data. It is hoped to ascertain the safe distance of mining from surface structures, the possibility of controlled extraction beneath surface structures, and the time dependency of subsidence.

Keyword(s): computer, prediction, modeling, monitoring methods, room-and-pillar, coal mining, active mines, surface structural damage, angle of draw, partial extraction, time factor

Location(s): Australia

Utah Board and Division of Oil, Gas, and Mining. Coal Mining and Reclamation Permanent Program, Chapter 1. Final Rules. Revised September 20, 1982, 300 p.

This report contains information concerning the regulations pertaining to surface effects of underground coal mining activities in Utah.

Keyword(s): law, surface subsidence damage, government, reclamation, mine operation, coal mining

Location(s): Utah, Rocky Mountain Coal Region, United States

Vaclav, S. A Study of Rock Movements in Long Wall Mining in Lignite Seams. Uhli, September 9, 1955.
Keyword(s): longwall

Van Besien, A. C. Analysis of Roof Fall Accident Statistics and its Application to Roof Control Research. Preprint No. 73-F-71, AIME Annual Meeting, Chicago, IL, February 25-March 1, 1973, 11 p.
Keyword(s): roof support, roof stability, ground control, mine safety

Van Besien, A. C., J. D. Rockaway. Statistical Analysis of Subsidence Events Over Room-and-Pillar Coal Mines. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 138-145.
This paper presents the results of statistical analyses of subsidence events over room-and-pillar coal mines. Data were collected on subsidence events in a number of coal fields, looking for geographic patterns in subsidence behavior and a number of site geologic parameters not known to have been examined in earlier studies. The study was primarily oriented toward identifying those site conditions, whether geologic or mining in character, that influence the delay between mining and the onset of surface distress caused by subsidence.
Keyword(s): coal mining, room-and-pillar, overburden, geologic features, literature search, abandoned mines, active mines, anthracite, bituminous, soils, roof stability
Location(s): Colorado, Wyoming, Oklahoma, Illinois, Indiana, Kentucky, Alabama, Ohio, Pennsylvania, Illinois Coal Basin, Rocky Mountain Coal Region, Appalachian Coal Region, West Virginia, United States

Van Besien, A. C., J. D. Rockaway. Influence of Overburden Materials on the Type and Time Required for Subsidence Development Over Room and Pillar Coal Mines. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October 1987, p. 51-62.
The magnitude and extent of the subsidence that occurs over coal mines may be estimated reasonably accurately by current empirical and numerical/physical prediction modeling. There are, however, few effective procedures for predicting the duration of time that elapses between mining and the initial surficial expression of subsidence. This is particularly so with respect to subsidence over mines in which the coal was extracted by room-and-pillar mining methods.
Keyword(s): coal mining, modeling, empirical model, time factor, room-and-pillar, overburden, prediction
Location(s): Illinois Coal Basin, United States

Van Besien, A. C., N. B. Aughenbaugh. Multiple Subsidence Incidents at an Elementary School. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October, 1987, p. 99-110.
This paper details investigations of two subsidence events at a school site in Illinois; the initial damage (to the old school) occurred in 1971. A second incident, this time to the new building, still under construction, followed in 1974. There is little doubt that both incidents were caused by mine subsidence. The occurrence of only partially collapsed mine workings in the vicinity of the school coupled with water-main ruptures, damages to private residences, surveyed displacements of the surface, and fractures of the ground surface indicated that damage to both old and new school structures was caused by episodic mine subsidence.
Keyword(s): abandoned mines, coal mining, surface structural damage, vertical displacement, utilities, room-and-pillar, angle of draw
Location(s): Illinois, Illinois Coal Basin, United States

Van Besien, A. C., J. D. Rockaway. Influence of Overburden on Subsidence Development over Room and Pillar Coal Mines. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 215-219.
The magnitude and extent of the subsidence that occurs over coal mines may be estimated reasonably accurately by current empirical and numerical/physical prediction modeling. There are, however, few effective procedures for predicting the duration of time that elapses between the advent of mining and the initial surficial expression of subsidence. This is particularly so with respect to subsidence over mines in which the coal was extracted by room-and-pillar mining methods. This undefined time delay may be a critical concern in areas above old or abandoned room-and-pillar mines where the uncertainty of potential subsidence affects property values and urban development. The

relationship between time and subsidence development was evaluated in this study by comparing data on mining systems, overburden and floor characteristics, physical properties of the coal seam, and the delay that occurred between coal extraction and initiation of surface deformation. The data were collected essentially from the Illinois Basin coal field with additional data from other coal-producing regions in the United States. Reasonably complete data sets from over 80 subsidence events were evaluated.

Keyword(s): coal mining, time factor, overburden, room-and-pillar, land-use planning, abandoned mines, prediction, geologic features

Location(s): Illinois, Colorado, Wyoming, Alabama, Michigan, Indiana, Ohio, West Virginia, Pennsylvania, Kentucky, Illinois Coal Basin, Appalachian Coal Region, Rocky Mountain Coal Region, United States

van der Knapp, W., A. C. van der Vlis. On the Cause of Subsidence in Oil-Producing Areas. 7th World Petroleum Congress, Mexico City, 1967, v. 3, p. 85-105.

Keyword(s): oil extraction

van der Merwe, J. N. Design Methods to Arrive at the Optimal Placing and Mining of Inter Panel Pillars to Alleviate Their Effects on Surface. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 133-144.

Current longwall panels normally incorporate the leaving of inter-panel pillars. These pillars are sometimes the cause of water accumulations on the surface. A method is described whereby the dimensions of crush pillars can be determined which do not have the same adverse effects on the surface.

Keyword(s): pillar strength, coal mining, mine design, longwall, modeling, yielding supports, computer, multiple-seam extraction, surface structural damage, surface water, agriculture

Location(s): South Africa

van der Merwe, J. N. Analysis of Surface Subsidence Over a Longwall Panel at 50m Below Surface. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 145-150.

Longwall coal mining in South Africa tends to occur at depths of around 100 meters below the surface. Very few shallow cases are available for analysis. The paper describes the results of an analysis of a longwall panel mined at a depth of 50 meters. It was found that the normalized surface strains did not deviate significantly from the expected values, while significantly greater tilts developed. There were also major differences between the dynamic and static profiles.

Keyword(s): active mines, longwall, surface subsidence damage, coal mining, survey methods, vertical displacement, horizontal displacement

Location(s): South Africa

van der Merwe, J. N. A Study of the Effects of Mining Relatively Shallow Overlying Longwall Panels with Staggered Inter-Panel Pillars at Sigma Colliery, South Africa. IN: Engineering Geology of Underground Movements, F.G. Bell, et al., eds., Geological Society Engineering Geology Special Publication No. 5, 1988, p. 243-255.

When two coal seams in close proximity are to be mined by longwall, a number of alternatives regarding the placing of the panels relevant to one another are possible. The main factors influencing the final choice are gate-road stability, face conditions and the extent of surface deformation. The paper describes the rationale and investigations leading up to the decision to stagger overlying longwall panels at Sigma Colliery. A two-dimensional boundary element program was used to predict the stability of gate roads, after having obtained excellent correlation between predicted and actual conditions in a test case. Observations to date also confirm the prediction of stability conditions in the staggered panels. Surface deformations were measured in detail. A computer program was written which permitted the analysis of a huge volume of data in a very short time. The results of the analysis confirm that less damaging surface disturbance is caused by staggering the panels, compared with superimposing them.

Keyword(s): coal mining, multiple-seam extraction, longwall, mine design, computer, survey data processing, boundary element, modeling, prediction, monitoring methods, geologic features, rock mechanics, vertical displacement, horizontal displacement

Location(s): South Africa

van der Merwe, J. N. Experiences with Undermining by Coal in South Africa. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 299-310.

The paper provides an overview of subsidence research conducted by the Sasol Company in South Africa over a period of more than 6 years. The magnitudes of subsidence elements in South Africa are largely similar to those in the United States and Australia, as opposed to Europe. The research resulted in a subsidence prediction method with a new approach to the prediction of ground strain. The paper also describes the effects of subsidence on various commonly occurring surface structures such as roads, overland conveyor belts, pipelines and power pylons. It is concluded that while most structures are not specifically designed to accommodate mining induced displacements, they can nonetheless be undermined safely and economically with only minor precautions.

Keyword(s): active mines, coal mining, prediction, horizontal displacement, roads, pipelines, surface structural damage, vertical displacement, agriculture, longwall, pillar extraction, utilities

Location(s): South Africa

van der Merwe, J. N. The Prediction of Subsidence in the Secunda and Sasolburg Areas. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 81-85.

The paper presents and empirically derived two-dimensional subsidence prediction method for the Sasolburg and Secunda areas in the Republic of South Africa. Although it is based on data obtained from an area that is small relative to the combined total coal fields of the country, more than 70% of all the underground high-extraction coal mining in the country is done there. A unique approach, taking cognizance of the noncontinuous inelastic nature of the overburden and the role of the soil cover to the prediction of strain is presented.

Keyword(s): empirical model, prediction, coal mining, active mines, geologic features, overburden

Location(s): South Africa

van der Merwe, J. N. The Effects of Subsidence on a Buried Water Pipe Line. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 157-162.

The paper describes the effects of subsidence of just less than 1 meter on a 1.1-m diameter main water supply pipe line. The pipe was in use during the undermining. The pipe was buried to a depth of 2 to 3 meters and was not uncovered prior to mining. Although the pipe was not functionally damaged, the bitumen insulation around the pipe suffered slight damage. It is thought that the shearing action of the ground against the pipe contributed to the damage, confirming the prudence of uncovering pipes of this nature prior to undermining.

Keyword(s): pipelines, utilities, longwall, active mines, coal mining

Location(s): South Africa

van der Merwe, J. N. The Effects of Subsidence on an Overland Conveyor Belt. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 165-171.

The paper describes the effects of subsidences of more than 1 meter on an overland coal-transporting conveyor belt. Apart from cutting the bolts that held the conveyor structure to its foundation blocks, no precautions were considered necessary. Freeing the structure from the ground surface allowed horizontal displacement of the ground without misaligning the belt structure. The structure had sufficient flexibility not to be damaged by vertical displacement, and yet sufficient rigidity in the transverse direction to maintain itself in a straight line. The operation of the conveyor was never disrupted by subsidence. Following the experiments, a number of routine underminings of a similar nature were done, all with positive results.

Keyword(s): coal mining, longwall, active mines, horizontal displacement, surface structural damage, structural mitigation, engineering, monitoring methods

Location(s): South Africa

van der Merwe, J. N. Handling the Effects of Subsidence on Structures: A Comparison of the Approaches Adopted in the U.S.A., Australia and South Africa. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 272-276.

The different needs, legislative styles, and general conditions require different methods of handling the effects of subsidence on surface structures. The paper compares the approaches in selected states of the United States and Australia to that in South Africa. The U.S. approach tends to

be more commercialized than the others, while the Australian approach is more regularized. In South Africa, the emphasis is on legislation and private negotiation between individual mine and surface owners. In the light of knowledge that has recently become available in South Africa, the opportunity is now there to obtain benefit from a more orderly approach based on joint planning and cooperation.

Keyword(s): law, surface structural damage, coal mining, room-and-pillar, longwall, government, mitigation, insurance

Location(s): United States, Australia, South Africa, Illinois, Pennsylvania, Maryland

van der Merwe, J. N. The Effects of Subsidence on Structures in the USA and Australia. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 278-281.

As subsidence elements in Australia, the United States, and South Africa tend to be largely similar, benefit may be derived from comparing the effects of subsidence on surface structures in those countries. The paper provides a summary of some descriptions of those effects, and supplies the guidelines developed abroad for situations where none exist in South Africa yet. It is concluded that the phenomenon and magnitudes of subsidence related effects on structures are not unique to South Africa and that first order projections of those effects for first off underminings of structures in South Africa can be based on examples in the United States and Australia.

Keyword(s): surface structural damage, coal mining, pipelines, roads, utilities, structural mitigation

Location(s): South Africa, United States, Australia

Van der Molen, W. H. Subsidence of Peat Soils After Drainage. Studies and Reports in Hydrology, IAHS-UNESCO, no. 19, 1975, p. 183-186.

Keyword(s): fluid extraction, soils

Van Dillen, D. E. Three-Dimensional Finite Element Analyses of Single- and Double-Entry Portions of Sunnyside Mine No. 1. Report No. R-7638-4534 to U.S. Bureau of Mines, October, 1978, 275 p.

Keyword(s): finite element, modeling, coal mining

Location(s): United States

Van Dillen, D. E., K. C. Ko, F. M. Jenkins, W. J. Karwoski. Stability Comparisons of Longwall Panel Entries Using Finite Element Analysis. IN: Rock Mechanics: A State of the Art, Proceedings 21st U.S. Rock Mechanics Symposium, May 28-30, 1980, D.A. Summers, ed., University of Missouri at Rolla, p. 1-8.

Seven configurations for panel entries of a longwall coal mine are compared and ranked according to structural stability. These entry configurations are analyzed using three-dimensional finite element modeling. The models include large dimensions to minimize boundary effects, elasto-plastic constitutive relations, and simulated excavation and construction of support systems. The stability criteria are formulated in a quantitative manner to facilitate the ranking of the entry configurations. These criteria are based on the expected volume of caved rock in the entry openings. The stability ranking is applied to the entry excavation phase, the headgate phase, and the tailgate phase of the entry life cycle. Parametric variations are applied using two-dimensional finite element models to determine the sensitivity to changes in mining and design parameters.

Keyword(s): finite element, longwall, modeling, coal mining, mine design, rock mechanics

Location(s): United States

Van Dorpe, P. Classification of Coal Mine Subsidence in Iowa. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October, 1987, p. 83-94.

In Iowa, subsidence above abandoned coal mines is well documented, but not well studied in terms of geologic control. Subsidence poses a significant threat to several communities, most notably, Des Moines, as well as rural areas. Subsurface geology and mining information are usually inadequate to document either causal relationships or physical conditions. Nevertheless, several subsidence incidents can be classified on the basis of surface morphology and geologic control.

Keyword(s): coal mining, abandoned mines, geologic features, room-and-pillar

Location(s): Iowa, United States

Van Dorpe, P. E., M. R. Howes, M. J. Miller, S. J. Lenker. Underground Mines and Related Subsidence Potential, What Cheer, Iowa. Iowa Geological Survey OFR 84-3, 1984, Iowa City, IA.

Numerous subsidence events above underground mines have been reported in Iowa. This report was prepared from extant coal mine information to assist in evaluation of subsidence events and to serve as a research base.

Keyword(s): historical, room-and-pillar, longwall, surface structural damage, agriculture, abandoned mines

Location(s): Iowa, United States

Van Dyke, M. Placing Fly Ash in the Ground Water Table. IN: Proceedings National Symposium and Workshops on Abandoned Mine Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 343-375.

The possible use of fly ash, from a city-owned power plant, for subsidence control in Colorado Springs is discussed. A concern at the outset of the project was potential impact on water quality resulting from introducing this material as backfill into flooded mine voids.

Keyword(s): coal mining, backfilling, subsurface water, environment, modeling, abandoned mines

Location(s): Colorado, Rocky Mountain Coal Region, United States

Van Dyke, M. W. Gravel Bulkheads for Confining Hydraulic Backfilling of Abandoned Underground Coal Mines. Preprint 85-363, SME-AIME Fall meeting, Albuquerque, NM, October 16-18, 1985, 2 p.

Keyword(s): coal mining, abandoned mines, hydraulic backfilling

Van Eeckhout, E. M. The Mechanisms of Strength Reduction Due to Moisture in Coal Mine Shales. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 13, 1976, p. 61-67.

Keyword(s): rock mechanics, roof stability, coal mining

Van Heerden, W. L. Stress Measurements in Coal Pillars. IN: Proceedings, 2nd International Congress on Rock Mechanics, 1970, Paper No. 4-16, 5 p.

Keyword(s): pillar strength, ground control, rock mechanics, coal mining

Van Heerden, W. L. In-Situ Determination of Complete Stress-Strain Characteristics for 1.4 M Square Coal Specimens with Width to Height Ratios of Up to 3.4. South Africa Council for Scientific and Industrial Research, Research Report No. ME 1265, 1975, 30 p.

Keyword(s): pillar strength, rock mechanics, ground control, in situ testing, coal mining

Location(s): South Africa

Van Impe, W. F., P. Menge, W. Wolski. Stabilizing Canal Dikes in a Mine Subsidence Urban Area. IN: Proceedings 9th Danube-European Conference on Soil Mechanics and Foundation Engineering, Budapest, October 2-5, 1990, p. 383-389.

Mining related subsidence of up to 7meters in Eisden, Belgium, was countered by stepwise lengthening of the dikes of the canal crossing the city. There were doubts about the stability of the heterogeneous slopes. The geotechnical characteristics of the banks were examined by vane shear and CPTs, samples taken for laboratory testing, and pore pressures monitored to investigate seepage flow. Stability analysis was carried out by the Bishop method. Geometrical changes are not possible, so remedial measures of soil nailing plus gravel column drains were installed in some cross sections of the dike to reach the required safety conditions.

Keyword(s): surface water, geotechnical, lab testing, soils, surface subsidence damage, abandoned mines

Location(s): Belgium

Van Roosendaal, D. J., D. F. Brutcher, B. B. Mehnert, J. T. Kelleher, R. A. Bauer. Overburden Deformation and Hydrologic Changes Due to Longwall Mine Subsidence in Illinois. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 73-82.

Subsidence-induced deformation and hydrologic changes were studied at two active longwall coal mines in Illinois. Site 1, a 725-foot-deep longwall operation in south-central Illinois, was characterized before and after subsidence by core drilling, geophysical logging, subsidence surveying, geotechnical monitoring, and hydrological testing. Results from surveying and geotechnical monitoring during subsidence are presented. Surface subsidence characteristics measured at both sites fall into a range common to other Illinois longwall operations.

Keyword(s): overburden, hydrology, coal mining, instrumentation, monitoring methods, monitoring equipment, subsurface water, longwall, active mines, angle of draw, geologic features, geotechnical, in situ testing, lab testing

Location(s): Illinois, Illinois Coal Basin, United States

Van Roosendaal, D. J., B. B. Mehnert, J. T. Kelleher, C. E. Ovanic. Three-Dimensional Ground Movements Associated with Longwall Mine Subsidence in Illinois. IN: Proceedings, Association of Engineering Geologists 34th Annual Meeting, Chicago, IL, September 29-October 4, 1991, p. 815-826.

