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Numerical Simulation of the Effect of Structural Stress Field on Stability of Surrounding Rock in Coal Seam Roadway

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Abstract

To research the effect of structural stress field on the stability of rock surrounding underground roadways, Phase2 software was used in the numerical simulation analysis of the stability of underground roadway in different location in the structural stress field. It is concluded that the stability of underground roadways in axis of syncline are poorer than in wings of syncline. Therefore, it is proposed that, in underground roadways configuration, we should base the appearance regularity of field stress, and prevent roadways arranged in the axis of syncline.

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Keywords: structural stress; stability of surrounding rock; Phase 2

1. Introduction

Tectonic stress comes from the stress produced from the horizontal movement of earth crust in rock mass. The main features of tectonic stress take horizontal stress as the principal thing and have obvious directionality and region. The measuring result of a mass of virgin rock stress around the world indicates that exceeding the high horizontal stress caused by Poisson's ratio exists widely in the underground rock, and horizontal tectonic stress is higher 0.5～0.55 times than vertical tectonic stress, which is higher in complicated geologic condition. One of important factor is tectonic stress that influences stability of wall rock in roadway and directly influences deformation of roadway. With sharply increasing intension of coal miner, people gradually realize that horizontal tectonic stress play an important role in destruction for wall rocks

The 12th layer seam of the axis of syncline of -210m filed stress is just located in MuChengjian mine at axis of syncline with tectonic stress concentration. this text through measurement of mechanics

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parameter for coal seam and roof-floor combining investigation in topography and landform with numerical analysis of stress condition for coal bed , the text is about influence situation of tectonic stress for roadway lying in different places (roadway lying in syncline axle and synclinal two wings)makes numerical analogy analysis, and it is concluded that stress situation of surrounding rocks so as to guide rational layout of workings under the condition of high tectonic stress.

2. The 12th layer seam in the axis of syncline of MuChengjian mine -210m group occurrence condition analysis

The 12th layer seam in the axis of syncline of MuChengjian mine -210m group is a single layer structure, fake roof is siltstone, which fall as mining; immediate roof is fine-grained sandstone, which' bedding is well developed, rock hardness is hard, immediate floor is sandstone, which' joint develop. Due to long-term old tectonic movement for coal bed and now upheaval from tectonic movement stratum and the settlement of the geological activity, shaping syncline coal seam. Under the influence of syncline structure, stress state in this area and influence on exploitation show obviously different in compare with other coal bed.

Tectonic stress is focus on the area that geologic structure move strongly, for example the place of the radius of curvature is small in belt of folded strata, the place a thickness of rock occur to twist, near single-layer, especially, the place of fault end and two faults meet, and the place thickness of bed of rock change radically, such as crustal of the bottom of the valley is usually bigger than flat area at the same depths; if roadway is excavated in the parts, owing to stress concentration, it can give rise to horizontal stress is higher than vertical stress, doing destruction to the roadways. the 12th layer seam of syncline's axis of -210m filed stress in MuChengjian mine, according to theoretical analysis and stress measurement data in under pit, it can make sure this coal body is in high stress state, so it is very important to analyze in detail the disposition of the roadway.

3. Numerical calculation

3.1. numerical model

The 12th layer seam of the syncline's axis of -210m filed stress in MuChengjian mine located in the syncline's axis and two wings of area nearby, axis plunge to the northward the dip angle 28°; the dip angle of rock formation and coal seam of two wings is 44°～84°, local have turned back in the south (see figure 1).

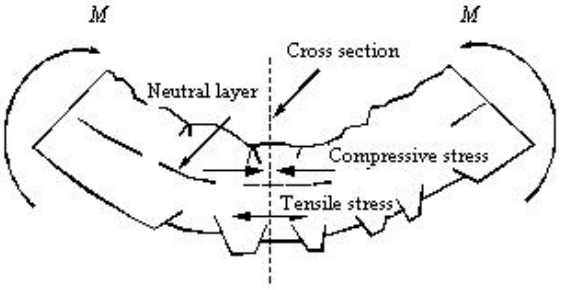


Fig.1 Mechanical diagram of syncline

As it is known from crustal stress measurement and numerical analyze: crustal stress field in MuChengjian mine belong to horizontal stress field, horizontal tectonic stress managing tectonic stress make sure that the regional structure tectonic stress field ,with a maximal orientation of NE90°. Maximum of syncline axle tectonic stress field is plumb. So, synclinal axle suffers from compressive force that is nearly horizontal from structure stress field, the axis of rock mass present high stress state(see figure 2).

