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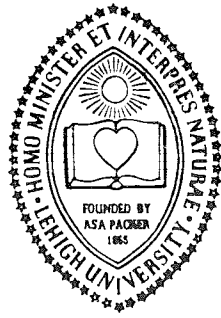
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342.6



LEHIGH UNIVERSITY

Earth Pressures and Retaining Structures

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**SUPPLEMENT TO
ANNOTATED BIBLIOGRAPHY
ON STEEL SHEET PILE STRUCTURES**

FRITZ ENGINEERING
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by
H. Y. Fang

March 1970

Fritz Engineering Laboratory Report No. 342.6

Earth Pressures and Retaining Structures

SUPPLEMENT TO ANNOTATED BIBLIOGRAPHY ON STEEL
SHEET PILE STRUCTURES

by

H. Y. Fang

This work has been carried out as a part of
an investigation sponsored by the American Iron
and Steel Institute.

Fritz Engineering Laboratory
Department of Civil Engineering
Lehigh University
Bethlehem, Pennsylvania

March 1970

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1. INTRODUCTION

The publication of the Annotated Bibliography on Steel Sheet Pile Structures as Fritz Engineering Laboratory Report No. 342.1 provided selected references of work on steel sheet bulkhead. Detailed abstracts and indexes on the different aspects related to theory, design and installation of sheet piling structures were provided. Since then enthusiastic response has been received by the author from concerned sources. In order to augment Fritz Engineering Laboratory Report No. 342.1 this supplement is prepared. The same format is used in this report as was used in the previous report. The general composition of this supplement report is given in the following headings:

Forms and Section Properties of Steel Sheet Piles;

Theories and Design Procedures; Field and Laboratory Tests;

Installation and Removal; Durability and Corrosion.

Those references marked by an asterisk have short abstracts in alphabetical order at the end of the report.

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5. ABSTRACTS

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Corrosion of Steel Piles in Salt Water,
Journal of the Waterways and Harbors Division, ASCE,
Vol. 87, No. WW3, Proceedings Paper No. 2886,
pp. 95-109, August 1961

The description of a field survey of steel sheet piles in bulkheads at eight Naval Stations is presented. The location, the elapsed time since their construction, and the percentage of remaining thickness in each zone of exposure are given. The method of protection used by the Navy for both steel bearing piles and sheet piles are included.

Becker, H.

Probleme des Schweissens von Spundwandbohlen,
Schweissen u Schneiden, Vol. 18, No. 4, pp. 157-161,
April 1966 (In German)

The problems of welding sheet piles are summarized and includes the different welding processes such as tack, butt, fillet, repair, and underwater welding. The suitability of the different steels, depending on the composition and the melting practice (killed vs. unkilld) are also discussed. The results of both good and bad practices are illustrated in examples.

Beverley, R. F.

Progress Report of Strain Gauge Measurements on an Anchored Bulkhead Wharf,
Proceedings, Fourth Australia-New Zealand Conference on Soil Mechanics and Foundation Engineering, pp. 69-75, Adelaide, 1963

Report on field installation of strain gauges on steel sheet piling. Information is given on the soil properties at the site, the design of the bulkheads, and the strain gauges. This report (10 months after filling was completed) presents the calculated pressures, moments, and deflections compared with those indicated by the strain gauges.

Bokhoven, V.

Recent Quay Wall Construction at Rotterdam Harbor,
Proceedings, Institution of Civil Engineers, London,
Vol. 35, pp. 593-613, December 1966

Examples of design and construction of recently built quay walls in Rotterdam Harbor where the original ground level is below sea level. Typical pile supported quay wall structures with sand drains in the adjacent fill areas are illustrated and discussed. Pile layout, cast steel saddle connections between precast concrete beams and steel sheet piling and a number of typical platform-type pile-supported walls are reviewed.

Bowles, J. E.

Foundation Analysis and Design,
McGraw-Hill Book Company, pp. 367-440, 1968

Detailed discussion of sheet pile structures and cofferdams, including design methods and analyses.

Boyer, W. C. and H. M. Lummis

Design Curves for Anchored Steel Sheet Piling,
ASCE, Proceedings, Vol. 70, Separate No. 165, p. 12,
January 1953

Three primary factors in anchored pile design: depth of embedment, bending moment in sheeting, and anchor pull are considered in the method of developing data for charts. The design curves given simplify calculations.

Brewer, C. E. and H. Y. Fang

Field Study of Shear Transfer in Steel Sheet Pile Bulkhead,
Fritz Engineering Laboratory Report No. 342.2, Lehigh University,
February 1969

The study was undertaken to locate the position of the neutral axis of bending for a sheet pile wall. Strain gage instrumentation can be protected against damage during driving of the pile and against groundwater corrosion. Within the range of applied loads encountered in this investigation the available data suggests that shear transfer takes place across the interlocks of arch-web steel sheet piles. It is believed that the European practice of assuming that the piles act as a unit more closely approximates the field conditions than the American practice of assuming individual pile action. Further investigation is necessary to fully understand composite action between the soil and the piling.