This study documents the complex, transient ground displacements and strains associated with dynamic subsidence above an active longwall operation in southern Illinois. During active subsidence, the most complex surface movements take place near the side of the panel where the static tensile zone develops after the passage of a dynamic subsidence wave. At this location, the ratio of horizontal to vertical measurements is at a maximum. To document these complex movements, survey monuments were installed in a 4 by 4 grid over the tension zone and also along the centerline of a longwall panel. Horizontal and vertical movements were monitored at frequent intervals as the mine face advanced under the instruments.

Keyword(s): horizontal displacement, vertical displacement, coal mining, active mines, longwall, monitoring methods, monitoring equipment, monitoring design, survey data processing, survey methods, instrumentation, overburden

Location(s): Illinois, Illinois Coal Basin, United States

Van Roosendaal, D. J., P. J. Carpenter, B. B. Mehnert, M. A. Johnston, J. T. Kelleher. Longwall Mine Subsidence of Farmland in Southern Illinois: Near-surface Fracturing and Associated Hydrogeological Effects. IN: Proceedings National Symposium on Prime Farmland Reclamation,1992, R.E. Dunker, R.I. Barnhisel and R.G. Darmody, eds., Department of Agronomy, University of Illinois, Urbana, p. 147-158.

The Illinois Mine Subsidence Research Program coordinated a study to document near-surface fracturing and hydrogeological changes caused by subsidence above an active longwall coal mine in southern Illinois. Seismic refraction, electrical resistivity, displacement measurements, and resistivity soundings were used in the monitoring program.

Keyword(s): seismic, monitoring methods, active mines, coal mining, longwall, subsurface water, hydrology, geophysical

Location(s): Illinois, Illinois Coal Basin, United States

Van Roosendaal, D. J., B. B. Mehnert, R. A. Bauer. Three-Dimensional Ground Movements During Dynamic Subsidence of a Longwall Mine in Illinois. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 290-298.

A closely spaced grid of survey points was installed over the tensile zone of a longwall panel in southern Illinois and monitored daily during subsidence to document the complex ground-surface movements associated with dynamic subsidence. Vertical and horizontal displacements were used to calculate maximum tilts and principal strains within the grid. The dynamic nature of subsidence is made evident by changes in both the direction and magnitude of maximum tilts and principal strains.

Keyword(s): horizontal displacement, vertical displacement, longwall, instrumentation, monitoring methods, monitoring equipment, active mines, coal mining, overburden

Location(s): Illinois, Illinois Coal Basin, United States

Van Voast, W. A., R. B. Hedges. Hydrogeologic Conditions and Projections Related to Mining near Colstrip, Southeastern Montana. Montana Bureau of Mines and Geology, Billings, 1975.

Keyword(s): hydrology, coal mining

Location(s): Montana, United States

Vandale, A. E. Subsidence--A Real or Imaginary Problem? Mining Engineering, v. 19, no. 9, February, 1967, p. 86-88.

This article presents a brief history of coal mining and surface protection in the Pittsburgh, Pennsylvania, area. Some of the regulations covering surface protection are included.

Keyword(s): historical, law, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Vanderwilt, J. W. Ground Movement Adjacent to a Caving Block in the Climax Molybdenum Mine. Transactions, AIME, v. 181, 1949, p. 360-370.

Varlashkin, V. M. Dopustimye Deformatsii Zemnoi Poverkhnosti Pri Razrabotke Ugol'Nykh Plastov Pod Grazhdanskimi Zdaniyami (Permissible Deformations of Land Surface During Working of Coal Seams Under Civil Buildings). Izvestiya Vysshikh Uchebnykh Zavedenij Gornyj Zhurnal, no. 8, 1975, p. 39-43.
Keyword(s): surface structural damage, government, engineering, coal mining
Location(s): Soviet Union

Varlashkin, V. M. Evaluation of the Flexural Rigidity of Buildings in the Case of Differential Settlements of Foundation Beds Above Mines. Soil Mechanics & Foundation Engineering, U.S.S.R., v. 12, no. 3, May/June, 1975, p. 171-173.
Keyword(s): surface structural damage, engineering, overburden, foundations
Location(s): Soviet Union

Vega, G. E. F. Subsidence of the City of Mexico: A Historical Review. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, December 13-17, 1976, International Association of Hydrological Sciences, Publication No. 121, Washington, D.C., 1977, p. 35-38.
Keyword(s): historical, surface subsidence damage

Veith, D. L. Mined Land Subsidence Impacts on Farmland With Potential Application to Illinois: A Literature Review. U.S. Bureau of Mines IC 9124, 1987, 16 p.
This report summarizes a USBM review of selected literature on the effects of subsidence due to high-extraction underground coal mining on farmland areas. The data are presented for consideration in evaluating the subsidence effects due to similar mining techniques on the prime farmland areas of Illinois.
Keyword(s): agriculture, surface subsidence damage, literature search, subsurface water, surface water, soils, land mitigation, room-and-pillar, longwall, prediction, coal mining
Location(s): Illinois, Illinois Coal Basin, Pennsylvania, Appalachian Coal Region, United States

Vervoort, A. Initial Roof Movement During the Development of Room and Pillar Sections. IN: Computer Methods and Advances in Geomechanics, Proceedings 7th International Conference, Cairns QLD Australia, May 6-10, 1991, G. Beer, J.R. Booker, and J.P. Carter, eds., v. 2, Balkema, Rotterdam, p. 1393-1398.
Keyword(s): roof stability, room-and-pillar, coal mining, active mines, computer

Vervoort, A., B. Jack. Room and Pillar Strata Behaviour Under Various Geological Conditions. IN: Proceedings International Congress on Rock Mechanics, Aachen, 1991, W. Wittke, ed., v. 2, p. 1375-1380.
Accurate underground measurements of the roof deflection were conducted in room-and-pillar panels during development and pillar extraction, improving the basic knowledge of roof behaviour in coal mines. The underground observations were simulated using linear elastic and non-elastic models. These simulations indicated the effect of changing geological conditions and enabled the extrapolation of the underground measurements.
Keyword(s): room-and-pillar, coal mining, monitoring methods, pillar extraction, roof stability, geologic features
Location(s): South Africa

Virginia Polytechnic Institute and State University. Prediction of Ground Movements Due to Underground Mining in the Eastern United States Coalfields Volume 2. Surface Deformation Prediction System. User's Manual. Department of Mining and Minerals Engineering, Blacksburg, VA, December, 1987, 112 p. (NTIS PB90-148263)
The Surface Deformation Prediction System (SDPS) is designed to provide the field engineer as well as the researcher with a detailed, in-depth analysis of ground deformations over undermined areas using three different prediction methods. For easy application, appropriate computer programs have been developed based on three different numerical formulations and a variety of ground deformation indices can be computed. Presented are the basic concepts of the SDPS, the monitoring program, subsequent analysis of the field results obtained, and the adaptation of the prediction methods for mining and geological conditions in the eastern United States. The use of the computer software developed for predicting ground deformations on the surface is discussed.
Keyword(s): coal mining, prediction, computer, influence function, profile function, zone area
Location(s): Appalachian Coal Region, United States

VNIMI (General Institute of Mining Surveying) The Movements of the Rock Masses and of the Surface in the Main Coal Fields of the Soviet Union. Ugletekhjizdat, Moscow, 1958, 250 p. (in Russian).
Keyword(s): coal mining
Location(s): Soviet Union

Voight, B., W. Pariseau. The Nature of Prediction in Subsidence Engineering. ASCE Conference, New York, October 1968, Preprint 762, 42 p.
Keyword(s): prediction, modeling, phenomenological model, elastic model, engineering

Voight, B., A. C. Samuelson. On the Application of Finite-Element Techniques to Problems Concerning Potential Distribution and Stress Analysis in the Earth Science. Pure and Applied Geophysics, v. 75, no. 4, 1969, p. 157-172.
Keyword(s): finite element, modeling, phenomenological model, elastic model

Voight, B., H. D. Dahl. A Post-Yield Phenomenological Approach to Mine Subsidence. IN: Proceedings International Scientific Symposium on Mine Surveying, Mining Geology, and the Geometry of Mineral Deposits, August 26-30, 1969, Prague, Czechoslovakia, Section III, Conference Paper III/3, 12 p.
Keyword(s): modeling, phenomenological model

Voight, B., W. Pariseau. State of Predictive Art in Subsidence Engineering. ASCE Journal Soil Mechanics & Foundations Division, v. 96, no. SM2, March, 1970, p. 721-750.
This paper gives a qualitative review of existing approaches to subsidence prediction; specific sections deal with both empirical and phenomenological methods. Also discussed are damage prediction and alleviation, with details on engineering design precautions and surface considerations.
Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, mine design, prediction, modeling, empirical model, phenomenological model, elastic model, ground control, prediction theories, mitigation
Location(s): United States

Voight, B., N. Orkan, K. Young. Deformation and Failure-Time Prediction in Rock Mechanics. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 919-929.
The purposes of this paper are to (1) develop the properties of a differential equation in order to describe material behavior during creep and some cases of cyclic loading, (2) develop equations to couple rate changes of various phenomena to the time of failure, (3) discuss alternative analytical and graphical procedures and criteria for failure prediction, and (4) demonstrate use of the method in rock mechanics by practical examples.
Keyword(s): rock mechanics, prediction, roof stability, bumps, coal mining, tunnelling

Von Schonfeldt, H., F. D. Wright, K. F. Unrug. Subsidence and Its Effect on Longwall Mine Design. Mining Congress Journal, v. 66, no. 5, 1980, p. 41-45, 53; also presented at the Annual AMC Coal Convention, St. Louis, MO, 1979, May 20-23.
This paper examines the characteristics of subsidence resulting from longwall extractions. From 1969 to 1979, longwall mining in the United States expanded from about 13 faces to more than 75. The main advantage of longwall mining, which is high extraction even at great depth, also can cause significant surface movements. New regulations in the United States covering coal-mining subsidence and reclamation operations require the mine operator to take certain steps in mine design. Specific sections qualitatively discuss the caving of strata, the effect of panel width and depth on settlement, and considerations governing panel design.
Keyword(s): mine design, monitoring design, monitoring installation, monitoring equipment, longwall, economics, coal mining, modeling, prediction, roof stability, National Coal Board, survey design, law
Location(s): Europe, Soviet Union, South Africa, United States, Illinois Coal Basin, West Virginia, Virginia, Poland

Vongpaisal, S. Prediction of Subsidence Resulting from Mining Operations. Ph.D. Thesis, McGill University, Montreal, 1973.
Keyword(s): prediction

Vongpaisal, S., D. F. Coates. Analysis of Subsidence from Inclined Workings. IN: Proceedings 10th Canadian Rock Mechanics Symposium, Kingston, September 2-4, 1975, Queen's University, v. 1, p. 181-201.

The studies described in this paper indicate

that for dipping orebodies, the pattern of surface settlement is similar to that caused by mining horizontal seams with the possible exception that some heaving may occur on the rise side. Any heaving that might occur over a steeply dipping orebody will increase greatly with an increase in length down-dip or with a decrease in width of the crown pillar above the opening. Horizontal movement and strain on the surface also have patterns that are similar to those for flat-lying seams. Two mine cases indicate that initial movement and initial cracking are predictable using a relatively simple model, which should provide useful guidance for mine planning.

Keyword(s): vertical displacement, horizontal displacement, finite element, modeling, mine design, metal mining

Vormberge, G. Working-Out a Seam in the Shaft Safety Pillar of a Pit Under Exceptionally Difficult Operating Conditions. International Strata Control Congress, Essen, West Germany, 1956.

Keyword(s): mine operation, pillar extraction, room-and-pillar

Vorster, G. J. P. Contractual Aspects to be Addressed in the Application of High Extraction Underground Coal Mining Methods Resulting in Surface Ground Movement. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 151-155.

Research into the effects of high-extraction mining on the land surface and structures is gaining momentum but considerable research is still required to bridge the information gap. Negotiating mining and other contracts related to high-extraction mining under structures and land surfaces is a sound method of preventing problems in a field where many obstacles and pitfalls prevail.

Keyword(s): law, surface structural damage, high-extraction retreat, longwall, pillar extraction, coal mining

Location(s): South Africa

Vos, G., F. A. M. Claessen, J. H. G. van Ommen. Geohydrological Compensatory Measures to Prevent Land Subsidence as a Result of the Reclamation of the Markerwaard Polder in the Netherlands. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication No. 151, 1986, p. 915-928.

If the Markerwaard polder is reclaimed the water level will fall 5 to 6 meters over an area of 410 square km. This will cause a drawdown of the piezometric levels in the Pleistocene aquifers underneath the eastern part of the province of North Holland. The spatial pattern of these drawdowns is calculated by a finite element groundwater model. Without countermeasures to compensate for the depletion of the piezometric level, settlement of the compressible Holocene clay and peat deposits will occur and resultant land subsidence may cause damage to buildings and infrastructures.

Keyword(s): fluid extraction, finite element, geologic features, surface subsidence damage

Location(s): Netherlands

Wade, L. V., P. J. Conroy. Rock Mechanics Study of a Longwall Panel. SME Fall Meeting, St. Louis, MO, 1977, Preprint No. 77-I-391.

This paper summarizes the results of the rock mechanics monitoring program performed as part of Old Ben Coal Company's longwall coal-mining demonstration project conducted in cooperation with the USBM. The work described herein included installation of instruments, collection of data, and data analysis performed during mining of the first longwall panel in mine no. 24. The rock mechanics monitoring program included both surface and underground instrumentation.

Keyword(s): rock mechanics, longwall, instrumentation, coal mining, monitoring methods, mine design, active mines

Location(s): Illinois, Illinois Coal Basin, United States

Wade, L. V., P. J. Conroy. Rock Mechanics Study of Old Ben Longwall Panel No. 1. IN: Proceedings, Illinois Mining Institute Annual Meeting, Springfield, October 13-14, 1977, p. 61-79.

This paper summarizes the results of the rock mechanics monitoring program performed as part of the Old Ben Coal Company's longwall coal mining demonstration project conducted in cooperation with the USBM. The work described included installation of instruments, collection of data, and data analysis performed during mining of the first longwall panel in mine no. 24. The rock mechanics monitoring program included both surface and underground instrumentation.

Keyword(s): longwall, instrumentation, coal mining, monitoring equipment, monitoring methods, survey data processing, rock mechanics

Location(s): Illinois, Illinois Coal Basin, United States

Wade, L. V., P. J. Conroy. Rock Mechanics Study of a Longwall Panel. Mining Engineering, v. 32, no. 12, 1980, p. 1728-1734.

Old Ben Coal Company successfully completed the first longwall panel in Illinois. The panel was mined using shield supports and was part of a cooperative agreement with the USBM. This paper describes the rock mechanics studies performed to monitor the performance of the supports, the stress changes in the coal and floor, convergence in entries, and caving mechanism of the roof. From this study, maximum support loads were obtained as well as the stress distribution in the panel, floor, and adjacent pillars.

Keyword(s): rock mechanics, longwall, coal mining, monitoring methods, monitoring equipment, instrumentation, roof stability

Location(s): Illinois, Illinois Coal Basin, United States

Wagner, C. B. A Report on Subsidence Literature Survey, and the Law on Subjacent Support. West Virginia University Bulletin, Series 42, no. 1-I, July 1941, 60 p.

Keyword(s): law, literature search

Location(s): United States

Wagner, H., M.D.G. Salamon. Strata Control Techniques in Shafts and Large Excavations. Association of Mine Managers of South Africa Papers and Discussions, v. 1972-1973, 1972, p. 123-140.

Keyword(s): ground control

Location(s): South Africa

Wagner, H. Determination of the Complete Load Deformation Characteristics of Coal Pillars. IN: Proceedings, 3rd International Congress Rock Mechanics, Denver, CO, 1974, v. 11-B, p. 1076-1082.

Keyword(s): pillar strength, ground control, rock mechanics, coal mining

Wagner, H., B. J. Madden. Fifteen Years Experience with the Design of Coal Pillars in Shallow South Africa Collieries: An Evaluation of the Performance of the Design Procedures and Recent Improvements. IN: Proceedings, International Society for Rock Mechanics Symposium on Design and Performance of Underground Excavations, Cambridge, U.K., September 3-6, 1984, E.T. Brown and J.A. Hudson, eds., British Geotechnical Society, London.

The pillar design procedure employed in South African collieries is reviewed. A comparison of actual and predicted pillar collapses shows good agreement. Three areas of improvement are identified. These concern the effects of regional differences in coal seam strength and method of mining on pillar design and the strength of squat pillars. Results of recent research in the latter two areas are presented. It is shown that the use of continuous miners enhances the strength of slender pillars. The strength of squat pillars is under-estimated by the pillar strength formula in use in South African collieries. Extensions to the formula, which take these differences into account, are proposed.