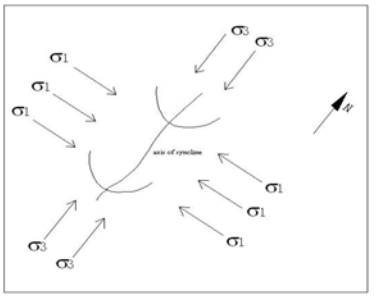


Fig.2 Measurements of field stress and relative position of MuChengjian syncline

Structure stress field is both element of rock mass and the environment of rock mass, when roadway lie in different place, stabilization of surrounding rock in roadway vary widely. in order to explore the influence of surrendering rock from the 12th layer seam with syncline stress field different place, this text apply to Phase2 ground numeral analyze software launched by Rocscience Company of Australian, on the basis of realistic geologic condition near mining area the 12th layer seam coal bed at -210msyncline axle and stabilization of different surrendering rock locating in syncline structure in the roadway.

Roadway in coal seam mainly is rectangular roadway, this text chooses rectangular roadway as excavating model, and upper base× bottom× height for model is 24m×24m×18m, base× bottom× height according to the real standard for roadway is 2.4m×2.4 m×1.8m. In the same conditions, roadway in syncline axle and roadway in synclinal two wings is founded numerical calculation model to analyze.

Due to the 12th layer seam at syncline axle of MuChengjian mining area lies in -210m～+140m horizontal, according to real measurement for crustal stress locating in MuChengjian mine -310m horizontal first cross-hole in the east of to commutate, it is concluded measure result of -210 horizontal crustal stress(see table 1).

Tab.1 Table of -210m filed stress in MuChengjian mine

location	Principal stress category	Principal stress value /MPa	azimuth/(°)	dip angle/(°)
-210m filed	major principal stress σ_1	13.82	90.12	17
	Intermediate principal stress σ_2	10.74	-46.34	67.16
	minimum principal stress σ_3	9.19	184.75	14.82

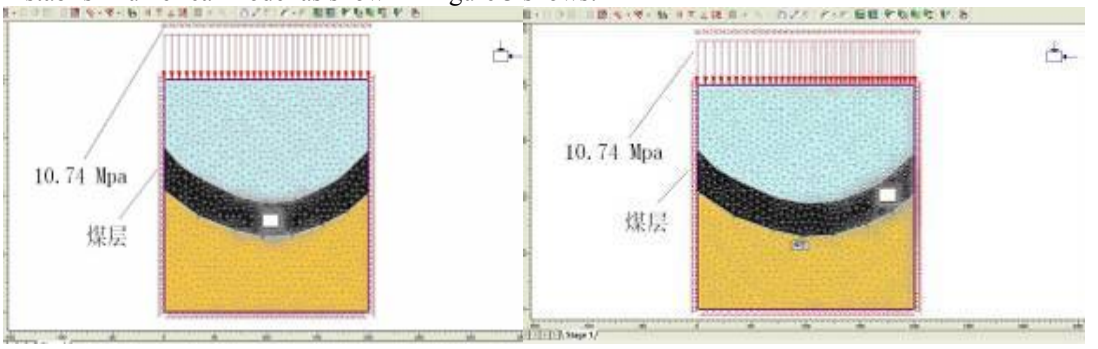
Parameter of physical mechanics of wall rock after acquisition and laboratory measurement as follows (see table 2).

Tab.2 Summary table of mechanical parameters results of roof and floor and the 12th layer seam in MuChengjian mine

Rock name	Rock Numbers	Natural depending on the density (kg/m3)	Tensile strength (MPa)	Compressive strength (MPa)	Elastic modulus (MPa)	Poisson's ratio (μ)	cohesion (MPa)	Internal friction Angle (°)	Rigidity coefficient (f)
Coal	Coal	1890	2.05	31.4	3886	0.21	2.85	45	1.0
Packsand	Roof	2656	5.70	46.16	8546	0.19	6.84	47	4.6
Siltstone	Floor	2706	6.99	53.25	9088	0.17	8.60	46	5.3

Coal seam in -210m the 12th layer seam is single layer structure, coal seam with a thickness of 1.1～8.7m, average at 4.4m, false roof is siltstone with a thickness of 0.7m, which fall as mining; immediate roof is fine-grained sandstone with a thickness of 27m, which is well developed, rock hardness is hard, immediate roof is sandstone with a thickness of 26m, which joint developed.

Establish numerical model as shown in figure 3 shows:



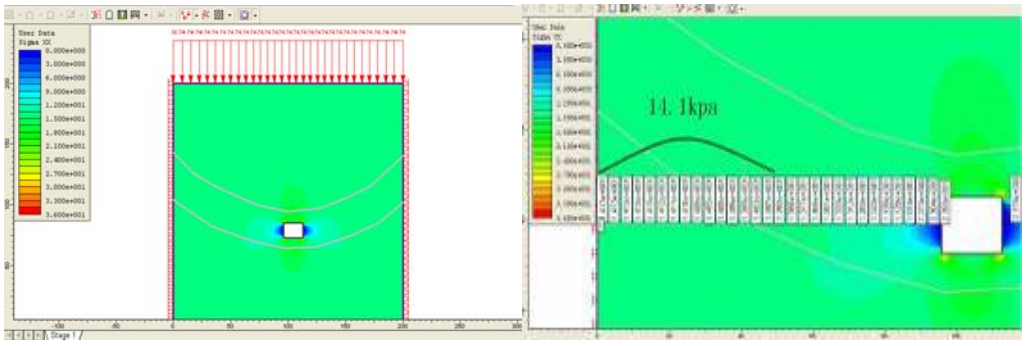
a -Roadway located in synclinal axis b- Syncline located in wings of roadway