Building a Dry Dock to Hatch an Aircraft Carrier,
Engineering News-Record, Vol. 157, No. 21, pp. 32-38,
November 22, 1956

A cellular diaphragm-type sheet pile cofferdam was designed to enclose the area for the building of a dry dock. A gravity slab held in place by a combination of its own weight, friction on the steel sidewalls of the dock itself, plus some allowance for reduced hydrostatic head due to impedance of groundwater moving through surrounding strata was considered for the floor. Details of design and construction are included.

Cardiff, M.

Lagoon Discharge Structures of Corrugated Steel Sheeting,
Civil Engineering, ASCE, Vol. 25, No. 4, p. 37, April 1955

Interlocking steel sheeting was applied to the problem of designing discharge structures for lime-sludge lagoons. An upstream channel was constructed with walls of corrugated steel sheeting driven to rock and creosoted timbers. Steel sheeting was also used for the cut off walls which were driven to rock at the middle of the dike. Two major advantages were obtained by using the steel sheeting in place of the conventional reinforced concrete walls: lower initial cost and salvage value.

Carle, R. J.

Cofferdams for the Town Creek Piers of the Silas N. Pearman
Bridge Over the Cooper River, Charleston, South Carolina,
Highway Research Record, No. 200, pp. 1-10, 1967

Describes the construction of a sheet pile cofferdam through a thick deposit of soft organic clay (under 21 feet of water) and the driving of vertical and battered H-piles to support the pier for the South Carolina bridge.

Carlson, N. A.

Drainage of Quay Walls: Calculation of Overpressure Behind Drained
and Undrained Quay Walls
Acta Polytechnica Scandinavia, No. C:40, p. 46, 1966

The overpressure on quay walls for varying water level in the harbor basin has been determined for the case of a constant draw-down velocity (rather than the usual case of an abrupt draw-down) in a homogeneous and isotropic fill. The wall is assumed drained by a vertical curtain, single vertical drains, and horizontal drain blanket, a horizontal line drain, or with no special drainage provisions. Plate model tests and theoretical calculations are used. The influence of the draw-down velocity, the permeability, and the specific yield of the backfill is demonstrated. A horizontal drain blanket was found to be the most efficient type of drain. Small permeabilities and the effect of high water valves also are considered.

Cathodic Protection Research Pinpoints Piling Failures,
Iron Age, Vol. 188, No. 19, pp. 118-119, November 9, 1961

Investigation of eight Naval harbors found that the highest rate of steel sheet-piling corrosion occurs in the region of periodic wetting by sea water. Peak corrosion builds up in the splash zone about two feet above the mean-high-water level. The beneficial effect of cathodic protection is noted.

Concrete Wales Brace Circular Cofferdam,
Engineering News-Record, Vol. 163, No. 15, pp. 36-38, October 8, 1959

The cofferdam is made up of six of the concrete circular wales, interlocking steel sheet piling, vertical steel soldier beams, and horizontal timber lagging to hold back the sandy soil. A 6.5 ft. high barrier dam was constructed in the existing sewer, its chief purpose is to divert sanitary sewage to the screen channel and wet well of the new pump station.

D'Appolonia, E., R. Alperstein, and D. J. D'Appolonia
Behavior of a Colluvial Slope,
Journal of the Soil Mechanics and Foundations Division,
ASCE, Vol. 93, No. SM4, pp. 447-473, July 1967

The paper describes measures taken to stabilize a slope in very clayey colluvial soil, highly fractured with slicken slides. An extensive field investigation as well as undrained triaxial tests and drained direct shear tests were carried out. Both peak and residual strengths were recorded. All evidence suggested that it was important to prevent shear strains from developing which would cause the strength of the soil to reduce toward the residual value. The cup slope was stabilized by means of an anchored sheet pile wall driven at the toe. Theoretical studies of the effect of these operations were made by stress path method.

Dismuke, T. D.
Field Study of Surcharge Effects on a Steel Sheet Pile Bulkhead,
Fritz Engineering Laboratory Report No. 342.4, Lehigh University,
December 1968

This paper presents the results and analysis of a field study conducted to determine surcharge effects on a steel sheet pile bulkhead. Slope indicator and strain gage data were used to determine the loads, shears, moments and deflections at one instrumented pile location. These results are compared to the results of theoretical calculations. It is concluded that the effects of wall friction should be included when flexible bulkheads with granular surcharges are designed. In addition, this study corroborated the results of previous field studies with respect to observed moment reduction (compared to the theoretical) for bulkheads when normally loaded by backfilling.

Domke, H.

Die Wellenspundwand,
Bauingenieur, Vol. 32, No. 4, pp. 117-119, April 1957
(In German)

A sheet pile retaining wall is designed in a wave form. The sheet pile described is driven into the ground without any foundation. It has flat sections with a highly waterproof lock. The sections are arranged in wave form with angles between the sections being 4 to 15°.

Duke, C. M.

Field Study of Sheet-Pile Bulkhead,
Proceedings, ASCE, Vol. 28, Separate No. 155, p. 26, October 1952

Field study of structural performance of flexible anchored bulkhead which retains 55 ft. height of fine sand hydraulic fill in Long Beach Harbor, California. During filling lateral soil pressure distribution was approximately in proportion to weight of overlying fill, after completion of filling lateral soil pressures above wale increased sharply and those below decreased due to settlement of fill accompanying partial support of fill in the rods and wale.