Keyword(s): coal mining, pillar strength, rock mechanics, mine design, room-and-pillar
Location(s): South Africa

Wagner, H., E.H.R. Schumann. The Effects of Total Coal Seam Extraction on the Surface and Surface Structures. IN: Colloquium on Recent Mining and Metallurgical Developments in the Eastern Transvaal, South Africa Institute Mining & Metallurgy, Witbank, September 1985; also Chamber of Mines of South Africa Research Report 20/85, 1985.
Keyword(s): coal mining, surface structural damage, active mines
Location(s): South Africa

Waite, B. A. Ground Water Monitoring of Underground Coal Mines. Mining Engineering, v. 34, 1982, p. 170-171.
Keyword(s): hydrology, subsurface water, monitoring design, coal mining, monitoring methods

Walbert, M. S., R. J. Sutherland. Economic Model for Evaluating the Tradeoffs Between Coal Mining and Surface Subsidence. Report to Department of Energy, Washington, D.C., by Los Alamos National Laboratory, LA-9438-MS, May, 1982, 65 p.
Keyword(s): coal mining, economics
Location(s): United States

Wald, M. L. Coal Mine Robots Lift an Industry. The New York Times, February 8, 1990, 3 p.
This article describes a longwall operation in West Virginia.
Keyword(s): coal mining, longwall, active mines, mine operation
Location(s): West Virginia, Appalachian Coal Region, United States

Walker, H. C. SPR Geotechnical Program Preliminary Long-Term Monitoring Plan. Sandia National Labs, August, 1980, 27 p. (NTIS SAND80-1750)
Keyword(s): geotechnical, instrumentation, monitoring design, monitoring methods
Location(s): United States

Walker, J. S., J. B. Green, M. A. Trevits. A Case Study of Water Level Fluctuations Over a Series of Longwall Panels in the Northern Appalachian Coal Region. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 264-269.
The purpose of this work was to provide detailed information that could be used to predict certain hydrologic effects of longwall mining in the Northern Appalachian Coal Region. Results of this case study indicate that water level fluctuations in the local groundwater system above longwall panels are associated with subsidence and that the static water level will generally re-establish at or near the pre-mining elevation after mining is completed.
Keyword(s): subsurface water, law, coal mining, longwall, hydrology, geologic features, active mines
Location(s): Pennsylvania, Appalachian Coal Region, United States

Walker, J. S., J. C. LaScola. Foundation Response to Subsidence Induced Ground Movements: A Case Study. IN: Proceedings, National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, December 7-11, 1987, Springfield, IL, University of Kentucky, p. 235-241.
The purpose of this USBM effort was to determine whether mining-induced ground movement is directly transferred to a structure and, if so, how that process takes place. A series of four concrete block walls with foundations were constructed and monitored over an active longwall panel as part of a comprehensive subsidence research program.
Keyword(s): surface structural damage, coal mining, active mines, longwall, monitoring methods, monitoring equipment, foundations, prediction
Location(s): West Virginia, Appalachian Coal Region, United States

Walker, J. S. Case Study of the Effects of Longwall Mining Induced Subsidence on Shallow Ground Water Sources in the Northern Appalachian Coalfield. U.S. Bureau of Mines RI 9198, 1988, 17 p.
The USBM monitored surface subsidence and water level fluctuations in 10 shallow observation wells above a series of four adjacent longwall panels in southwestern Pennsylvania for about 4 years. This study attempted to correlate the changes in the water levels within the observation wells to the measured vertical and horizontal ground movements associated with subsidence. Results of this study indicate that the fluctuation of the water levels appears to be a function of the well location relative to the mine layout and the proximity of mining. Wells are generally unaffected by mining of a preceding panel unless they are

located within the angle of draw for that panel. Wells located at the centerline of a longwall panel exhibit the greatest fluctuation and head loss. Nine of the ten wells investigated recovered to their premining water level after mining was completed.

Keyword(s): longwall, subsurface water, hydrology, coal mining, monitoring methods, active mines

Location(s): Pennsylvania, Appalachian Coal Region, United States

Walker, J. S., M. A. Trevits, R. D. Munson. Overview of the Bureau of Mines Research On the Detection of Subsidence. IN: Proceedings, Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 36-55.

The USBM Abandoned Mine Land Subsidence Research Program addresses the problems of mine void detection, the changing condition of the mine opening, and the development of effective and efficient subsidence abatement techniques. This paper summarizes two current efforts to evaluate the changing conditions of the mine opening using geophysical techniques. The research was conducted at two field sites, in Colorado and in Pennsylvania. The objective of this work was to develop an imminent subsidence detection system applicable to abandoned mine lands in all areas of the country.

Keyword(s): subsidence research, abandoned mines, coal mining, anthracite, bituminous, overburden, subsurface water, seismic, monitoring methods, surface structural damage, geophysical

Location(s): Colorado, Rocky Mountain Coal Region, Pennsylvania, Appalachian Coal Region, United States

Walker, J. S., J. C. LaScola. Foundation Response to Subsidence-Induced Ground Movements: A Case Study. U.S. Bureau of Mines RI 9224, 1989, 12 p.

The purpose of this effort was to determine whether ground movement caused by mining-induced subsidence is directly transferred to a structure and, if so, how that transfer takes place. Four concrete block walls with foundations were constructed and monitored over an active longwall panel. Three of the walls were located perpendicular to the direction of mining in zones where maximum inclination, maximum tension, and maximum curvature were predicted to occur. The fourth wall was constructed along the centerline of the panel, parallel to the direction of mining. All of the walls and the surrounding ground surface were instrumented with conventional survey monitoring points and extensometer stations to observe the vertical and horizontal movements. The fourth wall instrumentation also included continuously recording tiltmeters. The results of this investigation indicate that these simple structures respond to subsidence in a similar manner as the ground surface. This indicates that once the transfer mechanism is more fully defined, prediction models can be developed to accurately estimate the effect of mining on surface structures.

Keyword(s): foundations, coal mining, surface structural damage, longwall, active mines, instrumentation, vertical displacement, horizontal displacement, prediction, modeling

Location(s): West Virginia, Appalachian Coal Region, United States

Walker, J. S., M. A. Trevits. Development of an Early Warning System for Detection of Subsidence Over Abandoned Coal Mines. IN: Mine Subsidence - Prediction and Control, 33rd Annual Meeting of the Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 39-49.

Subsidence from abandoned underground mines has become an everyday concern of many citizens living in the coal-mining regions of the United States. The problem of subsidence prediction is that it is impossible to determine the location and timing of mine opening failure. If a system could be developed that would warn of imminent failure, in advance of surface manifestation, then subsidence abatement techniques could be implemented to minimize property damage. The USBM is evaluating the components of an imminent subsidence detection system at two locations in Pennsylvania. The components under evaluation include an active and passive seismic component as well as aerial photogrammetry.

Keyword(s): coal mining, abandoned mines, monitoring methods, seismic, remote sensing, photography, anthracite

Location(s): Pennsylvania, Appalachian Coal Region, United States

Walker, J. S., M. A. Trevits. Effects of Longwall Mining on Surface Structures. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 141-152.

Five residential structures spaced across a longwall panel were studied. Measurements were made using conventional surveying and electronic

instrumentation to characterize the ground surface and the structures in advance of, during, and subsequent to undermining.
Keyword(s): surface structural damage, longwall, coal mining, monitoring methods, instrumentation, vertical displacement, horizontal displacement
Location(s): Pennsylvania, Appalachian Coal Region, United States

Walker, J. S., M. A. Trevits. New Developments in Remote Pneumatic Stowing Technology for Subsidence Abatement Over Abandoned Coal Mines. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 183-192.
The USBM initiated a program for the development and evaluation of remote pneumatic stowing technology. A dedicated laboratory was constructed to test and improve currently available and prototype remote pneumatic stowing methods.
Keyword(s): pneumatic backfilling, lab testing, abandoned mines, coal mining
Location(s): United States

Walker, W. Hydraulic Stowage at Dalzell and Broomside Colliery. Iron and Coal Trades Review, July 12, 1912, p. 51.
Efficient mining of coal overlain by saturated gravel and adjacent to the Clyde River was allowed by backfilling.
Keyword(s): hydraulic backfilling, surface water, subsurface water, coal mining, overburden
Location(s): England

Wall, C. F. A Geophysical Method of Indicating Relative Sinkhole Susceptibility. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 485-493.
Keyword(s): geophysical

Wallace, M. R. Preventive Measures to Avert Crude Line Subsidence. Pipe Line Industry, June, 1988, p. 19-24.
Longwall mining can affect cross-country pipe lines. During such mining, the extraction of an entire seam of coal allows the roof of the mine to cave in behind the mining operation, thus causing subsidence of the surface. The subsidence travels in a wave-like fashion at ground level. As the wave passes under and beyond the pipe line, special measures must be taken to control its downward movement, thereby controlling bending stresses in the unsupported areas. Recently, longwall mining has affected Capline's 40-inch crude pipeline that operates from Louisiana to Patoka, Illinois. These mining operations extract coal from the 6- to 8-foot seam and over a panel 600 feet wide. Multiple parallel panels are frequently involved, which requires repeated corrective action to the pipeline each time a panel crosses the pipeline. The effects and corrective measures taken to properly support Capline during a four panel longwall mining operation are outlined in this article.
Keyword(s): coal mining, pipelines, longwall, survey design, survey equipment, survey methods, survey data processing, National Coal Board, structural mitigation, vertical displacement
Location(s): Illinois, Illinois Coal Basin, United States

Walters, R. F. Land Subsidence in Central Kansas Related to Salt Dissolution. Kansas Geological Survey Bulletin No. 214, 1977, 82 p.
Keyword(s): non-metal mining
Location(s): Kansas, United States

Waltham, A. C. Ground Subsidence. Blackie and Son Limited,Chapman and Hall, New York, 1989, 202 p.
This book presents an overview of all aspects of ground subsidence. Each style of subsidence is considered in its own right, because the causative mechanisms vary enormously. For example, sinkholes and collapses over random natural voids clearly contrast with the widespread and inevitable human-induced subsidence of drained peat. Mining subsidence, in its various forms, is covered together with the many other ways in which humans induce subsidence in their environment.
Keyword(s): fluid extraction, subsurface water, oil extraction, coal mining, geologic features, National Coal Board, empirical model, multiple-seam extraction, overburden, non-metal mining, foundations, surface structural damage, soils, soil mechanics, engineering, abandoned mines, active mines, geophysical, longwall, vertical displacement, horizontal displacement, prediction, room-and-pillar, computer, influence function, metal mining, structural mitigation, roads, engineering, pipelines, partial extraction, pillar strength, backfilling, land mitigation, mitigation, land-use planning
Location(s): United States, Appalachian Coal Region, China, United Kingdom, Pennsylvania, Florida, Australia, Illinois, Illinois Coal Basin, Germany, Europe, Japan, Kansas, California, Italy

Walton, G., R. K. Taylor. Likely Constraints on the Stability of Excavated Slopes Due to Underground Coal Workings. IN: Proceedings, Conference on Rock Engineering, University of Newcastle upon Tyne, England, April 4-7, 1977, p. 329-349.

This paper examines potential modes of slope failure that can be induced in surface coal mines largely as a consequence of former underground mine workings.

Keyword(s): engineering, rock mechanics, abandoned mines, room-and-pillar, longwall, coal mining

Location(s): England

Walton, G., A. E. Cobb. Mining Subsidence. IN: Ground Movements and Their Effects on Structures, Surrey University Press, P.B. Attewell and R.K. Taylor, eds., 1984, Chapman and Hall, p. 216-241.

The extraction of minerals by underground mining inevitably induces a risk of surface subsidence. Different methods of mining give rise to different risks of subsidence and different styles of ground movement. This chapter considers subsidence resulting from these mining methods; mineral extraction by solution, as in salt recovery, is not considered. Because coal mining is the most extensive and most researched form of mining in many parts of the world, most of the examples come from this sector of the industry.

Keyword(s): coal mining, surface structural damage, room-and-pillar, longwall, partial extraction, roof stability, floor stability, pillar strength, prediction, zone area, empirical model, National Coal Board

Location(s): United Kingdom, Europe

Wang, F. D., D. M. Ropchan, M. C. Sun. Structural Analysis of a Coal Mine Opening in Elastic, Multilayered Material. U.S. Bureau of Mines RI 7845, 1974, 36 p.

Finite-element structural analyses were performed to determine the stress distribution and displacements around a single rectangular coal mine opening in a multilayered rock system. The effects of changes in mechanical properties of roof and coal layers, roof layer and mine opening geometry, horizontal-to-vertical load ratio, and structural geologic features on the stress distribution about the opening were studied.

Keyword(s): roof stability, mine design, ground control, coal mining, finite element

Location(s): United States

Wang, F. D., D. M. Ropchan, M. C. Sun. Proposed Technique for Improving Coal-Mine Roof Stability by Pillar Softening. SME-AIME, v. 255, 1974, p. 59-63.

Keyword(s): roof stability, yielding supports, coal mining

Location(s): United States

Wang, W., M. M. Singh. A Numerical Method for Determination of Stresses Around Underground Openings. IN: Proceedings, 1st Congress International Society of Rock Mechanics, Lisbon, Portugal, v. 2, 1966, p. 363-373.

In this analysis, the rock is considered to be elastic and homogenous in each stratum, although the physical properties of each bed may vary. The method adopted employs a plain strain discrete model for which the finite-difference equations of equilibrium and boundary conditions are formulated. Two illustrative models, in the case of bedded rock, are included.

Keyword(s): boundary element, finite element, prediction, modeling, rock mechanics

Ward, T. The Subsidences in and Around the Town of Northwich in Cheshire. Transactions, Institute of Mining Engineers, London, v. 19, 1900, p. 241-264.

Keyword(s): surface subsidence damage, historical

Location(s): England

Wardell, K. A Comparison Between British and German Experience of Mining Subsidence. Transactions, Institute Mining Surveyors, v. 30, 1950, p. 51-70.

Keyword(s): England, Germany

Wardell, K. The Surveying Observations Required for the Determination of Ground Movements Caused by Mining. Transactions, Institute of Mining Surveyors, 1952, v. 32, no. 12.

Keyword(s): survey methods, survey design

Wardell, K. Some Observations on the Relationship Between Time and Mining Subsidence. Transactions, Institute Mining Engineers, London, v. 113, 1953-54, p. 471-483, 799.

This paper discusses the importance of the time factor in the study of mining subsidence and its influence on the movements accompanying an advancing face, as well as the limitations of existing methods of analysis.

Keyword(s): vertical displacement, time factor, prediction

Wardell, K. Mining Subsidence. Transactions, Royal Institute Chartered Surveyors, v. 86, no. 8, 1954, p. 53-70.
Location(s): England

Wardell, K. The Minimisation of Surface Damage by Special Arrangement of Underground Workings. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 13-20.

This paper contains a basic explanation of harmonic mining methods designed to negate the effects of surface strains, thereby minimizing surface damage. These stepped face methods of subsidence control are shown to be most applicable to depths of less than 400 to 500 meters. The author also analyzes ground movements that result from an advancing face.

Keyword(s): mine design, ground control
Location(s): Europe

Wardell, K., N. E. Webster. Some Surface Observations and Their Relationship to Movement Underground. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 141-148.

The concept of maximum surface subsidence is discussed as related to the area of influence, critical width, depth, and treatment of the goaf. Strain distribution is discussed in reference to its position within the subsidence trough and the effect of partial workings adjacent to a previously mined area. The authors close with a discussion of surface subsidence and underground convergence in relation to time and rate of advance of the extraction face.

Keyword(s): partial extraction, multiple-seam extraction, time factor, mine operation, angle of draw, mine waste, mine design

Wardell, K., N. E. Webster. Surface Observations and Strata Movement Underground. Colliery Engineering, v. 34, 1957, p. 329-336.

Keyword(s): subsurface subsidence damage, overburden, surface subsidence damage

Wardell, K. The Minimisation of Surface Damage. Colliery Engineering, v. 34, no. 403, September, 1957, p. 361-367.

Although numerous attempts have been made in Great Britain to minimize damage to surface structures by adopting a specially planned layout of underground workings, little has been published about the results of such experiments.

Keyword(s): surface subsidence damage, land mitigation, mine design, multiple-seam extraction, surface structural damage
Location(s): England

Wardell, K. The Problems of Analysing and Interpreting Observed Ground Movement. IN: Proceedings, International Strata Control Congress, Leipzig, October 14-16, 1958, p. 206-221 and XCI-XCVIII.

It is now generally accepted that the practical problems of surface support and surface damage, which arise as the result of ground movement caused by underground mining, can only be solved if a reasonable forecast can be made of the ground movements to be expected in any particular case. Many detailed observations of surface ground movements have been made by mining surveyors, and analysis of these data has enabled the general pattern of surface ground movement to be defined. Many investigators have, however, also attempted to rationalize the results of observations and to devise methods of precalculating ground movement that have a wide if not universal validity.

Keyword(s): coal mining, surface subsidence damage, prediction, horizontal displacement, vertical displacement, multiple-seam extraction
Location(s): United Kingdom

Wardell, K. The Protection of Structures Against Subsidence. Chartered Surveyor, v. 90, no. 10, April, 1958, p. 573-579.

The author emphasizes the main principles of the ground deformation process, mining precautions, and structural design considerations that pertain directly to the protection of surface structures.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, mine design, ground control, construction

Wardell, K. The Problems of Analyzing and Interpreting Observed Ground Movement. Colliery Engineering, v. 36, December, 1959, p. 529-540.

Keyword(s): ground control, descriptive theories

Wardell, K. Surface Ground Movements Associated with the Total and Partial Extraction of Stratified Mineral Deposits. M.S. Thesis, University of Nottingham, England, 1965, 167 p.

Keyword(s): partial extraction, longwall, mine design, surface subsidence damage
Location(s): United Kingdom

Wardell, K. Problems Posed by Past and Future Mineral Workings in a Development Area. The Chartered Surveyor, Mineral Workings, October 1966, p. 184-188.
Keyword(s): land-use planning, active mines, abandoned mines

Wardell, K., J. C. Wood. Ground Instability Problems Arising from the Presence of Old, Shallow Mine Workings. IN: Proceedings, Midlands Soil Mechanics & Foundations Engineering Society, v. 7, Paper No. 36, 1966, p. 5-30.
This paper discusses site investigation and development in undermined areas.
Keyword(s): abandoned mines, room-and-pillar, pillar strength, backfilling, roof stability

Wardell, K. Design of Partial Extraction Systems in Mining. IN: Proceedings, 4th Annual Canadian Rock Mechanics Symposium, Ottawa, March 29-30, 1967, Department Energy, Mines, and Resources, Ottawa, Canada, p. 271-296.
This paper presents an overview of partial-extraction mining methods and the various parameters involved with each method. Also, the mechanics of panel-and-pillar and room-and-pillar extraction are discussed.
Keyword(s): mine design, partial extraction, room-and-pillar, rock mechanics

Wardell, K. Report of Joint Meeting with Institution of Mining Engineers. Structural Concept of Strata Control and Mine Design. Transactions, Institute Mining & Metallurgy, London, v. 77, no. 743, Sec. A, October, 1968, p. A125-138; also The Mining Engineer, v. 127, no. 95, August 1968, p. 633-651.
Rock mechanics principles are related to problems in ground control and mine design.
Keyword(s): ground control, mine design, rock mechanics
Location(s): England

Wardell, K., R. J. Piggott. Report on Mining Subsidence. Selection of technical reports submitted to the Aberfan Tribunal, London, 1969.
These reports describe the conditions and effects of subsurface mining on coal waste banks involved in the Aberfan mining disaster.
Keyword(s): mine waste, surface subsidence damage
Location(s): England

Wardell, K. Ground Subsidence and Control. Mining Congress Journal, v. 55, no. 1, January, 1969, p. 36-42.
The author evaluates the mechanics of subsidence and explains how the panel-and-pillar mining system can be used to minimize ground deformations. An explanation of ground deformation parameters along with mathematical formulas used for subsidence prediction are included. The author also discusses the effects of subsidence on surface structures, and a general explanation of leveling procedures used for monitoring subsidence.
Keyword(s): vertical displacement, horizontal displacement, mine design, survey methods, mathematical model, modeling, prediction, monitoring methods, surface structural damage, ground control

Wardell, K. The Effects of Mineral and Other Underground Excavation on the Overlying Ground Surface. IN: Proceedings, Symposium on Geological and Geographical Problems of Areas of High Population Density, Washington, D.C., 1970, Association of Engineering Geologists, 1971, p. 20-217.
This paper details empirical studies concerning dimensional parameters of underground excavations and their influence on the surface. The author refers to the factor of geologic condition and discusses several theoretical models.
Keyword(s): modeling, prediction, surface subsidence damage

Wardell, K. and Partners. Guidelines for Mining Under Surface Water. Phase II and Final Report. Contract H0252021, U.S. Bureau of Mines OFR 30-77, 1977, 67 p. (NTIS PB 264 729)
Keyword(s): mine operation, surface water, mine design
Location(s): United States

Wardle, L. J., K. E. McNabb. Comparison Between Predicted and Measured Stresses in an Underground Coal Mine. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 531-538.
Rational design of complicated layouts such

as those encountered in longwall mining is only possible by use of an accurate and economical method for predicting stresses and displacements. A novel three-dimensional numerical stress analysis method is validated by comparison with results from stressmeters monitored during panel extraction. The study shows that by choosing appropriate anisotropic rock properties, predictions of vertical stresses and surface displacements are close to observed values.