Fig. 3 Roadway model

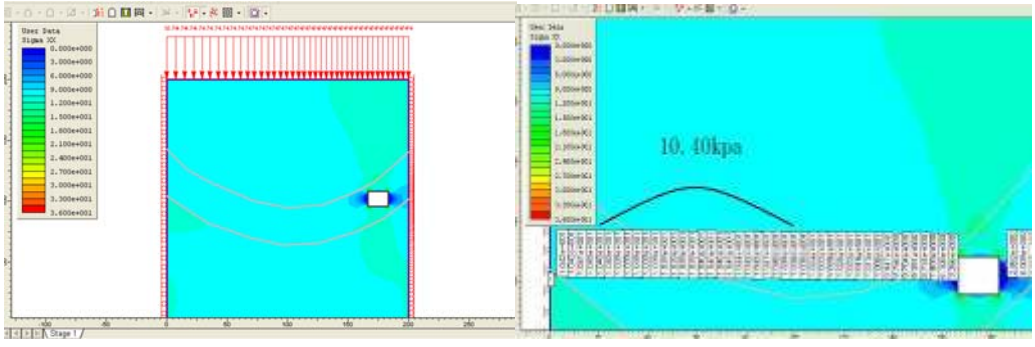
3.2. Numerical simulation analysis of the results

3.2.1. Surrounding rock stress distribution analysis

Coal gateways which located in from the axis of the surrounding rock of two wings and when stress simulation (see figure 4) :



a -Distribution of horizontal force when roadway in synclinal axis



b -Distribution of horizontal force when roadway in wings of roadway

Fig. 4 Stress simulation of surrounding rock

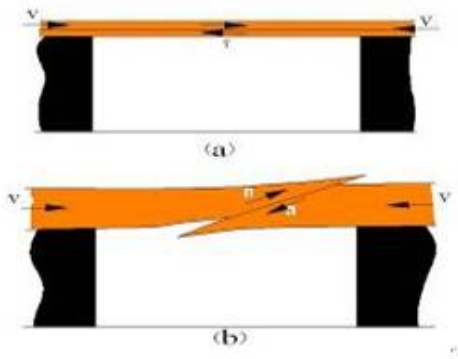


Fig.5 Collapse of roof effected by horizontal field stress

a- Carbonaceous shale roof of thin layer b -Thick sandstone roof

By above knowable, when roadways lie in syncline axle, horizontal stress on the both side of the roadway gradually increase up to 14.31kpa, but when roadways lie in synclinal two wings, horizontal

stress on the both side of the roadway gradually increase up to 10.54kpa, so horizontal stress on the both side of the roadway is higher, therefore, two sides of the roadway are more easy to deform. When roadways lie in syncline axle, the roof in the roadway suffers great shear stress owing to horizontal stress. There might be two forms of destruction for roof in the roadway: one is that thin-layer shale rock slips along bedding plane (see figure 5a), the other is thick-layer sandstone rock produces shear stress in small angle or along minor faults (see figure 5b), so when roadway lies in syncline axle, roof in the roadway is more easily unstable and caving under high horizontal tectonic stress, but the main destruction formation of roof is shear from roadway. At the same time, when roadway lies in syncline axle, high horizontal stress is one of main factors which bring about destruction for floor strata and floor heave, so under the condition of high horizontal tectonic stress in syncline axle, floor in the roadway more easily bulges to destroy. The two cases both emerge stress concentration in the corner of roadway, which easily is destroyed and is focal point for roadway maintaining. By above knowable in compare through stress, when roadway lies in syncline axle, it isn't instable and isn't maintained, layout of roadway is avoided at the syncline axle.

4. Conclusion

By stress situation of coal roadway laying in synclinal shaft and two wings numerical simulation analyze, it is known that it at the axis of syncline deteriorate and two side roadway is more easier to deform, upper plate and lower plate tend to been destroyed because wall rock' stress of roadway is high, the safety factor is low.

The 12th layer seam of the axis of syncline of -210m filed stress is just located near MuChengjian in syncline axle and two wings, where the tectonic stress exceed gravity stress of overlying rocks by a large margin. Thus, we should dispose the roadways according to the manifested rules of the tectonic stress, avoid laying them in axis of syncline. However, if it is inevitably influenced by the high horizontal stress at the axis of syncline, we'd better to adjust the connection between gateway direction and tectonic stress to maintain roadway, to choose rationally shape of section of a roadway and supporting method so as to service for coal producing better from now on.

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