Evans, W. N. and J. H. Boyd

Construction of Rocky Reach Hydroelectric Project,
Journal of the Construction Division, ASCE, Vol. 86, No. C03,
pp. 45-65, November 1960

Rocky Reach Dam was built in four steps in areas protected by berms and circular sheet pile cells, as much as 75 feet high, installed to rock through boulders. Rock bolts were used to tie down a section of the dam in which fault planes were encountered. Final river diversion was effected by connecting two big rocks by cable and dropping one rock upstream as an anchor and the other into 35 fps river flow.

Fang, H. Y. and L. Lamboj

Comparison of Maximum Moment, Tie Rod Force and Embedment Depth of Anchored Sheet Pile, Fritz Engineering Laboratory Report No. 365.1, Lehigh University, March 1970

Comparisons of maximum moment, tie rod force and embedment depth of anchored DP-2 steel sheet pile by various existing methods (such as: free-end, fixed-end, Blum, Anderson, Tschebotarioff and Rowe methods) and field data. Based on the available experimental data at Lehigh University no positive conclusions were drawn.

Fuhrmann, O.

Rammen und Ziehen im Kanal-und Tiefbau
(Pile driving and drawing in canal and below grade construction),
Tiefbau, Vol. 9, No. 4, pp. 253-257, April 1967 (In German)

Pile driving techniques employed in West German construction industry and range of pile drivers with corresponding pile drawing devices are reviewed; methods of driving of sheet piles and driving of piles into canal flooring.

Geddes, W. G. N., G. P. Martin and D. D. Land

The Clyde Dry Dock Project, Greenock,
Proceedings, Institute of Civil Engineers, London,
Vol. 33, pp. 598-635, April 1966

Design and construction features of a large dry dock, a repair quay, and a tanker cleaning installation, all founded on soft silty clay river deposits were underlain by boulder clay which in turn rested on sandstone or shale bedrock. Between the dock structure and the bedrock, a porous concrete drain-layer was installed to act as a pressure relief system. The excavation for the dock through the soft clay down to bedrock was carried out behind an anchored sheet pile wall. Details of the sheeting, the dock wall, the dock entrance construction, the pile supported repair quay with sheet pile facing, and the pile supported tanker jetty are discussed.

Gibbons, E. F. and P. R. Jasper

Analytical Comparison of Anchored Bulkhead Design,
M. S. Thesis, Princeton University, Princeton, New Jersey,
May 1954

The distribution and magnitude of lateral earth pressures on anchored bulkhead are discussed. The classical theories, the data obtained from model analysis, and the data obtained from observation of prototypes in the field have been accumulated and comparisons of results are presented. It is considered that the method outlined by Tschebotarioff as the Simplified Equivalent Beam Method for bulkhead designs in sands is the most straight forward and most satisfactory of those examined for adaptation to design purposes. It is also considered that the consolidated equilibrium approach for the design of bulkheads in clays is the method which promises to more nearly approach the duplication of actual pressure distribution.

Giraudet, P.

Le reconstruction des quais, etc.,
Travaux, No. 364, pp. 205-214, April 1965 (In French)

The rebuilding of the Pondi Cherry and Madagascar quays in the port of Havre is described. In view of the unfavorable conditions (sandy clay) the construction method which was selected consisted of the erection of a steel sheet pile face-wall anchored by means of tie rods to a steel-pile anchor wall. To prevent fractures caused by soil settlement, tie rods were attached to the sheet piles and anchor walls by means of pivot hinges. This type of construction proved to be eminently suitable for the poor grade of soil of low load-carrying capacity and high settlement.

Gronquist, C. H.

Raritan River Bridge Substructure Provides for Future Widening,
Civil Engineering, ASCE, Vol. 25, No. 4, pp. 54-59, April 1955

Detail of the design and construction of the Raritan River Bridge are included in the article. The important feature of this bridge is the provision for future widening by the addition of a third column. The bases of the piers were designed to be of tremie concrete construction, placed in open steel sheet pile cofferdams and supported by 14H89 steel piles with reinforced points driven to rock at depths varying from 50 to 80 feet below the water surface.

Haliburton, T. A.

Numerical Analysis of Flexible Retaining Structures,
Journal of the Soil Mechanics and Foundations Division, ASCE,
Vol. 94, No. SM6, Proceedings Paper No. 6221, pp. 1233-1251,
November 1968

A numerical method for computer analysis of flexible retaining structures is described. Nonlinear soil response, as well as various anchor-and brace-support conditions may be considered. Previous developments in the area are reviewed and analysis of flexible structures by considering them as beam-column on nonlinear foundation is proposed. Procedures for efficient beam-column analysis by numerical methods are given, as is a method for considering nonlinear soil behavior are described and the proposed method is illustrated by example problems.

Heavy Timber Sheeting Shores Deep Trench,

Construction Methods and Equipment, Vol. 41, No. 4,
pp. 158-160, 162, 164, April 1959

Widely spaced soldier beams on 17 ft. 10 in. centers make possible the use of 16 ft. pipe sections instead of 8 ft. sections at a reduction in price of more than \$30 per linear foot. This design method was chosen over an original proposal involving steel sheet piling. The latest theories of earth pressure were used when designing the shoring system.