Keyword(s): prediction, modeling, instrumentation, rock mechanics, longwall, coal mining

Location(s): Australia

Wardle, L. J., K. E. McNabb. Stress Monitoring During Wongawilli Extraction in 3 North Panel, Laleham No. 1, Colliery, South Blackwater, Queensland. Commonwealth Scientific and Industrial Research Organization, Mount Waverly, Australia. Division of Applied Geomechanics, May, 1985, REPT-59, ISBN-0-643-03570-2, 40 p. (NTIS PB85-232429/WNR)

The report describes investigations at the Laleham No. 1 Colliery, South Blackwater, Queensland, involving monitoring of stresses and convergences during Wongawilli (rib pillar) extraction in 3 North Panel. The project involved the installation of 16 vibrating wire stressmeters and 10 telescopic convergence rods. The aim of the project was to monitor changes in the stress distribution during extraction.

Keyword(s): instrumentation, monitoring equipment, monitoring installation, monitoring methods, pillar extraction, coal mining

Location(s): Australia

Wardle, L. J., K. E. McNabb. Stress Monitoring During Wongawilli Extraction in 3 North Panel, Laleham No. 1 Colliery, South Blackwater, Queensland. Queensland Government Mining Journal, November, 1985, p. 454-461.

This report describes investigations at the Laleham No. 1 Colliery, South Blackwater, Queensland, involving monitoring of stresses and convergences during Wongawilli (rib pillar) extraction in 3 North Panel. The project involved the installation of 16 vibrating wire stressmeters and 10 telescopic convergence rods. The instruments were installed in the fenders (rib pillars), roadway pillars, and the solid coal surrounding the panel. Instrumentation proved to be reliable and was monitored over a 6-month period. Results indicate that the major redistribution of stress occurs when a fender is isolated from the main extraction block by the drivage of a split. As the split face advances, isolating the fender, the load from the split/fender area is transferred to the main extraction block. The isolated section of the fender undergoes a constant rate of stress relaxation independent of subsequent mining. The fender is in a stress relieved state when extracted.

Keyword(s): instrumentation, monitoring methods, monitoring equipment, monitoring design, pillar strength, coal mining, mine design, pillar extraction

Location(s): Australia

Warren, J. P., L. L. Jones, W. L. Griffin. Costs of Land Subsidence Due to Ground Water Withdrawal. Texas Water Resource Institute, Texas A & M University, Technical Report 57, 1974, 79 p.

Keyword(s): fluid extraction, economics

Location(s): Texas, United States

Watkins, R. K. Structural Design in Buried Flexible Conduits. IN: Proceedings, Symposium on Soil-Structure Interaction, University of Arizona, Tucson, 1964, p. 246-255.

Keyword(s): utilities, pipelines, subsurface subsidence damage, engineering, soil mechanics

Location(s): United States

Watson, L. H. Economics of Support for Surface Properties. Chartered Surveyor, v. 92, February, 1960, p. 376-385.

Keyword(s): surface structural damage, economics

Watters, R. J., D. Finn, J. Coulthard. Pit Slope Instability Problems Induced by Disused Underground Mine Workings. IN: Engineering Geology and Geotechnical Engineering, Proceedings of the 25th Symposium, Reno, NV, March 20-22, 1989, R.J. Watters, ed., Balkema, Rotterdam, p. 101-106.

Pit slope instability occurred due to the adverse effects of old underground mine workings being intersected by slope excavations. Investigations are presently underway to develop a mitigation which will minimize or control their effects. These investigations involve both field and laboratory studies, slope stability analyses, analytical and physical modeling.

Keyword(s): abandoned mines, land mitigation, geologic features

Location(s): United States

Wayment, W. R., D. E. Nicholson. A Proposed Modified Percolation Rate Test for Use in Physical Property Testing of Mine Backfill. U.S. Bureau of Mines RI 6562, 1964, 24 p.
Keyword(s): hydraulic backfilling
Location(s): United States

Wayment, W. R., D. E. Nicholson. Improving Effectiveness of Backfill. Mining Congress Journal, v. 31, no. 3, August, 1965, p. 28-32.
This paper discusses water percolation rate, cement, and vibratory compaction, which are critical in improving backfill.
Keyword(s): hydraulic backfilling

Weaver, P., M. M. Sheets. Active Faults, Subsidence, and Foundation Problems in the Houston, Texas, Area, Field Excursion No. 5. Geology of the Gulf Coast and Central Texas and Guidebook of Excursions, Geological Society of America Annual Meeting, Houston, TX, 1962, p. 254-265.
Keyword(s): fluid extraction
Location(s): Texas, United States

Webb, B. A Study of Longwall Subsidence in the Appalachian Coalfield. M.S. Thesis, Virginia Polytechnic Institute & State University, 1982, 191 p.
Keyword(s): longwall, coal mining
Location(s): Appalachian Coal Region, United States

Weber, G. E., S. M. Raas. Geotechnical Problems Associated with Siting Large Structures Over Solution Collapse Features in Karst Terrain, East Sports Facility, University of California, Santa Cruz, California. IN: Engineering Geology and Geotechnical Engineering, Proceedings of the 25th Symposium, Reno, NV, March 20-22, 1989, R.J. Watters, ed., Balkema, Rotterdam, p. 259-265.
Construction of the East Sports Facility at the University of California, Santa Cruz, required the pool and associated building be constructed over a solution-collapse doline formed in limestone marble. Geologic and engineering investigations were conducted to determine the size and depth of the collapse doline and the potential for development of new voids below the proposed pool and building.
Keyword(s): geologic features, land-use planning, soils, geotechnical, engineering
Location(s): California, United States

Webster, N. E. Strata Control and the Influence on Underground and Surface Damage. Transactions, Institute of Mining Engineers, 1951, v. 3, Pt. 7, p. 445-475.
This paper discusses the need for maximum coal extraction combined with protection of the surface; control of subsidence effects would increase with better determination of subsidence parameters.
Keyword(s): ground control, surface subsidence damage, subsurface subsidence damage, coal mining

Weir, A. M. An Appraisal of Subsidence Observation. Colliery Guardian, v. 209, October 16, 1964, p. 513-518.
This article evaluates the design and construction of a subsidence monitoring network, and discusses methods for observation and data interpretation. It includes a discussion of monument type and effects to be observed for different purposes, such as studies of building damage, horizontal movement, vertical movements, permanent strain and traveling strain. Also, a mathematical solution for the principal strains of a biaxial system is reviewed.
Keyword(s): monitoring design, monitoring installation, monitoring equipment, monitoring methods, survey data processing, survey methods, modeling, mathematical model, surface structural damage, vertical displacement, horizontal displacement

Weir, A. M. Subsidence--The Interpretation of Traveling Strain Observations. Colliery Guardian, v. 212, May 6, 1966, p. 576-577.
The author proposes a formula stating that observed traveling strain is a function of distance between survey stations and rate of face advance.
Keyword(s): survey methods, survey equipment, survey data processing, survey design, active mines

Weir, A. M. The Prediction of Surface Subsidence with Particular Reference to Inclined Seams. Master of Philosophy Thesis, University of Nottingham, England, 1977.
Keyword(s): prediction

Weir, W. W. Subsidence of Peat Lands of the Sacramento San Joaquin Delta, California. Hilgardia, v. 20, no. 3, 1950, p. 37-56.
Keyword(s): soils
Location(s): California, United States

Weiss, I. G. Multivariate Analysis of Levelling Networks in Subsidence Areas. IN: Proceedings VIII Congress International Society for Mine Surveying, September 22-27, 1991, University of Kentucky, Lexington, UKY BU154, p. 283-285.

The height estimates of the points of the net that are needed to control the vertical movements of a subsidence area can be advantageously obtained in a multivariate model from repeated leveling in a monitoring network. In the model, a transformed multivariate hypothesis is proposed and tested successively for each point in each of two compared epochs to detect the significant height displacements at points after single epochs and after the whole campaign of observations as well.

Keyword(s): active mines, monitoring methods, modeling, vertical displacement

Location(s): Czechoslovakia

Wenzel, R. J., W. F. Eichfeld. Premining Subsidence Control Planning. IN: Proceedings, Conference on Ground Control in Room-and-Pillar Mining, Southern Illinois University, Carbondale, August 6-8, 1980, Y.P. Chugh, ed., SME-AIME, New York, 1982, p. 17-19.

The phrase "subsidence control planning" can refer to the use of specific mining methods and specialized techniques to control subsidence events or it can refer to planning for subsidence by predicting its magnitude and timing and further planning mitigation strategies. In the first case the objective is actually subsidence prevention; in the second, it is a design procedure that seeks to maximize the use of both surface and subsurface resources.

Keyword(s): ground control, land mitigation, subsidence research, coal mining, environment, engineering, subsurface water, agriculture, surface structural damage, monitoring methods, overburden, hydrology, government

Location(s): Illinois, Illinois Coal Basin, United States

Werner, E., J. C. Hempel. Effects of Coal Mine Subsidence on Shallow Ridge-Top Aquifers in Northern West Virginia. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 237-243.

The effects on aquifers by mining-induced subsidence varies significantly depending on the position of the aquifer with respect to the hydrologic base level. Aquifers above base level, generally called perched aquifers, are very sensitive to disruption by enlargement of fractures within underlying low-permeability beds because of the steep hydraulic gradients developed in these supporting beds. The effects are most intense when aquifer rocks are all of low matrix permeability and principal hydraulic transmission is through fractures. Most affected are regions near pre-existing fractures zones. The effects on these higher aquifers caused by mine subsidence are substantially different from the effects on the base level aquifers, and different principles apply.

Keyword(s): hydrology, subsurface water, surface water, coal mining, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

West, T. R., R. B. Jackson, D. Johnson. Stabilization of Underground Coal Mines Prior to Interstate Highway Construction, Birmingham, Alabama. IN: Engineering Geology and the Natural Resources Energy Spectrum, Association of Engineering Geologists Annual Meeting Program Abstracts, no. 17, 1974, p. 37-38. (NTIS Accession No. 75-06917)

Keyword(s): roads, coal mining, surface structural damage, engineering, abandoned mines

Location(s): Alabama, United States

West Virginia Department of Natural Resources. West Virginia Surface Mining Reclamation Regulations. Ch. 20-26, Sec. 7, 1982, p. 7-19 - 7-21.

Paragraph 7C provides details on the subsidence-related responsibilities of the mine operator in West Virginia.

Keyword(s): law, mine operation

Location(s): West Virginia, Appalachian Coal Region, United States

Westfield, J. Mining Subsidence and Backfilling. U.S. Bureau of Mines RI 4109, Flood Prevention Project at Pennsylvania Anthracite Mines, Progress Report for 1945 (Paper V), 1947, p. 42-50.

Keyword(s): backfilling, anthracite, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Weston, J. G. The Determination of Subsidence Profiles by Mathematical Functions. The Mining Engineer, London, v. 137, April 1978, p. 493-500.

This paper examines the similarity between the hyperbolic tangent function and a longwall subsidence profile; it describes the application of this function to single panel and multipanel partial-

extraction systems. A zone area system based on the use of the function and a computer method of subsidence prediction based on the National Coal Board Subsidence Engineers' Handbook is also described.

Keyword(s): vertical displacement, horizontal displacement, National Coal Board, prediction, mathematical model, longwall, partial extraction, computer, zone area, coal mining, modeling

Location(s): United Kingdom

Whaitte, R. H., A. S. Allen. Pumped-Slurry Backfilling of Inaccessible Mine Workings for Subsidence Control. U.S. Bureau of Mines IC 8667, 1975, 83 p.

This report summarizes the results obtained in a study of a hydraulic backfilling technique. Fill material was pumped as a slurry through a closed system and widely distributed in inaccessible mine workings from a single borehole.

Keyword(s): hydraulic backfilling, abandoned mines, ground control

Location(s): United States

Whetton, J. T., K. N. Sinha. Gob Stowage. Colliery Engineering, 1943, v. 25, no. 292, p. 188-193; no. 293, p. 225-242; no. 294, p. 255-276.

The authors describe hydraulic, pneumatic, and mechanical stowing methods, and list examples of their effectiveness.

Keyword(s): hydraulic backfilling, pneumatic backfilling

Whetton, J. T., K. N. Sinha. Gob Stowage at Michael Colliery. Colliery Engineering, v. 25, no. 295, September, 1948, p. 291.

Keyword(s): mine waste, stowing

Whetton, J. T., K. N. Sinha. Mechanical Methods of Gob Stowing. Colliery Engineering, v. 26, no. 299, January, 1949, p. 4.

Keyword(s): stowing, mine waste

Whetton, J. T., K. N. Sinha. Mechanical Stowing on the Continent. Colliery Engineering, v. 26, no. 307, September, 1949.

Keyword(s): stowing

Location(s): Europe

Whetton, J. T., K. N. Sinha. Power Stowing of the Goaf: Scientific Tests and Investigations. Transactions, Institute Mining Engineers, v. 109, 1949, p. 534.

Keyword(s): stowing, mine waste

Whetton, J. T., P. H. Broadhurst. Plasticity Tests on Materials Used for Pneumatic Stowing in the Goaf. Transactions, Institute of Mining Engineers, v. 111, 1952, p. 906, and v. 112, 1952, p. 351.

Keyword(s): pneumatic backfilling, stowing

Whetton, J. T., H. J. King, M. B. Jones. The Field Measurement of Subsidence and Strain. IN: Proceedings, the European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 99-105.

The authors discuss problems associated with measuring horizontal strains above extraction areas. Measurements along single lines not parallel or perpendicular to the extraction face are considered to be of little use because the actual magnitude of strain is not detected. As an alternative, two parallel lines are used and strains are resolved from triangular measurements along and between lines, so that a strain contour grid is produced. An accuracy of one part in 10,000 is considered necessary to accurately define strain distribution.

Keyword(s): survey design, instrumentation, horizontal displacement, survey methods

Whetton, J. T. A General Survey of the Ground Movement Problem. Colliery Engineering, v. 34, no. 398, April, 1957, p. 153-157.

In Great Britain, a Royal Commission was appointed in June, 1923, to report on the consequences of mining subsidence from a number of different aspects. Part 2 of the Minutes of Evidence was concerned among other things, with what was called the "basic laws of subsidence." Today most of that evidence would be very strongly contested. It is very noticeable in these Minutes of Evidence that there was no mention of lateral displacements and the derivative of surface displacement, namely the straining of the surface.

Keyword(s): angle of draw, time factor, abandoned mines, active mines, longwall, prediction, multiple-seam extraction, stowing, vertical displacement, horizontal displacement

Location(s): United Kingdom

Whetton, J. T., H. J. King. Aspects of Subsidence and Related Problems. Transactions, Institute of Mining Engineers, London, v. 118, 1958-59, p. 663-676.

An account is given of the general practice underlying an attempt to simulate the strata movement by model apparatus. Some of the results obtained from the model are presented and implications are discussed. In a two-dimensional investigation, the model indicates that, with low ratios of width and extraction to depth, the maximum amplitude of convergence grows much more rapidly with increasing width than it does with increasing depth.

Keyword(s): modeling

Whetton, J. T., H. J. King. The Time Factor in Mining Subsidence. IN: Proceedings, International Symposium on Mining Research, Rolla, MO, February, 1961, G.B. Clark, ed., Pergamon Press, v. 2, 1962, p. 521-539.

This paper discusses theories of time lags in subsidence development and presents data from field observations in Great Britain. Subsidence development curves are plotted and are similar for different cases. The author mentions the possibility of delayed violent and sudden collapse in cases of partial extraction systems.

Keyword(s): vertical displacement, horizontal displacement, time factor, partial extraction, coal mining

Location(s): England

White, H. Accurate Delineation of Shallow Subsurface Structure Using Ground Penetrating Radar. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 23-26.

Ground-penetrating radar uses pulsed electromagnetic waves to accurately map the subsurface. Pulses are radiated from an antenna into the subsurface. These pulses propagate through the subsurface and are reflected back from electromagnetic interfaces. The depth to the interface can be calculated by measuring the two-way travel-time of the reflected pulses. Data are presented with the emphasis on three particular applications: (1) karst environments, (2) delineation of shallow subsurface bedrock fracturing as a consequence of shallow underground mining, and (3) mapping of old-mine workings from surface on the Witwatersrand.

Keyword(s): geophysical, geologic features , abandoned mines, geotechnical

Location(s): South Africa

White, W. A. Properties of Clay as Related to Coal Mining Problems. IN: Proceedings Illinois Mining Institute, 1954.

Keyword(s): floor stability, mine operation, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

White, W. A. Underclay Squeezes in Coal Mines. Mining Engineering, v. 8, no. 10, October 1956, p. 1024-1028; also Illinois State Geological Survey Reprint 1956-R, 1956; also Transactions, AIME, v. 205, 1956.

This is a preliminary report on the mechanism of squeezes in a "dry" mine without the action of additional moisture. The likelihood of underclay squeezes based on the physical and mineral content of the clay materials is discussed.

Keyword(s): floor stability, in situ testing, lab testing, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Whitelock, G. C. H. Subsidence Due to Coal Mining. Transactions, Institute of Mine Surveyors, 1920.

Keyword(s): coal mining

Whitfield, L. M. Ground Movements from Coal Extraction in the Vicinity of Dams and Storages in New South Wales, Australia. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 298-313.

The New South Wales Dams Safety Committee was established as a statutory authority in 1979 to maintain a surveillance of all dams in the state above a certain size and storage capacity and to ensure their continuing safety. The Committee also makes recommendations on proposals for coal-mining operations in the vicinity of such dam structures and storages, specifying the conditions under which such mining may be carried out.

Keyword(s): surface water, coal mining, active mines, surface subsidence damage, land-use planning, multiple-seam extraction, longwall

Location(s): Australia

Whitfield, L. M. Monitoring and Investigation of Water Inflow Into a Coal Mine in New South Wales, Australia. IN: Groundwater in Engineering Geology, Proceedings 21st Annual Conference of the Engineering Group of the Geological Society, September 15-19, 1985, J.C. Cripps, et al., eds., University of Sheffield, the Geological Society Engineering Geology Special Publication No. 3, 1986, London, p. 115-126.

The Dams Safety Committee is responsible for ensuring the safety and integrity of all substantial dams and storages in New South Wales. Coal mining is currently taking place beneath the Sydney

Water Board catchment where a system of five reservoirs constitute part of the urban water supply for the cities of Sydney and Wollongong. Pillar extraction of the Wongawilli seam adjacent to Avon storage resulted in an unexpected inflow of water into the mine workings. Algal analysis indicated that a proportion of this inflow may have originated from a surface source. The paper outlines the events that occurred, the monitoring initiated, and the results of the investigations.

Keyword(s): coal mining, surface water, subsurface water, hydrology, pillar extraction, surface structural damage, room-and-pillar, inflow

Location(s): Australia

Whittaker, B. N., D. R. Hodgkinson. Design and Layout of Longwall Workings. The Mining Engineer, London, no. 134, November, 1971, p. 79-96.

The principles of strata control are reviewed with special reference to the control of underground conditions. Investigations of underground studies of working layout and its effect on interaction with other workings are described. Roadway design and subsequent deformations have been examined under a variety of conditions with special reference to deriving guidelines to assist in prediction of roadway convergence and assessing support performance. Leaving rib pillars between successive longwall faces as opposed to total extraction is discussed and examples are used to highlight the respective advantages and disadvantages. Interaction between workings in the same seam and in other seams above and below the current working horizon is examined in detail and several examples given together with a discussion on how to minimize such effects both in existing and future working layouts.

Keyword(s): mine design, longwall, multiple-seam extraction, coal mining

Location(s): United Kingdom

Whittaker, B. N. Strata Control Developments on the European Continent. The Mining Engineer, London, v. 132, no. 153, June, 1973, p. 435, 443.

Keyword(s): ground control

Location(s): Europe

Whittaker, B. N. An Appraisal of Strata Control Practices. Mining Engineering, v. 166, 1974, p. 9-24.

Keyword(s): mine design, longwall, ground control, mine waste, mine operation

Whittaker, B. N., D. J. Forrester. Measurement of Ground Strain and Tilt Arising from Mining Subsidence. IN: Proceedings, Symposium on Field Instrumentation in Geotechnical Engineering, London, May 30-June 1, 1973, Halsted Press, 1974, p. 437-447.

Mining subsidence is the mass lowering of a body of strata overlying mine workings whose extracted area is sufficiently great as to permit collapse of immediately overlying strata and subsequent propagation of the movement to the surface. In the United Kingdom, the ratio of extraction width-depth for mine workings needs to be greater than 1/10 before a discernible depression is formed at the surface.

Keyword(s): monitoring design, monitoring methods, survey methods, instrumentation, survey design, geotechnical, geologic features, overburden

Location(s): United Kingdom

Whittaker, B. N., J. H. Pye. Design and Layout Aspects of Longwall Methods of Coal Mining. IN: Design Methods in Rock Mechanics, Proceedings 16th Symposium on Rock Mechanics, University of Minnesota, Minneapolis, September 22-24, 1975, C. Fairhurst and S.L. Crouch, eds., ASCE, New York, 1977, p. 303-314.

The factors influencing the layout of longwall coal mining workings are examined on the basis of experience gained in European coalfields. An account is given of the main design aspects that need consideration when a longwall layout is planned. A selection procedure for panel layout is described. The strata mechanics of underground mining associated with the longwall method are discussed with special reference to effective strata control.

Keyword(s): mine design, longwall, ground control, coal mining, overburden

Location(s): Europe

Whittaker, B. N., C. D. Breeds. The Influence of Surface Geology on the Character of Mining Subsidence. IN: Proceedings of International Symposium on the Geotechnics of Structurally Complex Formations, Capri, Italy, 1977, Association Geotechnica Italy, Milan, v. 1, p. 459-468.

This paper describes the principles of mining subsidence associated with the working of predominantly level coal seams.

Keyword(s): surface structural damage, subsurface structural damage, geologic features, coal mining, geotechnical

Location(s): England

Whittaker, B. N., J. H. Pye. Ground Movements Associated With the Nearsurface Construction Operations of a Mine Drift in Coal Measures Strata. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 14, no. 2, March, 1977, p. 67-75.

Keyword(s): overburden, rock mechanics, subsurface subsidence damage, coal mining

Whittaker, B. N., H. I. Hazine. Simulation of Surface Subsidence Due to Longwall Mining. IN: Proceedings, 19th U.S. Rock Mechanics Symposium, Stateline, NV, May 1-3, 1978, Mackay School of Mines, Reno, p. 221-228.

This paper reviews coal-mining subsidence knowledge and related problems due to longwall extraction in England, with consideration given to findings based on modeling of surface subsidence by a finite element method. The authors present and discuss the results of isotropic and anisotropic solutions. The treatment of surface strain is discussed and the validity of deriving strain from ground curvature examined. The paper concludes with the authors' findings on the modeling of surface subsidence using a finite element method, and examples are given of its application to current mining subsidence problems in the United Kingdom.

Keyword(s): vertical displacement, horizontal displacement, longwall, prediction, modeling, finite element, coal mining

Location(s): United Kingdom

Whittaker, B. N., R. N. Singh. Design and Stability of Pillars in Longwall Mining. The Mining Engineer, July 1979, p. 59-70.

This paper briefly reviews the circumstances of the use of rib pillars in longwall mining and considers the ultimate strength approach to pillar design for use in longwall layouts. Both average pillar stress and peak stresses are examined. Attention is focused on the influence of rib pillars on gate roadway stability and the scope for reducing rib pillars is discussed. Special comments are made on the rib pillar versus no rib pillar argument for longwall layout planning. Gate roadway stability in relation to various rib pillar conditions is examined. The paper presents several field observations and discusses pillar stability with reference to subsidence and mine barrier requirements.

Keyword(s): mine design, pillar strength, coal mining, longwall

Location(s): United Kingdom

Whittaker, B. N. Investigation and Evaluation Studies of Surface and Subsurface Drainage Pattern Changes Resulting from Longwall Mining Subsidence. Presented at 1st International Mine Drainage Symposium, Denver, CO, May 20-23, 1979, 25 p.; available upon request from A.J. Fejes, U.S. Bureau of Mines, Denver, CO.

This paper gives a general review of subsidence characteristics associated with longwall mining; it describes test instruments designed to investigate the zones of increased permeability resulting from longwall extraction.

Keyword(s): surface water, subsurface water, survey equipment, longwall, hydrology

Whittaker, B. N., R. N. Singh, C. J. Neate. Effect of Longwall Mining on Ground Permeability and Subsurface Drainage. IN: Proceedings, 1st International Mine Drainage Symposium, Denver, CO, 1979, G.O. Argall and C.O. Brawner, eds., p. 161-183.

Keyword(s): longwall, hydrology, subsurface water, coal mining

Whittaker, B. N., A. G. Pasamehmetoglu. Ground Tilt in Relation to Subsidence in Longwall Mining. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 18, no. 14, August, 1981, p. 321-329.

Observations of ground tilt arising from longwall mining subsidence were made using a direct method involving trials with an electrolevel. The results are compared to tilt derived by precise levelling and by a current prediction method. The electrolevel proved to be highly successful in investigating ground tilt changes and enabled variations not hitherto appreciated to be examined. Subsidence and angle of draw were investigated, and the electrolevel was used to determine when a significant change in ground tilt condition occurred owing to the approach of mining subsidence effects towards surface structures.

Keyword(s): longwall, rock mechanics, horizontal displacement, angle of draw, surface structural damage, monitoring methods, survey methods, coal mining, vertical displacement

Location(s): United Kingdom

Whittaker, B. N., D. J. Reddish. Mining Subsidence in Longwall Mining with Special Reference to the Prediction of Surface Strains. IN: Proceedings, 2nd International Conference on Stability in Underground Mining,1984, A.B. Szwilski and C.O. Brawner, eds., SME-AIME, New York, p. 576-588.

Keyword(s): longwall, coal mining, prediction, horizontal displacement

Whittaker, B. N., D. J. Reddish, D. J. Fitzpatrick. Ground Fractures Due to Longwall Mining Subsidence. IN: Mine Water, Proceedings 2nd International Congress, Granada, Spain, September 1985, R. Fernandez-Rubio, ed., v. 2, p. 1057-1072.

This paper discusses experimental results of a large model employed to study fracture development in the ground overlying longwall mining operations. The model uses gravity loading only as the means of developing caving and fracturing of the ground above the longwall excavation. The results show fracture development and caving propagation as a longwall face develops from its starting point. The effect of rock strength in the immediately overlying roof is discussed in relation to subsidence development. Special attention is focused on subsidence development to aquifer horizons. The thickness of cover between the mine horizon and overlying bodies of surface water (e.g., rivers and the sea) is considered in relation to underground excavations. The paper concludes with a general discussion on guidelines for undermining aquifers and surface water bodies with special reference to longwall operations.

Keyword(s): subsurface water, surface water, hydrology, longwall, overburden, geologic features, modeling, vertical displacement, inflow

Location(s): United Kingdom

Whittaker, B. N. Surface Subsidence Aspects of Room and Pillar Mining. Mining Department Magazine, University of Nottingham, v. 37, 1985, p. 59-70.

This paper reviews the forms of subsidence behaviour observed with room-and-pillar mining of stratified mineral deposits. The factors governing surface subsidence behaviour are examined and design procedures are discussed. The long-term aspects of subsidence occurring above such mine workings are discussed as are instrumentation and remedial measures available to assist in monitoring and controlling subsidence development.

Keyword(s): room-and-pillar, surface subsidence damage, coal mining, geologic features, pillar strength

Location(s): United Kingdom

Whittaker, B. N., D. J. Reddish, D. Fitzpatrick. Calculation by Computer Program of Mining Subsidence Ground Strain Patterns Due to Multiple Longwall Extractions. Mining Science and Technology, v. 3, 1985, p. 21-33.

The general character of surface ground strains under conditions in the United Kingdom is discussed with particular reference to calculation of principal strains at the surface for multiple-seam longwall extractions. The program uses data from the National Coal Board Subsidence Engineers' Handbook as the basis for its calculations. The principle of superposition is then applied to extend single-panel data into multi-panel data. Examples of the graphical capability of the program and of possible applications are included in the discussion.

Keyword(s): computer, longwall, prediction, National Coal Board

Location(s): United Kingdom

Whittaker, B. N., S. F. Smith. Stability and Operational Aspects of Room and Pillar Mining in UK Sedimentary Ironore Deposits. IN: Underground Mining Methods and Technology, A.B. Szwilski and M.J. Richards, eds., 1987, Elsevier, p. 393-402.

Keyword(s): room-and-pillar, metal mining, active mines

Location(s): United Kingdom

Whittaker, B. N., R. C. Frith. Aspects of Chain Pillar Design in Relation to Longwall Mining. IN: Proceedings, 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., West Virginia University, Morgantown, p. 172-182.

The paper examines the role of chain pillars in longwall mining layouts as used in several countries. The application of chain pillars in relation to their expected design role is discussed. An important feature is the specification of the pillar design to meet strata loading conditions as imposed by the mining and geological setting. The paper relates longwall width and chain pillar configurations to pillar size to satisfy anticipated loading and strength expectations. Reference is made to laboratory work that examines criteria for pillar stability.

Keyword(s): pillar strength, mine design, longwall, coal mining

Location(s): Europe, United States, South Africa, Australia, United Kingdom

Whittaker, B. N., R. C. Frith. Design of Support Systems for Mining Tunnels in Carboniferous Rock Conditions. IN: Proceedings, 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., West Virginia University, Morgantown, p. 258-270.

The paper briefly reviews the type of support and stability problems encountered in mining tunnels in the United Kingdom. Stability prediction of mining tunnels is discussed and a computer-based model dealing with stratified rock conditions is described. Various schemes for monitoring the stability of mining tunnels are examined and the application of the results discussed. Comparisons between predicted and measured closure values are presented for a major coal-mining tunnelling project. Conclusions are drawn concerning the application of the present prediction technique together with the importance of underground monitoring.

Keyword(s): tunnelling, coal mining, computer, modeling, geologic features, prediction, roof stability, floor stability, rock mechanics, instrumentation, ground control

Location(s): United Kingdom

Whittaker, B. N., D. J. Reddish. Subsidence Occurrence, Prediction and Control. Developments in Geotechnical Engineering 56, Elsevier Science Publishers, Amsterdam, 1989, 528 p.

Surface subsidence is recognized as a problem in most countries, particularly those with significant mining and other underground resource extraction industries. This book addresses the problems relating to subsidence, whether caused naturally or by mining or other forms of underground extractive activity. Its main purpose is to bring together subsidence knowledge, experiences, and research findings in many countries and rationalize such information especially in respect to its particular field of application. Emphasis has been given to collating field data on subsidence from different countries in order to make direct comparisons. Prediction of subsidence, particularly its occurrence and general characteristics has been seen as an important area where the book can contribute significantly in terms of reviewing available knowledge, methods, scope of application, and orders of accuracy achieved. The book also examines methods of controlling subsidence and discusses the response of surface structures to and protection against subsidence.

Keyword(s): geologic features, non-metal mining, historical, prediction, longwall, engineering, prediction theories, profile function, empirical model, influence function, modeling, phenomenological model, coal mining, computer, horizontal displacement, vertical displacement, multiple-seam extraction, tunnelling, room-and-pillar, longwall, subsurface water, time factor, angle of draw, fluid extraction, oil extraction, abandoned mines, active mines, metal mining, surface structural damage, backfilling, mine waste, overburden, finite element, zone area

Location(s): United Kingdom, Australia, France, South Africa, Yugoslavia, Japan, India, United States, Pennsylvania, Illinois, Louisiana, Spain, Canada, Czechoslovakia

Whittaker, B. N., P. Gaskell, D. J. Reddish. Subsurface Ground Strain and Fracture Development Associated with Longwall Mining. Mining Science and Technology, v. 10, no. 1, January, 1990, p. 71-80.

Experiments employing physical modeling to study ground behavior above longwall faces in different geological conditions are reported. The development of subsurface fractures from longwall mining extractions, and the resulting principal strain patterns are described. The significance of the strain patterns in relation to the mining dimensions and the geological setting in terms of rock strength are discussed. The effect of faulting on subsidence behaviour is also considered.

Keyword(s): overburden, geologic features, modeling, longwall, rock mechanics, coal mining, prediction, instrumentation

Location(s): United Kingdom

Whittaker, B. N., D. J. Reddish, G. Sun. Mine Design and Planning Aspects: Undermining Aquifers and Surface Water Bodies. IN: Proceedings 4th International Mineral Water Association Congress, Ljubljana (Slovenia)-Portschach (Austria), September, 1991, p. 199-210.

The paper discusses the development of fractures associated with underground mining operations. Physical modeling test results are compared with field observations and assessed by finite element and image analysis techniques. General comments are made regarding the influence of geological factors such as lithology, rock strengths, and hydrogeology in relation to the design and planning aspects of underground mines.

Keyword(s): overburden, modeling, finite element, geologic features, rock mechanics, hydrology, subsurface water, surface water, longwall, stowing, coal mining, physical model, inflow

Location(s): United Kingdom

Whitworth, K. R. Induced Changes in Permeability of Coal Measure Strata as an Indicator of the Mechanics of Rock Deformation Above a Longwall Coal Face. IN: Strata Mechanics, Proceedings of the

Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 18-24.

In the Coal Measures of South Staffordshire below the unconformity at the base of Trias, there is a zone of increased fissure permeability and porosity in which most sandstones and coals give small makes of water. Occasionally, considerably larger flushes have occurred on longwall coal faces working in or close to this zone, even though these faces are at levels much further below the Trias unconformity than the minimum 60 m permitted. One such flush at West Cannock Colliery and the resultant investigation boreholes are described. The information gained from these boreholes demonstrated the existence of tensile zones in the form of bed separations that occur in a regular geometric pattern relating to a series of beams of uniform thickness over the edge of a worked panel.

Keyword(s): overburden, longwall, subsurface water, hydrology, rock mechanics, coal mining, geologic features, inflow

Location(s): United Kingdom

Wiborg, R., J. Jewhurst. Ekofisk Subsidence Detailed and Solutions Assessed. Oil and Gas Journal (Technology), February 17, 1986, p. 47-51.

Keyword(s): oil extraction

Wickham, G. E. Support Determination Based on Geologic Predictions. IN: Proceedings, Rapid Excavation Tunnelling Conference, AIME, 1972, p. 43-64.