Hendry, A. W. and L. G. Jaeger

Load Distribution in Highway Bridge Decks,
Transactions, ASCE, Vol. 123, pp. 1214-1244, 1958

The method described provides an accurate and easily applied way of computing the load distribution in many common types of highway bridge decks. The primary difficulty in applying the theory is not the distribution theory itself but in assessing the effective moments of inertia, torsional constants, and elastic moduli of the bridge elements, particularly compound concrete and steel members. Nevertheless, even wide variations in the assumed properties of the elements result in relatively small variations in the distribution coefficients.

Herbert, R.

Seepage Under Sheet Piles,
Civil Engineering and Public Works Review, Vol. 63, No. 746,
pp. 977, 979-980, September 1968

A new method for representing seepage under sheet pile by adapting the normal resistor network technique for seepage systems to simulate the singularity which occur when a flow line turns through a sharp angle, for example at the base of sheet piles. The use of the Laplace equation for describing the head distribution of seepage systems in confined or unconfined aquifers in the steady state is shown and the technique developed to enable singularity in general and sheet piles in particular to be accurately modeled is described. By replacing the normal mesh values at the base of a sheet pile by resistors 1.634 times the normal value an automatic method is obtained which can accurately represent a sheet pile system of almost any degree of complexity. Three different seepage systems for which analytical solution exists were solved by three methods to illustrate the advantages of the proposed resistor network technique.

Highway Research Board

Bethlehem Steel Comes Up With New High-Strength Interlock
Sheet Piling,
Highway Research News, No. 36, p. 28, Summer 1969

Bethlehem Steel Corporation has recently introduced a new sheet piling section with an interlock strength of 28,000 lb. per in. 75 percent higher than the previous strength of similar flat-web sections. The new sheet piling is designated as "SP 7b". Mechanical properties of the steel from which SP 7b is manufactured includes a minimum yield strength of 45,000 psi. This value which is above the current standard specification requirements of ASTM A328 (Steel Sheet Piling) insures high load performance of both the web and the interlock. This higher strength steel is automatically provided by producer when the SP 7b section is specified under the A328 specification.

Hurtado, J.

Calcul electronique des rideaux de soutènement; parois moulees le sol; palplanches,
Genie Civil, Vol. 144, No. 10, pp. 730-734, October 1967
(In French)

The article considers the electronic computation of retaining walls, bentonite-grouted walls, and sheet pilings. The computer programs are analyzed with due consideration given to the design methods used and their relation to available methods. Also discussed in the article are methods for calculating active and passive earth pressures in cohesive and non-cohesive soils and in waters, the effect of concentrated overload on a common wall, the effect of berm on passive earth pressure, and the calculation of retaining wall characteristics.

Irvine, J. W. and R. F. Gaston

Concrete Addition to Cellular Sheet Pile Shipway,
Journal of the Construction Division, ASCE, Vol. 86, No. C02,
pp. 27-36, May 1960

A graving dock used as a shipway and constructed of cellular sheet piling in the early days of World War II, has been lengthened 100 ft. The additional length was provided by sinking a reinforced concrete trapezoidal-shaped cofferdam with the aid of open dredged wells.

Jalil, W. A.

Sollicitations horizontales des pieuz,
Construction, Vol. 22, No. 5, 7-8, 10, pp. 83-89, May 1967;
pp. 306-312, July-August, pp. 361-366, October 1967 (In French)

The paper deals with horizontal stresses on piles. The aim of the full scale experimental study was to work out a method of evaluating horizontal forces which deep foundations can receive at their head in the case of homogeneous soil (stiff clay) and the displacements compatible with conditions of use. The caisson piles consisting of metal sheet piling were equipped with inclinometers and induction-type sensors of deformation and were tested using a 12 m high mobile testing rig capable of applying stresses of up to $250 \cdot 10^4$ newtons. A description of the testing methods and discussion of the results are included.

Jeliniek, R.

Remarks on the Safety of Cofferdams and Sheet Pile Anchorages, Proceedings, Fifth International Conference on Soil Mechanics and Foundation Engineering, Paris, Vol. III, pp. 330-332, 1961

Graphical methods (based on logarithmic spiral failure surfaces) for determining the minimum resistance of earthfilled cofferdams and sheet pile anchorages. Variations of the theoretical failure surface inclination with changes in the cofferdam width to height ratio are shown to be small.

Kavanagh, T. C.

Maintenance - The Systems Approach, Civil Engineering, ASCE, pp. 31-33, July 1966

Advocates the incorporation of total maintenance cost over the years as a major factor in design and material selection and illustrates this approach with a PERT diagram, an organization chart, an example of comparative cost data for coating of bulkhead sheet piling.

Klein, G. K.

Calculation of Sheet Pile Walls at the Elastic and Limit Stages of Work of the Foundation Bed, Soil Mechanics and Foundation Engineering, pp. 328-333, November-December 1965 (In Russian)

A study of the failure patterns and displacements of vertical sheet pile walls has been made on the assumption that the coefficient of subgrade reaction increases linearly with depth. Formulae are developed on the bases of which graphs are constructed, indicating the required depth of sheet piling relative to the angle of internal friction of the soil and for determining the horizontal displacement of the top of the sheet pile wall.