Keyword(s): geologic features, tunnelling, roof support

Location(s): United States

Wier, C. E., F. J. Wobber, O. R. Russell, R. V. Amato. Study of Application of ERTS--An Imagery to Fracture Related Mine Safety Hazards in the Coal Mining Industry. Earth Satellite Corporation, Washington, D.C., May, 1973, 15 p. (NTIS E73-10681)

Keyword(s): mine operation, mine safety, survey methods, photography, coal mining, remote sensing

Location(s): United States

Wier, C. E., F. S. Wobber, O. R. Russell, R. V. Amato, T. V. Leshendok. Relationships of Roof Falls in Underground Coal Mines to Fractures Mapped on ERTS-I Imagery. IN: Proceedings, 2nd Symposium on ERTS-I Imagery, 1973, NASA Publications, NASA SP-351.

Keyword(s): roof stability, photography, coal mining, remote sensing

Location(s): United States

Wiggil, R. B. The Effects of Different Support Methods on Strata Behavior Around Sloping Excavations. Journal South African Institute Mining & Metallurgy, v. 63, April, 1963, p. 391-426.

Keyword(s): ground control

Location(s): South Africa

Wiid, B. L. The Influence of Moisture Upon the Strength Behavior of Rock. Ph.D. Thesis, University of Witwaterstrand, 1967, 184 p.

Keyword(s): rock mechanics, lab testing

Wiid, B. L. The Influence of Moisture on the Pre-Rupture Fracturing of Two Rock Types. IN: Proceedings, 2nd International Conference on Rock Mechanics, Belgrade, v. 2, 1970, p. 239-245.

Keyword(s): rock mechanics, lab testing

Wildanger, E. G., J. Mahar, A. Nieto. Mine Subsidence Report St. David, Illinois, Sinkhole Type Subsidence Over Abandoned Coal Mines in St. David, Illinois. Abandoned Mined Lands Reclamation Council, Springfield, IL, 1980, 88 p.

On June 26, 1979, the Illinois Abandoned Mined Lands Reclamation Council (AMLRC) entered into cooperative agreement with the Federal Office of Surface Mining (OSM) to perform two tasks related to mine subsidence in the Village of St. David. The first and most immediate task involved the repair of a road damaged by mine subsidence. As a second task, OSM authorized the AMLRC to conduct a study of mine subsidence cases in St. David and the surrounding area. This work has been completed and the findings are presented.

Keyword(s): abandoned mines, coal mining, surface structural damage, roads, reclamation

Location(s): Illinois, Illinois Coal Basin, United States

Wildanger, E. G., J. W. Mahar, A. Nieto. Sinkhole-Type Subsidence Over Abandoned Coal Mines in St. David, Illinois. Mine Subsidence Report, St. David, Illinois. Departments of Civil Engineering and Geology, University of Illinois at Urbana-Champaign, June, 1980, 88 p.

This report examines the geologic conditions, mining history, subsidence trends, and damage in the area. A large section is devoted to detailed analyses of sinkholes and the mechanisms of sinkhole formation.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, abandoned mines, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Wildanger, E. G., J. W. Mahar, J. Shively, R. D. Gibson. Mine Subsidence at the District 11 State Police Headquarters in Maryville, IL. Abandoned Mined Lands Reclamation Council, Springfield, IL, Progress Report: May 12 to September 9, 1980, 47 p.
Keyword(s): surface structural damage, abandoned mines, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Wildanger, E. G. Sinkhole-Type Subsidence Over Abandoned Coal Mines in St. David, Illinois. M.S. Thesis, University of Illinois at Urbana-Champaign, 1980, 88 p.
Keyword(s): coal mining, abandoned mines, surface structural damage, geologic features, lab testing, literature search, overburden, subsurface water
Location(s): Illinois, Illinois Coal Basin, United States

Wildanger, E. G., A. Leung, J. W. Mahar, R. A. Bauer. Mine Subsidence at the Northland Drive - Southland Court Area, Belleville, IL. Progress Report for February 20 to June 30, 1981, Abandoned Mined Lands Reclamation Council, Springfield, IL, 1981, 61 p.
Keyword(s): surface structural damage, abandoned mines, coal mining, structural mitigation
Location(s): Illinois, Illinois Coal Basin, United States

Wilde, P. M., J. M. Crook. The Significance of Abnormal Ground Movements Due to Deep Coal Mining and Their Effects on Large Scale Surface Development at Warrington New Town. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 240-247.
From the outset of development of Warrington New Town, a systematic approach to the problems of mining subsidence has been adopted and one vital component of this has been the installation and monitoring of an extensive subsidence levelling network. One objective of this work is the identification of distorted patterns of subsidence that can be further investigated and, if practical, surface development delayed or restricted.
Keyword(s): surface structural damage, land-use planning, coal mining, active mines, monitoring methods, abandoned mines, geologic features
Location(s): United Kingdom

Wilde, P. M., J. M. Crook. The Monitoring of Ground Movements and Their Effects on Surface Structures - A Series of Case Histories. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 182-189.
The aim of this paper is to present a series of case histories connected with land and its associated structures that have been subject to settlements both connected with the surface development of the land inducing net increases in ground loading pressures and/or underground coal mining operations, which have involved partial removal of ground support.
Keyword(s): surface structural damage, coal mining, geotechnical, foundations, partial extraction, active mines, soils, survey methods, monitoring methods
Location(s): United Kingdom

Williams, R. E., S. D. Vincent, G. Bloomsburg. Hydrogeologic Impacts of Mine Design in Unsaturated Rock. Mining Engineering, October, 1990, p. 1177-1183.
A modeling scheme is developed to simulate the hydrogeologic effects of mine design and development in unsaturated rock. Simulations are conducted using the UNSAT2 finite element computer program and hydrogeologic data from the site of a proposed mined-out waste repository at Yucca Mountain, Nevada.
Keyword(s): modeling, computer, mine design, hydrology, finite element, subsurface water
Location(s): Nevada, United States

Williamson, W. H. Hydrogeological Aspects of Coal Mining Under Stored Waters Near Sydney, Australia. IN: Symposium on Water in Mining and Underground Works, SIAMOS--78, Granada, Spain, 1978, p. 309-328.
Hydrogeological evidence figured importantly in a public inquiry on whether coal mining should be permitted under the stored waters of five dams providing part of Sydney's water supply. Reference is made to the natural groundwater regime, entry of

water into existing mines, and test bores showing aquifer systems to be retained over the workings. Estimates, based on water discharge from the mines, are given of vertical permeability. It is concluded it is practicable to mine under the stored waters without causing undue leakage.
Keyword(s): hydrology, subsurface water, coal mining, surface water, geologic features
Location(s): Australia

Willis, A. J. Surface Stability in Areas Underlain by Old Coal Workings. M.S. Thesis, Department of Engineering, University of Aberdeen, 1976.
Keyword(s): abandoned mines, coal mining

Willis, A. J., J.A.F. Chapman. Old Coal Workings--Client, Consultant and Contractor. Ground Engineering, v. 13, no. 10, 1980, p. 22-39.
Keyword(s): abandoned mines, coal mining

Wilson, A. A. Geological Factors in Land-Use Planning at Aldridge-Brownhills, West Midlands. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 87-94.
This paper is a verification of the planning as it affects future land use in a study area. Pillar and stall workings are a hazard. The effects of subsidence induced by coal mining are greatest in a faulted area. Dry, abandoned coal mines and the old marl quarries overlying them are a major, controlled, chemical waste disposal facility.
Keyword(s): land-use planning, abandoned mines, geologic features
Location(s): United Kingdom

Wilson, A. H. A Laboratory Investigation of a High Modulus Borehole Plug Gage for the Measurement of Rock Stress. IN: Proceedings 4th Symposium on Rock Mechanics, March 30-April 1, 1961, H.L. Hartman, ed., Bulletin 76 of the Mineral Industries Experiment Station, The Pennsylvania State University, University Park, p. 185-195.
A solid plug of relatively high modulus will serve as a suitable borehole plug gage for measuring change in rock stress when the modulus of elasticity of the rock is not known. An estimate of the rock modulus will increase the accuracy of the measurement, even though this estimate may not be very precise.
Keyword(s): rock mechanics, in situ testing, monitoring equipment

Wilson, A. H. Conclusions from Recent Strata Control Measurements Made by the Mining Research Establishment. Mining Engineering, April, 1964, p. 367-380.
Roof to floor convergence of a normal, adequately supported longwall face is shown to depend upon several factors, including face advance, extraction height, and depth of the working. The author presents a formula for the estimation of the expected convergence in Great Britain, which is accurate to within 25%.
Keyword(s): mine design, mine waste, ground control, roof stability, floor stability, longwall, prediction
Location(s): United Kingdom, Europe

Wilson, A. H., D. P. Ashwin. Research Into the Determination of Pillar Sizes--Part I, An Hypothesis Concerning Pillar Stability; Part II, Measurements of Stresses in Two Pillars at Lea Hall Colliery. The Mining Engineer, v. 141, June, 1972, p. 409-430.
Keyword(s): room-and-pillar, ground control, mine design, pillar strength
Location(s): United Kingdom

Wilson, A. H. Pillar Stability in Longwall Mining. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, September, 1982, Y.P. Chugh and M. Karmis, eds., SME-AIME, p. 85-95.
This paper discusses estimating the design of supporting pillars to permit the correct siting of main roadways. This is important when laying out districts for longwall extraction, particularly if the results of previous experience are not available in the area to be exploited.
Keyword(s): pillar strength, longwall, coal mining, mine design
Location(s): United Kingdom

Wilson, E. D. Progress Report (Pt. 2) of Geologic Factors Related to Block Caving at San Manuel Copper Mine, Pinal County, Arizona, April 1956-March 1958. U.S. Bureau of Mines RI 5561, 1960, 43 p.
Keyword(s): metal mining, geologic features
Location(s): Arizona, United States

Wilson, G. V. Early Differential Subsidence and Configuration of the Northern Gulf Coast Basin in Southwest Alabama and Northwest Florida. Gulf Coast Association of Geological Societies Transactions, v. 25, 1975, p. 196-206.

Keyword(s): fluid extraction
Location(s): Alabama, Florida, United States

Wilson, I. Subsidence Prediction Over Room and Pillar Mining Systems. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 223-242.

Measurements taken over room-and-pillar mining systems, where the pillars remain, are rare in the United Kingdom. Those available for consideration, however, prove conclusively that subsidence does result from such mining systems and by examination of these recorded data, a preliminary prediction model may be devised. The work described in this paper was initiated in order to provide some first steps towards a subsidence prediction model for current and potentially larger, future enterprises, perhaps in areas previously sterilized due to the sensitivity of the surface.

Keyword(s): room-and-pillar, prediction, coal mining, modeling
Location(s): United Kingdom

Wilson, R. G. Source of Groundwater Entering Collieries Beneath Reservoirs. IN: Mine Water, Proceedings 2nd International Congress, Granada, Spain, September 1985, R. Fernandez-Rubio, ed., v. 1, p. 59-68.

Some collieries in New South Wales, Australia, operate beneath reservoirs of the Sydney water supply. Special conditions are imposed upon mining beneath the reservoirs. Historically, entry of water into these collieries is minor. Dykes and faults normally have no effect. Groundwater systems are maintained even when major fractures appear on the surface over areas of full extraction. In one colliery, investigations have been undertaken to determine whether a reservoir is the source of a water inflow. Chemical analyses of the water have shown little change and are different from those of the reservoir.

Keyword(s): subsurface water, hydrology, coal mining, overburden, geologic features, monitoring methods, survey methods
Location(s): Australia

Wilson, T. H., G. He, W. F. Haslebacher. Seismic Studies Over Active Longwall Mines. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 289-302.

Common offset and refraction seismic data have been collected over four longwall panels at two locations in West Virginia. Surveys were made prior to, during, and after mining in both areas. The velocity of seismic wave propagation in the overburden rocks is observed to decrease in response to panel emplacement. Variations in the magnitude of this reduction, apparent as an additional first arrival time delay in the after mining common offset surveys, do not appear to correlate directly to the amount of subsidence that has occurred.

Keyword(s): active mines, coal mining, longwall, seismic, overburden
Location(s): West Virginia, Appalachian Coal Region, United States

Wilson, W. E. Casing Failures in Irrigation Wells in an Area of Land Subsidence, California. Geological Society of America, Special Paper 121 (abstract), 1969, p. 323-324.

Keyword(s): fluid extraction, pipelines, utilities
Location(s): California, United States

Wilson, W. P. A Background to Mine Subsidence Legislation in the State of New South Wales and the Duties and Functions of the Mine Subsidence Board. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute Mining & Metallurgy, Illawarra Branch, Paper 13, p. 13-1--13-3.

Subsidence due to mining operations has always given some cause for concern to mining operators, underground workmen, surface owners, and the public. This paper describes events leading to the passage of mine subsidence legislation, then details the mine subsidence compensation acts of 1928 and 1961. The present Mine Subsidence Board is constituted under the 1961 Act and is responsible for its administration.

Keyword(s): law, government, mitigation, surface structural damage, historical, insurance, active mines, abandoned mines, coal mining
Location(s): Australia

Windes, S. L. Physical Properties of Mine Rock. Part 1. U.S. Bureau of Mines RI 4459, 1949, 79 p.

Keyword(s): rock mechanics, lab testing
Location(s): United States

Windes, S. L. Physical Properties of Mine Rock. Part 2. U.S. Bureau of Mines RI 4727, 1950, 37 p.

Keyword(s): rock mechanics, lab testing
Location(s): United States

Winfield, P. F. Foundations for Sites Over Natural Voids and Old Mine Workings. IN: Mineworkings 84: Proceedings International Conference on Construction in Areas of Abandoned Mineworkings, M.C. Forde, B.H.V. Topping, and H.W. Whittington, eds., Edinburgh, Engineering Technics Press, 1984, p. 266-272.

Keyword(s): foundations, abandoned mines, geologic features

Winstanley, A. Longwall Roof Control. Transactions, Institute of Mining Engineers, v. 81, 1930-31, p. 373-405; v. 82, 1931-32, p. 107-109, 334-337.

This article covers convergence studies of roof control, and discusses the use of packing for roof support.

Keyword(s): longwall, roof support, backfilling

Winstanley, A. Strata Movements. Transactions, Institute of Mining Surveyors, 1938, v. 19, Pt. 1.

Keyword(s): ground control

Winters, D., C. Y. Chen. Current Status of Federal Regulations and Rulemaking Governing Subsidence Due to Underground Mining. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University Department of Mining Engineering, p. 1-5.

This paper discusses background, current regulations, recent developments, and related issues of the Surface Mining Control and Reclamation Act (SMCRA), which was enacted on August 3, 1977.

Keyword(s): law, government, reclamation, active mines, surface structural damage, land-use planning

Location(s): United States

Wintz, W. A. Jr., R. G. Kazmann, C. G. Smith, Jr. Subsidence and Ground-Water Offtake in the Baton Rouge Area. Louisiana Water Resources Research Institute Bulletin 6, 1970, 90 p.

Keyword(s): fluid extraction, subsurface water, hydrology

Location(s): Louisiana, United States

Withers, R. J., E. Nyland. Theory for the Rapid Solution of Ground Subsidence Near Reservoirs on Layered and Porous Media. Engineering Geology, v. 10, 1976, p. 169-185.

Keyword(s): fluid extraction, surface water

Wohlrab, B. Effects of Mining Subsidences on the Ground Water and Remedial Measures. IN: Land Subsidence, Proceedings, International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 89, v. 2, p. 502-512.

This paper discusses the effects of mining subsidence on groundwater.

Keyword(s): subsurface water, hydrology, land mitigation

Wold, M. B. A Blocky Physical Model of Longwall Caving Under Strong Roof Conditions. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 1007-1014.

A well-scaled blocky physical model was used to study the feasibility of longwall coal mining under strong and massive sandstone roof conditions. Caving spans and height, bulking factor, angle of break, support loads and their interaction with the structural geology are discussed with respect to predicted mine behavior.

Keyword(s): modeling, physical model, longwall, roof stability, instrumentation, multiple-seam extraction

Location(s): Australia

Womack, W. R. Detection of Shallow Abandoned Room and Pillar Workings Using High Resolution Earth Resistivity. IN: Proceedings National Symposium and Workshops on Abandoned Mine Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 42-62.

High resolution earth resistivity surveys were conducted as portions of the site investigations at two abandoned coal mine sites in eastern Montana. The depth of the original workings varied from 30 to 70 feet, although the associated voids often occur at more shallow depths due to roof collapse. A proposed highway corridor was found to be undermined at four locations, resulting in abandonment of the corridor. At a residential site, excellent delineation of individual rooms and pillars was achieved. Experience at these and other sites shows that the technique is conservative, i.e., all known voids were detected, but anomalies were also detected that do not represent voids. Most of the false anomalies occurred in areas of rough terrain and could be resolved by considering site geomorphology.

Keyword(s): seismic, geophysical, abandoned mines, coal mining, surface structural damage, roads

Location(s): Montana, Rocky Mountain Coal Region, United States

Wong, I. G., J. R. Humphrey, W. J. Silva. Microseismicity and Subsidence Associated with a Potash Solution Mine, Southeastern Utah, USA. IN: Proceedings 4th Conference on Acoustic Emission/ Microseismic Activity in Geological Structures and Materials, Pennsylvania, October 22-24, 1985, Clausthal-Zellerfeld, Trans Tech Publications, 1989, p. 287-306.

Microseismic activity was monitored during a pumping-refill cycle. Several thousand events were recorded that could be classified as identical to regional tectonic microearthquakes or surface wave like events, whcih are thought to be associated with collapse of a pillar in the main shaft. Microseismic activity was thought to be associated with subsidence, but there is also evidence of contribution due to local/tectonic stress fields and preexisting zones of weakness.

Keyword(s): non-metal mining, seismic

Location(s): Utah, United States

Wood, C. C., G. J. Renfrey. The Influence of Mining Subsidence on Urban Development of Ipswich, Queensland. IN: Proceedings, 2nd Australia and New Zealand Conference on Geomechanics, Brisbane, Institute of Engineers of Australia Publication 75/4, 1975, p. 4-9.

Keyword(s): land-use planning

Location(s): Australia

Wood, P. A. Underground Stowing of Mine Waste. International Energy Agency Coal Report I CTIS/TR23, Swiftprint of New Malden, Ltd., London, April, 1983, 67 p.

This paper evaluates the effectiveness and characteristics of types of mine waste as a backfilling material for use in active and abandoned coal mines.