Krizek, R. J. and G. M. Karadi

Effectiveness of Leaky Sheetpile, Highway Research Record No. 282, pp. 57-62, 1969

The steady-state seepage flow under and through a leaky sheetpile partially or fully embedded in a homogeneous, isotropic porous medium underlain by an impervious substratum is studied by means of its electric analog. Results are correlated with theoretical and experimental work.

Kurata, S. and S. Kitajima

Design Method for Cellular Bulkhead Made of Thin Steel Plate, Proceedings; Third Asian Regional Conference on Soil Mechanics and Foundation Engineering, Haifa, pp. 215-219, 1967

Model tests were conducted in Japan to study the deformation and overturning of sand-filled cellular bulkheads made of prefabricated thin-walled steel tubes. On the basis of the observed behavior and resistance of the fill, a new design method is outlined for determining the effective width of the shell structure by considerations of sliding, overturning, deformation, and reaction; and the thickness of the sheet wall as well as the tensions in it.

Lambe, T. W.

The Behavior of Foundations During Construction, Journal of the Soil Mechanics and Foundations Division, ASCE, Vol. 94, No. S1, pp. 93-130, January 1968

The deformations and pore pressure variations which occurred during the foundation preparation for one of the buildings on the MIT campus are described in considerable detail. The construction operation involved driving sheet piles, excavation for a basement (bracing the piles as the excavation proceeded), dewatering, and pouring of the foundation slab. Careful observations were made of vertical heave of the bottom, lateral movement of the walls, and pore water pressures in the soil. These movements were then compared to theoretical values predicted by various types of laboratory soil tests. While the predicted values were of the right order of magnitude, the agreement was not altogether satisfactory, especially as to the rate and amount of heave. An unusually large amount of data are presented and analyzed. Further work of this kind is, however, required in order to locate the sources of errors in the prediction techniques.

Lazeknik, G. E. and E. I. Chernysheva

Effect of Construction Methods on the Magnitude of Forces on Thin Single-Anchor Retaining Walls, Hydrotechnical Construction, ASCE, No. 5, pp. 472-474, May 1967

Discussion of the forces on anchored sheet pile walls created by deepening the excavation in front of the wall subsequent to installation of the wall. The main suggestion of the author is that any potential changes of the water depth subsequent to construction should be anticipated in the design and compensated for by additional anchor and sheet pile strength. A few diagrams are presented to illustrate the changes in loading on anchors and wall due to deepening of the excavation in front of the wall.

Liesche, H. and G. Schlecht

Wanddickenmessungen an Stahlspundwaenden mit Ultraschall
(Ultrasonic measurement of wall thickness of steel sheet
pile bulkhead),
Bauplanung-Bautechnik, Vol. 21, No. 4, pp. 191-195,
April 1967 (In German)

Selected example of method application; comparative results of
ultrasonic measurements with various devices and methods are
given.

Little Railroad Gets Biggest Lift Bridge,

Engineering News-Record, Vol. 159, No. 10, pp. 36-42,
September 5, 1957

Anchoring a cofferdam on solid rock with no overburden to provide
lateral stability was one of the main problems involved in the
building of the lift span. To solve this problem a fender system
was designed for the end of each pier. It was installed before
the pier footing itself and could be used as an anchor for
subsequent construction. This part of the fender system consists
of a series of rock-filled sheet pile cells installed in the form
of a triangle at either end. Design and construction details are
included.

Mansur, C. I. and M. Alizadeh

Tie-Backs in Clay to Support a Deep Sheet Excavation,
Journal of the Soil Mechanics and Foundations Division,
ASCE, Vol. 96, No. SM2, pp. 495-509, March 1970

Site conditions, design, construction procedures, and observations
and stress measurements made during construction of a cofferdam for
a 30 ft. to 45 ft. deep excavation for the Pierre Laclede building
in Clayton, Missouri are described. Stress, deflection, and
settlement measurements made during excavation and after completion
of the excavation are presented.

McNeill, R. L., B. E. Margason, F. M. Babcock and J. A. Barneich

Design Methods for Transient Response and Isolation of
Groundfounded Microprecision Slabs,
Journal of Spacecraft and Rockets, Vol. 5, No. 11, pp. 1297-1303,
November 1968

Design methods and case histories are presented for transient
response and isolation problems for groundfounded microprecision
slabs. State of art in energy-barrier technology is described for
cutoff trenches and sheet pile walls; pertinence to designs of
foundations for transient loads encountered with impact-testing
machines and forge hammers are described.

Mead, C. F.

Measurement of Earth Pressure on a Sheet Pile Breastwork, Fourth Australia-New Zealand Conference on Soil Mechanics and Foundation Engineering, pp. 34-36, Adelaide, 1963

In Auckland, New Zealand steel sheet piles were driven into sandstone with scoria backfill. Earth pressures were measured with ten Goldbeck-type pressure cells located at varying depths 3 ft. behind the sheet piles. Results comply with those of Duke but not with other investigators. This may be due in part to erroneous readings. Diagrams of measured pressures are shown.

Mile-Long Face Lift for a Weary Pier,

Engineering News-Record, Vol. 157, No. 18, pp. 36-40, November 1, 1956

Complete rehabilitation of over a mile of bulkhead is being done to safeguard the underpinning of the huge wharf and pier that make up most of the South Boston Army Base. A mass concrete gravity wall was decided on because it could be constructed without removing or disturbing the existing bulkhead. Maintenance is estimated to be low; and the wall itself is considered to be capable of lasting indefinitely with minimum repair. Design and construction details are included in the article.

Minnich, H.

Erweitertes Verfahren zur Berechnung Verankerter Spundwaende, Bauingenieur, Vol. 37, No. 9, pp. 344-347, September 1962
(In German)

An extended method for calculating anchored sheet pilings is presented. Equations are given for sheet piling anchored at the top and fully restrained at the bottom, with a trapezoidal-shape distribution of passive earth pressure.

Mohn, S. and D. Wartel

Pile Driving is Better Electrically, Electric Light and Power, June 1967

A twenty percent time saving in pile driving and extracting operations in difficult soil conditions was realized with a unique electric vibratory hammer. An air driven hammer tended to cause running out at the interlocks, and the sheets refused to penetrate shell pockets in the soil; but the vibratory hammer overcame these difficulties. The hammer was also used to drive in place three caissons.

Mullen, F. E.

St. Anthony Falls Navigation Project,
Journal of the Construction Division, ASCE, Vol. 89, No. C01,
Proceedings Paper No. 3447, pp. 1-18, March 1963

St. Peter sandstone is a soft loosely bonded rock that disintegrates readily when subjected to flowing water. This type of foundation, encountered in the St. Anthony Falls project, called for careful geological investigating and testing. Deep seated steel sheet piling wellpoint system, and chemical grouting were adopted as essential construction safety measures. A type of structure selected in order to assure that the foundation under and adjacent to the completed locks and dams would not be disturbed.

Olmstead, L. W. and G. A. Lynde

Feeder Beaches and Groins Restore Presque Isle Peninsula,
Civil Engineering, ASCE, Vol. 28, No. 3, pp. 42-45, March 1958

The beach erosion along the Lake Erie side of Presque Isle Peninsula has been counteracted by pumping in about 4,200,000 cu. yd. of sand for regular and "feeder" beaches, plus the construction of steel sheet piling groins 300 ft. long and 1000 ft. apart.

Pappas, N. D. and D. P. Sexsmith

Performance Monitoring of a Deep Cofferdam in Sensitive Clay,
Canadian Geotechnical Journal, Vol. 5, No. 2. pp. 80-94,
May 1968

This article describes the design and construction of a 90 ft. diameter by 70 ft. deep sheet pile figure eight temporary cofferdam which was constructed in soft sensitive Leda clay. Because of the size and importance of this structure, even though it was only temporary, extra precautions were taken and the performance was monitored. Mechanical strain gages were used to record the strain which developed in many of the important bracing members. Slope indicators were used to monitor the deformations near the toe. These instruments were read and the data analyzed at very frequent intervals. This was useful in insuring the safe performance of this structure until the permanent structure could be built.

Paunescu, M.

Resistance to Vibration Extraction of Piles and Sheet Piles, Soil Mechanics and Foundation Engineering, No. 3, pp. 191-194, May-June 1964

Values of the specific lateral resistance to static and dynamic extraction of piles and sheet piles have been determined experimentally. Tables and graphs illustrate the influence of pile type and soil type and permit the empirical determination of the magnitude of the lateral friction between the pile and the soil.

Piles Vibrated in Cramped Space,
Roads and Streets, January 1967

Vibratory hammers working in cramped space under a bridge teamed up to drive steel sheet piling cofferdams. Because of the many splices in the sheeting, which left upper pieces slightly out of line with lower sections, considerable backing up was necessary to keep the sheets going down. Again, the vibrating driver facilitates instant switching to extraction operation, permitting the contractor to ease the steel out of the ground.

Rombas Steel Sheet Piling

Wendel-Sidelor, 4, rue des Clercs, 57-Metz, France, 1968

This manual includes the section properties with description of Larssen and Rombas piles. Discussions include information on the driving and characteristics of helmets and anchorage accessories. Case histories and discussions of cofferdams, maritime quay walls, dolphins, piers, wharfs and locks are given.

Rowe, P. W.

Sheet-Pile Walls in Clay,
Proceedings, Institution of Civil Engineers, London,
Vol. 7, pp. 629-654, July 1957

A theoretical relation was developed between the maximum bending moment on a sheet pile wall driven into clay and the stability number, the flexibility number, and the geometrical parameters. The limited experiments show reasonable agreement. Consideration is also given to the final earth pressures some time after construction. The design is briefly outlined.

Rowe, P. W.

Sheet-Pile Walls Subject to Line Resistance Above Anchorage, Proceedings, Institution of Civil Engineers, London, Vol. 7, pp. 879-896, August 1957

The bending moments and the tie loads acting on the sheet pile wall were calculated for the case where the wall is prevented from inward deflection at the top. The results are expressed in terms of a free-earth support calculation with no resistance at the top. The limited experiments are described using loose sand.

Ryan, L. T.