Keyword(s): backfilling, mine waste, abandoned mines, active mines, coal mining

Wood, R. M., G. J. Colaizzi. Overview of Methods and Techniques for the Reclamation of Mine Subsidence, Mine Drainage, and Landslide Problems on Abandoned Mined Lands. IN: Proceedings National Symposium and Workshops on Abandoned Mine Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 248-276.

This paper describes subsidence, mine drainage and slope stability (landslides) problems related to abandoned mines lands. Discussions of subsidence include pothole and trough-type subsidence problems.

Keyword(s): abandoned mines, coal mining, reclamation, mine waste, mine fires, land mitigation, backfilling, hydraulic backfilling, pneumatic backfilling, local backfilling, grouting

Wood, W. O. The Permian Formation in East Durham. Transactions, Institute of Mining Engineers, v. 65, 1922-23, p. 178; v. 66, 1923-24, p. 196-199.

Water-pumping stations were de-watering magnesian limestones and causing subsidence, which was often blamed on the extraction of the coal far below.

Keyword(s): subsurface water, fluid extraction, coal mining

Wright, F. D. Lateral Thrust, Bedding, and Jointing in Roof Stability Calculations. IN: Ground Control Aspects of Coal Mine Design, Proceedings Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 86-91.

In sedimentary formations, bedding planes are generally fairly smooth and flat, and the bond between the beds is weak. Hence, the roof rock over an underground opening can become detached from the rock above to form a slab or plate loaded by its own weight or additionally by thinner, less rigid slabs above.

Keyword(s): roof stability, geologic features

Wright, F. D., R. C. Howell, J. A. Dearinger. Rock Mechanics Study of Shortwall Mining. Final Technical Report, 30 April 1979. University of Kentucky, Lexington, Department of Energy contract, April, 1979, 288 p. (NTIS PC A13/MF A01)

Keyword(s): shortwall, rock mechanics

Location(s): United States

Wright, L. The Influence of Subsidence on Coal Conservation. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Australasian Institute of Mining & Metallurgy, A.J. Hargraves, ed., Wollongong, N.S.W., Australia, 1973, p. 15-1--15-9. (NTIS Accession No. 76-07944)

Coal is a diminishing asset that is not replaceable. Considerable reserves are overlain by stored water, and the conflicting interests of coal mining and preservation of water supplies must be reconciled. The problems of subsidence effects are becoming of increasing importance. However, accurate forecasts can be made on strata behavior, including amount and extent of subsidence of the surface and intervening strata. This will permit the maximum recovery of coal consistent with adequate safeguards to surface features.

Keyword(s): engineering, coal mining, environment, surface water, subsurface water, surface structural damage, active mines, inflow

Location(s): Australia

Wu, J., S. Zhao. System Behavior Analysis of the Ground Movement Around a Longwall. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 845-852.

In this paper, the surrounding rocks and supports in a longwall are taken as an integral system. The structural characteristics and behavior of the system are discussed based on in situ observations. A set of equations, which describe the interaction among the supports, immediate roof and main roof, are developed. These equations can be used to design longwall powered supports more reasonably and economically.

Keyword(s): longwall, roof stability, modeling, roof support

Location(s): China

Wu, W., C. Haycocks. Interaction During Overmining for Longwall Operations. IN: Proceedings 4th Annual Workshop Generic Mineral Technology Center Mine Systems Design and Ground Control, Moscow, ID, October 21-26, 1986, Department of Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, p. 45-56.

To study the interaction problems during overmining by longwall methods, the photoelastic modeling method was used. Using this experimental stress analysis method, a full distribution of maximum shear stress field, as well as area of stress concentration, is easier to obtain than through use of numerical modeling methods such as finite element.

Keyword(s): longwall, modeling, multiple-seam extraction, coal mining

Location(s): Appalachian Coal Region, United States

Wu, W., C. Haycocks, Y. Zhou. Designing for Interaction in Close-Seam Multi-Seam Mining. IN: Rock Mechanics: Proceedings of the 28th U.S. Symposium, Tucson, AZ, June 29-July 1, 1987, I.W. Farmer, et al., eds., Balkema, Rotterdam, p. 1107-1114.

Research into ground control problems resulting from the mining of seams in close proximity has been carried out using finite element and body-loaded photoelastic modeling methods in conjunction with statistical and empirical analysis of numerous case studies. As a result of this research, an integrated design model has been constructed and formed the basis for a computer program (MSEAM) that can assist field engineers in dealing with interaction problems caused by multi-seam mining.

Keyword(s): multiple-seam extraction, finite element, modeling, computer, ground control, overburden, pillar strength

Location(s): Appalachian Coal Region, United States

Wuest, W. J. Controlling Coal Mine Floor Heave: An Overview. U.S. Bureau of Mines IC 9326, 1992, 17 p.

This report presents an overview of ground control considerations associated with floor heave. Factors affecting heave, such as in situ stress, floor characteristics, and mine geometry are described. Floor-displacement monitoring and data analysis methods are outlined. Finally, floor heave remediation is discussed. The remedial techniques are divided into four categories: mine maintenance, supplemental support, mine structure, and techniques for multiple-seam operations. Other subjects covered in the report include laboratory and in-place testing of floor rocks, case studies, effects of mine layout, determination of excess horizontal pressure, and types of heave failure. The emphasis of this report is on practical considerations.

Keyword(s): floor stability, coal mining, mine design, multiple-seam extraction, lab testing, in situ testing

Location(s): United States

Xiao, G. C., R. A. Irvin, I. W. Farmer. Use of Database in Ground Control to Identify Weightings and Water Inflows. IN: Proceedings, 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 177-183.

A database, incorporating historical data from British mines, to study the factors affecting inflows from proximate aquifers into longwall workings, showed that a main causal factor was the immediate roof strata lithology. When this comprised principally stronger sandstone, there was a tendency for periodic inrushes associated with face weighting. This phenomenon is explained by the collection of water in bed separation cavities, where free water connected to a high pressure head aquifer source, may be trapped.

Keyword(s): subsurface water, computer, longwall, hydrology, overburden, geologic features, roof stability, coal mining, inflow

Location(s): United Kingdom

Xu, Z., Y. Pan, D. Qi. The Numerical Simulation of Lessening the Surface Subsidence by Grout Injection. IN: Computer Methods and Advances in Geomechanics, Proceedings 7th International Conference, Cairns QLD Australia, May 6-10, 1991, G. Beer, J.R. Booker, and J.P. Carter, eds., v. 2, Balkema, Rotterdam, p. 1417-1421.

In this paper, the testing of grout injection to lessen surface subsidence is introduced, then the mechanism of the reduction of surface subsidence is expounded. On the basis of the mechanism, a mathematical model is established. Finally, a numerical simulation is carried out.

Keyword(s): modeling, computer, grouting, mathematical model, coal mining, active mines, multiple-seam extraction., longwall, surface structural damage

Location(s): China

Yang, G., Y. P. Chugh, Z. Yu. Application of a Laminated Model to Surface Subsidence Prediction: A Case Study. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y. P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 329-342.

This paper presents the development of a numerical model based on a laminated linear elastic mechanics model and the results of its application to prediction of subsidence due to coal mining in a southern Illinois mine. The predicted vertical and horizontal surface displacements and associated differential movements, along with their comparison with field observations, are also included.

Keyword(s): modeling, elastic model, prediction, coal mining, vertical displacement, horizontal displacement

Location(s): Illinois, Illinois Coal Basin, United States

Yang, G., Y. P. Chugh, Z. Yu. A Numerical Approach to Subsidence Prediction and Stress Analysis in Coal Mining Using a Laminated Model. IN: Proceedings, 34th U.S. Rock Mechanics Symposium, 1993.

A three-dimensional numerical model for the computation of ground movements and stresses due to coal mining is presented. It is based on a simple stratified continuum model. Analysis techniques for longwall panels with chain pillars, room-and-pillar workings and weak floor strata are discussed. The effectiveness of the model is demonstrated with a case study for a southern Illinois coal mine.

Keyword(s): prediction, coal mining, modeling, boundary element, longwall, room-and-pillar, floor stability

Location(s): Illinois, Illinois Coal Basin, United States

Yao, J. An Approach to Damage Assessment of Existing Structures. Purdue University Report CE-STR-79-4, Lafayette, IN, October, 1979.

Keyword(s): surface structural damage

Location(s): United States

Yao, X. L., D. J. Reddish, B. N. Whittaker. Evaluation of Subsidence Parameters for Inclined Seams in UK Coalfields. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 225-232.

This paper analyses the effects of mining extraction geometry (width/depth ratio) and dip of seam on subsidence parameters based on a large database, containing 120 longwall mining cases all within coalfields in the United Kingdom.

Keyword(s): coal mining, geologic features, computer, longwall, vertical displacement, horizontal displacement, prediction, National Coal Board

Location(s): United Kingdom

Yao, X. L., B. N. Whittaker, D. J. Reddish. Influence of Overburden Mass Behavioural Properties on Subsidence Limit Characteristics. Mining Science and Technology, v. 13, no. 12, 1991, Amsterdam, p. 167-173.

An analytical calculation model for the angle of draw is introduced in this paper on the supposition that the roof is considered as an elastic beam. This model indicates the importance of the main factors that control the extent of subsidence produced on the surface and also provides some appreciation of the influence of overburden strength on the angle of draw. A finite element model was developed for application to subsidence-related rock mechanics problems.

Keyword(s): modeling, roof stability, overburden, angle of draw, finite element, rock mechanics, coal mining, geologic features

Location(s): United Kingdom

Yarbrough, R. E. Effects of Mine Subsidence on Structures--Mine Subsidence Insurance Program in Illinois. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 253-258.

As a result of concern for Illinois citizens owning structures above abandoned mine workings, the Illinois State Legislature passed House Bill 158 in 1978. This bill amended the Illinois Insurance Code and created the Mine Subsidence Reinsurance Fund.

Keyword(s): surface structural damage, engineering, geotechnical, insurance, monitoring methods, survey methods, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Yarbrough, R. E. Surface Subsidence--An Overview. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al.,

eds., Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, 1983, p. 603-608.
This paper gives a brief history of the systematic study of surface disturbance and describes the current legislation under SMCRA (1977). It introduces the book's subsidence chapter and the papers that follow.
Keyword(s): law, subsidence research, government, reclamation, historical
Location(s): United States, England

Yarbrough, R. E. Monitoring of Two Foundations Subsided by a High Extraction Coal Mine, Sesser, Illinois. Phase I, Preliminary Data. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 151-158.
The major objective of the research project is to monitor the response of two constructed foundations to ground movement induced by subsidence from high-extraction coal mining. The Illinois Mine Subsidence Insurance Fund leased land for the project for 3 years.
Keyword(s): abandoned mines, active mines, coal mining, insurance, surface structural damage, subsurface structural damage, monitoring methods, monitoring equipment, foundations, structural mitigation, vertical displacement, horizontal displacement
Location(s): Illinois, Illinois Coal Basin, United States

Yarbrough, R. E. Digitilt Tiltmeter System Utilized to Monitor Structural Response to Ground Movements Induced by Coal Mine Subsidence. The Indicator, v. 15, no. 1, 1986, Slope Indicator Co., Seattle, WA, p. 6.
The Illinois Mine Subsidence Insurance Fund and the USBM Twin Cities Research Center have chosen the Digitilt Tiltmeter as an instrument to monitor structural response to ground movements induced by coal mine subsidence. The Fund and the Bureau sponsored a program to construct and monitor two 30 x 40 foot foundations in front of a high-extraction panel in Sesser, Illinois.
Keyword(s): foundations, monitoring equipment, computer, surface structural damage, high-extraction retreat, monitoring methods, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Yarbrough, R. E., L. R. Powell, L. A. Sneed, E. W. Murphy. Monitoring Horizontal Displacement and Tilt Over a Longwall Panel, West Frankfort, Illinois. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 377-386.
In 1988, the Illinois Mine Subsidence Insurance Fund and the USBM, in cooperation with Old Ben Coal Company, initiated a monitoring program over an 850-foot-wide longwall panel at a depth of 650 feet near West Frankfort, Illinois. This paper presents the response of the ground surface to vertical, horizontal, and tilt displacements. Measuring and understanding the importance of these displacements is necessary to develop a methodology to better determine ground strains.
Keyword(s): horizontal displacement, longwall, monitoring methods, vertical displacement, survey methods, survey equipment
Location(s): Illinois, Illinois Coal Basin, United States

Yarbrough, R. E., J. E. Feddock. Horizontal Ground Movements and Mining Damage. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, Pittsburgh, PA, p. 165-172.
This paper gives an overview of research done in the United States and abroad to predict and monitor ground movement caused by subsidence.
Keyword(s): horizontal displacement, vertical displacement, prediction, monitoring methods, foundations, coal mining, longwall, surface structural damage
Location(s): United States, Europe, United Kingdom

Yarbrough, R. E., L. R. Powell. Longwall Mining, Pseudo-Subsidence and the Human Factor. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 343-351.
This paper summarizes results of research on mine subsidence in the Illinois Coal Basin conducted by the Illinois Mine Subsidence Research Program and the USBM. It also suggests ways of dealing

with surface and structure owners who live over or near subsiding areas.
Keyword(s): subsidence research, active mines, modeling, prediction, surface structural damage, longwall, vertical displacement, horizontal displacement
Location(s): Illinois, Illinois Coal Basin, United States

Yerkes, R. F., R. O. Castle. Surface Deformation Associated With Oil and Gas Field Operations in the United States. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 88, v. 1, p. 55-66.
Keyword(s): fluid extraction, oil extraction
Location(s): United States

Yi, Y. H. Subsidence Due to Mining. Thesis, University of Pittsburgh, PA, 1925.
Keyword(s): coal mining
Location(s): United States

Yin-Huai, L., Y. Ci-Shu, Z. Bing-Wen. Mining Under Rivers in Fuxin Coal Mines. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 167-176.
In Fuxin Coal Mines, there are more than 20 million tons of coal buried under seasonal streams. The coal seams are mostly shallow. The key to success in mining shallow, under-stream coal seams, according to the authors' analysis, is that valleys or alluvia subside gently and basically evenly with contractible tension fissures and that fissures both in valleys or alluvia and in rock seams are blocked up or sealed by cohesive deposits either from alluvia or rock.
Keyword(s): surface water, overburden, coal mining, active mines, longwall, inflow
Location(s): China

Yokel, F. Y. Guidelines for Housing Construction in Mine Subsidence Areas. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 129-139.
The purpose of this paper is to discuss suggested approaches to the problem of construction in subsidence-prone areas. The guidelines will have to address themselves to three areas: (1) site evaluation to determine subsidence risks, (2) feasibility of construction of roads, utilities, and other improvements, and methods by which subsidence effects on these facilities can be attenuated, and (3) feasibility and methods of housing construction in subsidence areas.
Keyword(s): coal mining, room-and-pillar, surface structural damage, land-use planning, utilities, roads, construction, structural mitigation, abandoned mines, active mines, horizontal displacement, vertical displacement, engineering
Location(s): United States

Yokel, F. Y., L. A. Salomone, R. M. Chung. Construction of Housing in Mine Subsidence Areas. Geotechnical Engineering Group, Structural and Material Division Center for Building Technology, National Engineering Laboratory, National Bureau of Standards, January 1981, 24 p. (NTIS NBSIR 81-2215)
This report evaluates criteria for site exploration and development, risk assessment, and housing construction in areas of actual and potential mine subsidence. Suggested measures to mitigate damage to housing are also given. The appendix explains a mathematical model, which can be used for the prediction of subsidence profile characteristics.
Keyword(s): vertical displacement, horizontal displacement, surface structural damage, ground control, construction, mathematical model, prediction, engineering, structural mitigation, land-use planning

Yokel, F. Y., L. A. Salomone, R. E. Gray. Housing Construction in Areas of Mine Subsidence. Journal Geotechnical Engineering Division, American Society of Civil Engineers, v. 108, no. GT9, September, 1982, W.F. Marcuson III, ed., p. 1133-1149.
Many areas in the United States are underlain by abandoned mines and many more areas will be undermined in the future. As mine cavities collapse, they cause settlement and ground distortions on the surface that may damage or destroy buildings and utilities. Many of these subsidence-prone areas are presently used or will be used in the future for residential housing development. Three problems associated with the development of mine subsidence areas are addressed: site exploration and evaluation, site development, and housing construction in mine subsidence areas. This paper is derived from a study sponsored by the Department of Housing and Urban Development.
Keyword(s): engineering, construction, prediction, surface structural damage, abandoned mines, utilities, land-use planning, active mines,

coal mining, horizontal displacement, vertical displacement, pipelines, roads, foundations, National Coal Board
Location(s): United States

Young, C. M. Subsidence Around a Salt Well. Transactions, AIME, v. 74, 1926, p. 810-817.
This paper contains observations of subsidence of a salt well in Kansas, as well as a description of subsidence over a sulfur deposit.
Keyword(s): non-metal mining, surface subsidence damage
Location(s): Kansas, United States

Young, L. E. Surface Subsidence in Illinois Resulting from Coal Mining. Illinois State Geological Survey, Mining Investigation Bulletin 17, 1916, 113 p.
The author examines case studies of subsidence due to mining operations in Illinois.
Keyword(s): coal mining, surface structural damage, subsurface structural damage, mine design, historical, backfilling, room-and-pillar, ground control, descriptive theories
Location(s): Illinois, Illinois Coal Basin, United States

Young, L. E., H. H. Stoek. Subsidence Resulting from Mining. University of Illinois Engineering Experiment Station Bulletin 91, v. 13, no. 49, August 1916, 205 p.
This bulletin summarized current knowledge (1916) of mine subsidence in Illinois, Pennsylvania, and West Virginia, as well as in other states and abroad.
Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, surface water, subsurface water, mine design, backfilling, law, literature search, coal mining, historical
Location(s): Illinois, Illinois Coal Basin, Pennsylvania, West Virginia, Appalachian Coal Region, United States, Europe, United Kingdom, India

Young, L. E. Influence of Rate of Advance and of Time Factor in Support of Active Workings in Bituminous Coal Mines. Transactions, AIME, v. 130, 1938, p. 270-283; also AIME Technical Paper no. 933.
Keyword(s): coal mining, roof support, time factor, active mines, bituminous
Location(s): United States

Young, S. G. Surface Effects of Underground Mining. Mining Congress Journal, v. 64, 1978, p. 37-39.
Keyword(s): surface subsidence damage

Yu, Z., Y. P. Chugh, G. Chen, G. Hunt. Determination of Floor Deformations Underneath and Around a Pillar Based on Plate Loading Test and Theoretical Analyses. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 149-165.
A method for determining the floor deformation underneath and around a pillar subjected to vertical loads is presented in this paper. The method is based on results of a plate loading test conducted in the field and theoretical analyses. Plate loading tests have been used extensively in the Illinois Coal Basin for determining the ultimate bearing capacity (UBC) of the weak floor.
Keyword(s): floor stability, in situ testing, modeling, finite element, ground control, room-and-pillar, active mines
Location(s): Illinois, Illinois Coal Basin, United States

Yu, Z., Y. P. Chugh, G. Yang. Determination of Plate Size Effect on Ultimate Bearing Capacity of Weak Floor in Underground Coal Mines Using a Boundary Integral Approach. IN: Proceedings, 12th International Conference on Ground Control in Mining, S.S. Peng, ed., West Virginia University, Morgantown, 1993.
An equation was developed to characterize the relationship between ultimate bearing capacity (UBC) and plate size using a boundary integral approach. The equation was validated by the results from more than 70 plate loading tests of different sizes conducted in various underground coal mines throughout the Illinois Basin. The equation indicates that the UBC decreases as the plate size increases.
Keyword(s): coal mining, in situ testing, floor stability, instrumentation, monitoring equipment
Location(s): Illinois, Illinois Coal Basin, United States

Yu, Z., Y. P. Chugh, P. E. Miller, G. Yang. A Study of Ground Behavior in Longwall Mining Through Field Instrumentation. IN: Proceedings, 34th U.S. Symposium on Rock Mechanics, 1993.