Cathodic Protection of Steel-Piled Wharves, Journal of the Institution of Engineers, Australia, Vol. 26, No. 7-8, pp. 160-168, July-August 1954

Design, installation, and operation of cathodic protection system to prevent underwater corrosion of steel piled wharf at Lae, New Guinea; selection of anodes; experiments on scale models; magnitude of pretreatment and maintenance currents; measurement of pile potential; protection achieved with minimum expenditure.

Schenck, W.

Verfahren Beim Rammen Besonders Langer, Flachgeneigten Schraegpfaehle (Driving techniques for very long batter piles), Bauingenieur, Vol. 43, No. 5, pp. 158-162, May 1968 (In German)

Fixed base and floating batter pile drivers are described and their operation illustrated by example of actual work performed in anchoring of sheet wall piers.

Sheet Pile Cells and Sand Make a Pier,

Engineering News-Record, Vol. 160, No. 16, pp. 62-63, April 1958

Some 650,000 cu. yds. of hydraulically placed fill behind an L-shaped string of sheet pile cells projected into Narragansett Bay make a pier with a deck area of over 896,000 sq. ft. The piles are driven into what is basically a medium to firm fine sand, although in some places going to full depth necessitated driving through medium-size stones and hardpan. An asphalt and fabric was applied to the interior of outboard piles to contain sand finer in the fill. Design and construction details are included.

Silinsh, J.

Prestressed Pipe Struts Brace Sheet Pile Wall,
Construction Methods and Equipment, Vol. 43, No. 4,
pp. 112-115, 118-119, April 1961

The tallest building in New Orleans will rest on the deepest foundations built in that city. Pile driving and concreting of pile caps were carefully scheduled to keep the excavation symmetrical until pipe struts were installed to brace the sheet pile wall. The steel pipe struts are precompressed an amount equal to active earth pressure on the outside of the sheeting during installation. The struts help reduce site congestion.

Smith, E. A.

What Happens When Hammer Hits Pile,
Engineering News-Record, Vol. 159, No. 10, pp. 46-48,
September 1967

It is now possible to calculate in a practical and economical manner by means of electronic digital computers what happens at the instant a hammer hits a pile. As a result, it is possible to tell with far more accuracy than ever before that a certain type pile driven with a particular hammer to a determined number of tons ultimate driving resistance. The ability to compute the driving resistance accurately will greatly improve the engineer's position in determining the safe bearing value of a pile.

Sowers, G. B. and G. J. Sowers

Failures of Bulkhead and Excavation Bracing,
Civil Engineering, ASCE, Vol. 37, No. 1, pp. 72-77,
January 1967

Failures of anchored bulkheads and excavation bracing are caused by the neglect of backfill loads, construction operations that produce excessive earth pressure, poorly designed support systems, inadequate allowance for deflection, deterioration and corrosion, and poor design and construction details. Adequate attention to the soil structure system behavior as well as a detailed analysis of the factors responsible for earth pressure are essential to avoid failures and to provide economical design and construction.

Splash Zone Coating Protects Corroded Steel Piling,
Materials Protection, Vol. 2, No. 10, pp. 81-82, October 1963

A compound was perfected by Shell Chemical Laboratories to prevent corrosion at the splash zone at sea water level of steel sheet pilings which support offshore drilling islands. The new product, said to be hard and tough as metal itself, is epoxy resin, a heavy bodied coating applied to submerged, wet and dry piling surfaces and cured in place to a plastic barrier that is resistant to sea water, impact, and abrasion. The new coating can be expected to prevent corrosion and erosion for at least three years.

Swatek, E. P., Jr.

Cellular Cofferdams Design and Practice,
Journal of the Waterways and Harbors Division, ASCE,
Vol. 93, No. WW3, Proceedings Paper 5398, pp. 109-132,
August 1967

Several recent high head steel sheet pile cellular cofferdams are described including comments on their design and construction. Cell movement, interlock stress determination, sliding resistance, cell drainage, overturning stability, driving penetration and sheet-pile failures are discussed. The factor of shape in the plan arrangement of cells is mentioned. One use of bracing struts in combination with partial mass stability of cells is described. This paper principally treats cofferdams founded on rock, filled with granular materials. The use of a deflector for constructing cells in turbulent water is described. New developments and future trends are mentioned.

Swedes 'Swayback' a Retaining Wall,
Engineering News-Record, pp. 163-164, September 1965

A new type retaining wall has been developed and patented in Sweden. Interlocking steel sheet piles are driven in a continuous series of slightly curved lines behind drilled - in caissons, thus resembling a tennis net held in a vertical plane by rigid posts. Horizontal forces are transferred through the sheet pile interlocks to the caissons, which are installed first. The caissons are socketed into the rock foundation, thus obviating the need for toe-hold of the sheet piles. Clear diagrams illustrate the procedure.

Task Committee on Small Craft Harbors, Committee on Ports and Harbors
Small Craft Harbors Development (Progress Report),
Journal of the Waterways and Harbors Division, ASCE,

In five parts, the Progress Report on Small Craft Harbors Development covers every aspect of harbor development from the aesthetic factors to the raising of funds. Because of the many different purposes and services that the small craft harbor must supply the scope of the planning of such projects extends well beyond engineering practice. The wants and needs of the small craft user must be taken into account in designing small craft harbors. The report makes note of these factors as an aid to the engineer.