Because they impact face and mine stability, surface and subsurface deformations as well as stresses and displacements in the vicinity of the longwall face should be considered in longwall ground control. However, in the past, most studies emphasized either surface deformations or in-mine stability studies. In this research, both surface deformations and in-mine stability studies were conducted. The objectives were to study (1) subsidence characteristics, including time effects; (2) stress and deformation changes in chain pillars as a function of time and face location; (3) roof, pillar, and floor deformations in entries as a function of time and face location; and (4) relationships between the surface subsidence and underground strata behavior.

Keyword(s): longwall, monitoring methods, instrumentation, active mines, coal mining, monitoring equipment, vertical displacement, horizontal displacement, geotechnical

Location(s): Illinois, Illinois Coal Basin, United States

Yulun, Z., C. Shu, S. Guanghan, W. Ge. Identification of the Model and Parameters of Mining Subsidence and Their Practical Use. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardif,f July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 266-279.

This paper analyzes the problems which exist in predicting subsidence resulting from underground mining and discusses the concepts whereby models and parameters may be identified for the prediction of mining subsidence. Based on system theory, the rock mass model has been considered as a complex system that contains various forms of failure, such as faults, fractures, and bed separations. From this, a new theory about model and parameter identification of mining subsidence has been established. The theory and method have been validated using actual examples from the Zao-Zhuang coal district.

Keyword(s): prediction, modeling, geologic features, overburden, coal mining

Location(s): China

Zaburunov, S. A. Controlling Subsidence with Stowing: A Case History. Reprinted from Coal Mining, September, 1986, 3 p.

This article details the steps taken to prevent further subsidence damage to a school in Pennsylvania. An abandoned coal mine 70 feet below the school's foundation was deteriorating. Plans were drawn up and carried out to backfill the mine by using pneumatic stowing.

Keyword(s): pneumatic backfilling, stowing, surface structural damage, abandoned mines, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Zachar, F. Some Effects of Sewickley Seam Mining on Later Pittsburgh Seam Mining. Mining Engineering, v. 4, no. 7, 1952, p. 687-692.

Unmined blocks in the Sewickley seam surrounded by worked out areas had been found to transmit overburden loads through the interval strata to the Pittsburgh seam 90 feet below.

Keyword(s): multiple-seam extraction, overburden

Location(s): Pennsylvania, Appalachian Coal Region, United States

Zachar, F. Factors Influencing the Selection of Mining Systems. Mining Congress Journal, v. 55, no. 10, October, 1969, p. 32-44.

This paper evaluates the factors affecting the mine layout, mining equipment, and economics of the mining systems used in the United States at the time.

Keyword(s): mine design

Location(s): United States

Zachar, F. Shortwall: A Way to Boost Production. Coal Mining and Processing, v. 9, no. 12, December, 1972, p. 39.

The author presents a discussion of reasons for reduced coal production with conventional room-and-pillar mining. He states that ventilation, dust control, and roof control required by safety legislation has lead to lower production levels. This article presents a report of the shortwall concept and proposed methods of using it to increase production.

Keyword(s): law, mine safety, shortwall, roof support, coal mining

Zaman, M. M., J. L. Ahern, Y. M. Najjar. Stability Analysis and Characterization of Ground Subsidence of Abandoned Lead-Zinc Mines in Northeastern Oklahoma. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 707-714.

This paper presents the results of a study involving characterization of ground subsidence of abandoned lead-zinc mines in northeastern Oklahoma. Two coordinated efforts were undertaken: (1) collection and analysis of available data such as drillers' logs, geologic cross sections, structure contour maps, and stratigraphic sections, and (2) development of a numerical (finite element) technique for prediction of collapse in mine subsidence. An in-depth analysis of a major collapse in the region was conducted. The factors contributing to this collapse were identified.

Keyword(s): metal mining, abandoned mines, geologic features, prediction, finite element, modeling, subsurface water

Location(s): Oklahoma, Kansas, Missouri, United States

Zenc, M. Comparison of Bals' and Knothe's Methods of Calculating Surface Movements Due to Underground Mining. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 6, 1969, p. 159-190.

The theoretical analysis of Bals' and Knothe's methods is discussed. Preliminary calculation is made of surface movements according to both methods compared with the results of measurement in the Ostrava-Karvina Coal Basin.

Keyword(s): vertical displacement, horizontal displacement, prediction theories, prediction, empirical model, profile function, influence function

Location(s): Czechoslovakia

Zeng, R. H., S. S. Peng. Prediction of Subsidence Basin by the Weibull Distribution Function. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 78-90.

Many subsidence researchers in the United States have developed new empirical function methods to predict subsidence, or they have attempted to validate some empirical functions developed by foreign researchers for use in the United States. An attempt is made in this paper to develop a new empirical function to predict a surface subsidence basin due to longwall mining.

Keyword(s): prediction theories, computer, longwall, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Zhang, H. C. Problem of Subsidence Caused by Coal Cutting Under the Floodbank. IN: Proceedings 6th International Congress International Association of Engineering Geology, Amsterdam, August 6-10, 1990, v. 4, Balkema, Rotterdam, p. 2699-2707.

Coal extraction under subsidence-sensitive sites is becoming more common. The case of mining under the flood prevention embankments of Weishan Lake is considered. Predictions of subsidence using the following methods are illustrated: cut and trial, structural mechanics, and geomechanics. Results, together with those from engineering comparison and probabilistic integral methods, are compared to observed ground movements. The geomechanics method gives promising results. Recommendations are made for mining practices to minimise danger for sensitive sites.

Keyword(s): prediction, coal mining, surface water, surface subsidence damage, engineering

Zhong, W. L., W. M. Ma, S. S. Peng. Prediction of Surface Subsidence by Probability Function Integration Method. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 104-121.

The probability function integration method is one of the influence function methods. It is widely accepted in many mining districts in China and Poland because its theory and formulas can well represent the surface subsidence basins caused by longwall mining of flat or near-flat seams. This paper introduces the basic theory of the probability function integration method and determines its four basic parameters by analyzing the measured subsidence profiles in eight longwall panels in the Northern Appalachian coal field. It also discusses the two methods for determining the four parameters. Finally the acquired parameters are used to predict the subsidence and deformation of the houses for damage assessment. Comparisons are made between the measured and the predicted subsidence.

Keyword(s): prediction theories, prediction, influence function, empirical model, surface structural damage, longwall, coal mining

Location(s): China, Poland, Appalachian Coal Region, United States

Zhou, X., S. Zhang. Stability Evaluation of Alternative Designs of Drift-and-Fill Stoping in Zhaoyuan Gold Mine, P.R. China. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 285-292.

Mining economics is such that being too conservative in safety will result in a considerable penalty in mining cost. Initial planning and design of a mining project often must be done, however, without complete information. The assurance of economical and safe mining is thus difficult. This study focuses on the improvement of the mine design associated with Zhaoyuan Gold Mine in China. Attention is given to the selection of backfill structures. A design, which is based on a proposed practical finite element model and thought to be not only reliable but also cost effective, is recommended for further mining operations.

Keyword(s): metal mining, mine design, finite element, modeling, economics

Location(s): China

Zhou, Y., C. Haycocks. Geologic and Spatial Factors in Multi-Seam Mining. IN: Proceedings 4th Annual Workshop, Generic Mineral Technology Center Mine Systems Design and Ground Control, Moscow, ID, October 21-26, 1986, Virginia Polytechnic Institute and State University, Blacksburg, p. 115-126.

Considerable experience has been gained regarding interactions between room-and-pillar operations when mining over a previously mined underlying seam. To ameliorate upper seam conditions, design guidelines have been proposed based on model and statistical analysis of field studies for predicting upper seam stability. Although these methods are useful for predicting when potential hazards may occur in the upper seam, the precise location and magnitude of problem areas cannot as yet be determined. Studies relating upper seam damage to strata subsidence have demonstrated considerable variation. This variability is attributable to the structural conditions and their spatial locations associated with multi-seam operations, the effects of which are not yet clearly defined.

Keyword(s): multiple-seam extraction, room-and-pillar, mine design, geologic features, overburden, roof stability, modeling, finite element, pillar strength, computer

Location(s): Appalachian Coal Region, United States

Zhou, Y., C. Haycocks. Failure Mechanisms in Ultra-Close Seam Mining. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 613-620.

Virtually every coal seam in Appalachia will at some time be subject to multi-seam interaction. Many such problems result from seams that lie in close proximity or have split and lie within 30 feet vertically of one another. Existing techniques for multi-seam design have concentrated on conditions where the entire innerburden is not the failing member and are unsuitable for ultra-close multi-seam design. Structural integrity of the innerburden must be maintained if two superimposed seams are to be mined separately. Understanding possible failure mechanisms of the innerburden is an essential first step in the design process.

Keyword(s): coal mining, multiple-seam extraction, mine design, pillar strength, modeling, room-and-pillar

Location(s): Appalachian Coal Region, United States

Zhou, Y., C. Haycocks. Pillar Stability in Ultra-Close Seam Mining. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 137-144.

Sooner or later virtually every seam in the Appalachian coal region will experience ground control problems due to multi-seam interaction. Mining of ultra-close seams that lie within 25 feet vertically of each other, such as where seams have split, gives rise to many of these problems. Previous multi-seam research offers solutions to some of the problems of ultra-close mining using mechanisms involving load transfer, arching, subsidence, and innerburden failure. However, field observations show that ultra-close workings separated by less than 25 feet frequently involve unique failure mechanisms of the innerburden that can affect the structural behavior of both upper and lower seam pillars.

Keyword(s): multiple-seam extraction, pillar strength, geologic features, coal mining, yielding supports, room-and-pillar

Location(s): Appalachian Coal Region, United States

Zhou, Y., C. Haycocks, E. Topuz, M. Karfakis. Controlling Subsidence Effects Using Partial Backfilling. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 193-198.

Partial backfilling can be used to reduce and control surface subsidence damage caused by longwall mining or pillaring operations in room-and-pillar mines. The use of partial backfill as opposed to total backfill minimizes the cost associated with such efforts.

Keyword(s): longwall, room-and-pillar, pillar extraction, coal mining, grouting, pneumatic backfilling, hydraulic backfilling

Location(s): United States

Zhou, Y. Site Characterization for Ultra-Close Multi-Seam Mining. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 161-166.

Data from these field studies and previous case study data have been combined to define ultra-close seam mining environments and relate them to observed failure conditions. A rating system for ultra-close multi-seam design has been developed and field studies have verified the applicability of the design criteria according to geologic structures, lithology, and spatial data.

Keyword(s): multiple-seam extraction, coal mining, active mines, geologic features

Zhu, D., M. Qian. A Computer Simulation of Breakage of the Main Roof in Longwall Mining. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 205-211.

A computer simulation method, based on the results of field observation and physical model analyses, has been developed for simulating the breakage of the main roof. By this method, various parameters of rock property, different boundary conditions of the working face, as well as the initiation, development, and results of the breaking process of the main roof with different geometric dimensions can be effectively simulated. Since the main and immediate roofs and the coal seams are treated as an integrated mechanical system, the interaction among them can be studied in detail.

Keyword(s): modeling, computer, roof stability, rock mechanics, longwall, coal mining

Location(s): China

Zhu, D., S. S. Peng. A Study of Displacement Field of Main Roof in Longwall Mining and its Application. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 149-156.

A computer simulation method, based on the results of in situ observations and physical model analysis, has been developed to predict the behavior of main roof breakage in longwall mining by considering it as a Kirchoff plate on a Winkler elastic foundation. This method is used to investigate the initiation and development of the breaking process of the main roof and its displacement field before and after its breakage. In this paper, the simulation method is introduced, characteristics of the displacement field of the main roof are discussed, and monitoring variation of the displacement field of the main roof in a Chinese longwall face is demonstrated.

Keyword(s): longwall, modeling, computer, prediction, roof stability, coal mining

Location(s): China

Zorychta, H., D. W. MacFadden, F. Smith. Strata Control Measurements in the Sydney Coalfield. Transactions, Canadian Institute of Mining and Metallurgy, v. 70, 1967, p. 38-48.

Keyword(s): coal mining, ground control, instrumentation

Location(s): Australia

Zwartendyk, J. Economic Aspects of Surface Subsidence Resulting from Underground Mineral Exploitation. Ph.D. Thesis, The Pennsylvania State University, State College, 1971, 411 p.

The author presents an extensive historical survey of theories, remedies, and laws concerning surface subsidence. The study is subdivided based upon pre-WWI, post-WWI, and post-WWII conditions. It includes a historical survey of the development of hydraulic and pneumatic stowing. Also included is an extensive bibliography.

Keyword(s): economics, historical, hydraulic backfilling, pneumatic backfilling, literature search, law, prediction theories

Zwartendyk, J. Economic Aspects of Surface Subsidence Resulting from Underground Mineral Exploitation. U.S. Bureau of Mines OFR 7-72, 1971, 412 p. (NTIS PB 207 512)

This report consists of an extensive historical survey and bibliography of theories, remedies, and laws concerning surface subsidence.

Keyword(s): economics, surface subsidence damage, historical, hydraulic backfilling, pneumatic backfilling, law, literature search

Location(s): United States

Zych, J. The Asymmetry of Movements Produced at the Ground Surface by the Mining of a Horizontal Seam. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 243-254.

Detailed investigations carried out in situ and on models prove that geometric-integral theories are characterized by systematic discrepancies between the theoretical values of the deformation indices and the results of geodetic measurements. In practice, it is only possible to achieve a limited degree of accuracy using these theories, and the accuracy cannot be increased further. For this reason, the studies conducted by the author have had as an aim the elimination of these systematic divergences and, as a result, an increase in the accuracy of estimates of the effects of mining extraction on the ground surface.

Keyword(s): modeling, prediction, horizontal displacement, vertical displacement

Location(s): Poland

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Keywords

National Research Council (1981), Nawrot, J. R. (1977), Nishida, R. (1986), Nix, J. P. (1960), O'Riordan, N. J. (1984), Okonkwo, I. O. (1988), Padgett, M. F. (1987) (1988), Paone, J. (1977), Park, D-W. (1987), Patey, D. R. (1977), Payne, H. M. (1910), Peng, S. S. (1986) (1988) (1992), Persche, E. P. (1986), Peters, W. R. (1980), Phillips, R. A. (1986) (1989), Piggott, R. J. (1978), Pineda, L. (1984), Pottgens, J. J. E. (1986), Powell, L. R. (1988) (1989), Price, D. G. (1969), Prickett, T. A. (1979), Reifsnyder, R. H. (1989), Roberts, J. M. (1986), Royse, K. W. (1984), Saric, J. A. (1987), Schwarz, S. D. (1988), Scott, A. C. (1957), Segatto, P. (1992), Sendlein, L. V. A. (1992), Sgambat, J. P. (1980), Sherman, G. D. (1986), Sladen, J. A. (1984), South African Mining and Engineering Journal (1970), Southwestern Illinois Metropolitan and Regional Planning Commission (1983), Speck, R. C. (1990), Stache, J. E. (1992), Statham, I. (1987), Stephenson, R. W. (1978) (1979), Sturges, F. C. (1970), Symons, M. V. (1978) (1985), Systems Planning Corporation (1973), Taylor, R. K. (1968) (1975), Thorburn, S. (1978), Transportation Research Board, Washington D.C. (1976), Treworgy, C. G. (1989) (1991), Turka, R. J. (1990), Turney, J. E. (1986), U.S. Bureau of Mines (1975) (1976) (1991) (1991) (1991) (1991) (1992) (1992), U.S. Department of the Interior, Bureau of Mines (1972), U.S. General Accounting Office (1979), University of Illinois, Urbana, IL (1982), University of Wyoming, Mining Engineering (1988), Urban, D. W. (1982), Van Besien, A. C. (1985) (1987) (1988), Van Dorpe, P. (1987), Van Dorpe, P. E. (1984), Van Dyke, M. (1984), Van Dyke, M. W. (1985), Van Impe, W. F. (1990), Walker, J. S. (1989) (1990) (1990), Waltham, A. C. (1989), Walton, G. (1977), Wardell, K. (1966) (1966), Watters, R. J. (1989), West, T. R. (1974), Whaitte, R. H. (1975), Whetton, J. T. (1957), White, H. (1992), Whittaker, B. N. (1989), Wildanger, E. G. (1980) (1980) (1980) (1980) (1981), Wilde, P. M. (1985), Willis, A. J. (1976) (1980), Wilson, A. A. (1987), Wilson, W. P. (1973), Winfield, P. F. (1984), Womack, W. R. (1984), Wood, P. A. (1983), Wood, R. M. (1984), Yarbrough, R. E. (1985), Yokel, F. Y. (1979) (1982), Zaburunov, S. A. (1986), Zaman, M. M. (1989)

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seismic

vertical displacement

viscoelastic model