Tide Riding Rig Rings Itself with Piles,
Engineering News-Record, p. 41, July 1968

File driving method described was used by Brazilian contractor and centers pile driving operations on job at hand with 360 degree crane and pile hammer mounted on round floating platform; rig serves as template for driving circular caissons of steel sheet piles.

Turabi, D. A. and A. Balla
Distribution of Earth Pressure on Sheet-Pile Walls,
Journal of the Soil Mechanics and Foundations Division,
ASCE, Vol. 94, No. SM6, Proceedings Paper No. 6228,
pp. 1271-1301, November 1968

All theoretical solutions of the sheet pile problem used at present assume linear earth pressure distribution above dredge level and disregard the effect of wall deformation on the pressure distribution. The distribution coefficient method as evolved herein provided a solution in which wall deformation and earth pressure distribution are interrelated. The variation of the coefficient of earth pressure is presented as a function of sheet-pile flexural rigidity number, penetration depth, tie-rod position, tie-rod yielding and soil characteristics. The obtained earth pressure distribution curves exhibit the effect of arching in the soil mass. Both the pressure distribution curves and the computed maximum bending moment and tie-rod load values are in close agreement with test results.

Turabi, D. A. and A. Balla

Sheet-Pile Analysis by Distribution Theory,
Journal of the Soil Mechanics and Foundations Division,
ASCE, Vol. 94, No. SMI, Proceedings Paper No. 5769,
pp. 291-322, January 1968

A distribution theory is introduced for the analysis of sheet-pile walls. It is valid for the case of linearly varying soil stiffness modulus. The upper part is assumed to be loaded by Coulomb earth pressure. The pressure acting on the lower part of the sheet pile, below the dredge level, as well as the deformations, are determined from the distribution method. The effects of influencing factors, such as soil characteristics, sheet-pile flexibility, penetration depth, position of anchorage and tie-rod yielding, as obtained from the theory, are generally in agreement with previous experimental and theoretical results. The values of the maximum bending moment and tie-rod load can be read from charts suitable for design purposes.

Underwood, A. E., J. D. Norfolk and J. N. Eathorne

The Design and Construction of the Queen Elizabeth
Graving Dock at Falmouth,
Proceedings, The Institution of Civil Engineers,
London, Paper No. 6407, Vol. 15, pp. 49-64, January 1960

The paper describes the design and construction of a new graving dock at Falmouth. The dock was constructed for the repair of large ships, especially "supertankers" of up to 85,000 tons dead weight and is complete with dewatering pumping station and auxiliary facilities. The new pumping station is connected by culverts constructed in heading to three other docks and will serve all four docks in the future. A siphon discharge system was constructed for the main pumps. A box gate, probably the largest of its type so far constructed, is used to close the entrance to the dock. A gravity steel sheet pile cofferdam was used to enable excavation to proceed in the dry. Excavation was in rock removed by drilling and blasting. Construction was generally in mass and reinforced concrete.

Veillez, A.

Securite effective des rideaux de palplanches metalliques ancrees en tete (safety of head anchored sheet pile wall),
Liege Universite, Memoires, No. 17, December 1966 (In French)

It is shown that value of safety coefficient "n" of passive horizontal resistance adopted for calculation of penetration depth should be carefully re-examined prior to calculation of critical forces determining dimensions of sheet piling; optimum safety condition must be examined by varying value on "n" between 0.70 and 2; calculation must be made on grounds of earth pressure diagram in which passive horizontal resistance behind wall is not taken into consideration.

Verdeyen, J. and J. Nuyens

Analysis of Anchored Sheet Pile Walls,
Proceedings, Sixth International Conference on Soil Mechanics
and Foundation Engineering, Montreal, Vol. 2, pp. 417-421,
1965 (In French with English Summary)

A model test study of the mode of failure and the strength of sheet pile anchors in granular soil. Various depths and sizes of anchorages were studied. The results are tabulated but require further analysis before conclusions can be drawn.

Verdeyen, J. and V. Roisin

Nouvelle theorie du soutènement des excavations profondes,
Annales de l'Institut Technique du Batiment et des Travaux
Publics No. 54, pp. 601-628, June 1952 (In French)

New theory for supports of deep excavations; experience with use of sheet piling as retaining walls has shown that majority of resulting accidents were due to insufficient use of stanchions or inadequate anchorage; new calculating methods for metal sheet piling bulkhead, free at top, supported at top, supported at several levels; propping of deep cuts.

Verdeyen, J. and V. Roisin

Stresses in Flexible Sheet Pile Bulkheads due to Concentrated Loads Applied to the Surface of the Retained Mass,
Proceedings, Sixth International Conference on Soil Mechanics and Foundation Engineering, Montreal,
Vol. 2, pp. 422-426, 1965 (In French with English Summary)

A large number of model tests were performed to determine the additional earth pressure acting on a vertical wall caused by a loaded strip footing running nearby and parallel to the wall. The apparatus measured about 20 cm x 30 cm and was filled with dry sand. The measured pressures were considerably different than those predicted by Terzaghi's theoretical method.

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7. ACKNOWLEDGMENTS

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