DEVELOPING LAW OF WATER-CONDUCTING FISSURE ZONE AND STRESS VARIATION①

Xu Guoyuan, Gu Desheng, Chen Shouru
Department of Resources Exploitation Engineering, Central South University of Technology, Changsha 410083

ABSTRACT Based on previous study, the intrinsic relationship between the developing of water-conducting fissure zone (W-F Zone) and the stress variation in surrounding rocks of the roof has been analysed by means of numerical simulation. It had been proved that the developing of W-F Zone was dominated by tensile stress, and the numerical simulation could be used to predict the developing of W-F Zone.

Key words backfilling method numerical simulation stress state water-condlucting fissure zone

1 INTRODUCTION

Kuanjiawan ore bodies are underneath water bodies. In this case, their mining is rather complicated, the problems involved are interesting and important. One among these problems is the developing law of W-F Zone in roof surrounding rock, but the research work about it at home and abroad is very limited. Therefore the designers have to refer the empirical formulas from colliery[1] to predict max developing height of W-F Zone in this metallic mines. It is known that the differences between colliery and metallic mines, such as mining technique and surrounding rock conditions are obvious. According to the requirement of the study on mining of Kuanjiawan orebody No. 1, the authors investigated the developing law of W-F Zone by means of a numerical simulation, and the results showed that the developing of W-F Zone in the overlying strata is not only related with the thickness of orebody but also to volume of the worked-out stope, original stress state, with or without intervening pillars, and the mechanical properties of cementing tailings[2]. In the paper, the investigation is focused on the relationship between the stress variation and the development of W-F Zone in the roof in order to reveal the mechanism of developing of W-F Zone.

2 FEATURE OF SURROUNDING ROCK STRESS AND FORM OF DEVELOPING OF W-F ZONE

2.1 *Modeling Conditions*

The orebody is flat, gently inclined and of medium-thickness, its thickness is 12 m and depth is −405 m. In design, two-steps stoping was adopted, the width of room was 12~13 m, artificial pillar of cemented tailings with a constitution ratio 1∶5 were being contacted with roof. The room was filled with full tailings uncontacting with roof. The stope is perpendicular to the strike, and the model is set along the strike. Therefore, the model may be regarded as a plane strain model. For further simplifying calculating, it is postulated that the model is elastic and symmetrical about centre line, and one half of it is put into calculating as shown in Fig. 1. Where S_c and B express the worked-out stope scale and lateral dimension of the model, respectively. When S_c is 100 m, 200 m, 300 m, 400 m, the correspondent B is 300 m, 400 m, 500 m, 600 m.

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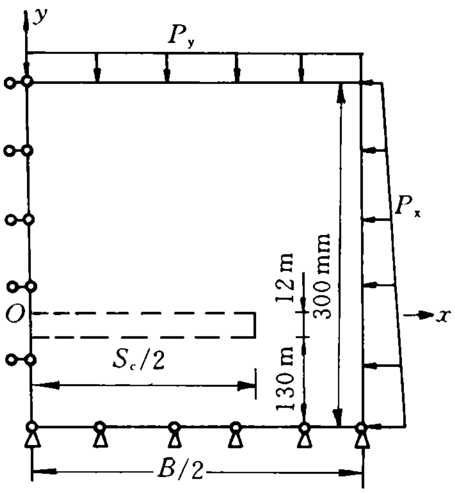

Fig. 1 Schematic diagram of model

On the model, the load is exerted on the external boundaries as shown in Fig. 1, and it is expressed of times of sole weight of overly strata:

$$P_y = 0.01 h_i \gamma, \text{ MPa} \quad (1)$$

$$P_x = 0.01 \lambda h_i \gamma, \text{ MPa} \quad (2)$$

where h_i —the distance from surface to a point on the model vertical boundary, m; γ —weighted average volume weight of overlying strata, 10^3kg/m^3; λ —average side-compression coefficient, provided $\lambda = 0.19$, stress field caused by gravity is simulated on the model.

In the digital simulation studying, the theory of maximum tension and Mohr-Columb have been adopted to determined the W-F Zone occurred in roof; no tensile stress criterion and Mohr-Columb theory have been adopted to determine maximum latent W-F Zone possibly produced. The max height and configuration of the zone are disignated to express the developing feature of W-F zone.

In addition, the mechanical parameters of ore, rock and cemented tailings which should be put in the model are listed in Table 1.

2.2 *Results of the Model Study*

2.2.1 The developing of W-F Zone

When S_c is 100 m, 200 m, 300 m, 400 m, the correspondent developing forms of W-F Zone are shown as Fig. 2(a), 2(b), 2(c), 2(d), and the max height of the zones is listed in Table 2. Where H_{am} and H_{pm} are, respectively, the max height of the W-F Zone occurred and the max height of the maximum latent W-F Zone possibly produced.

The results showed that if the S_c varies, the distribution of the height of W-F Zone occurred in roof will be in form of character "W", and along with S_c widening H_{am} is increasing. Whereas the distribution of the height of the possibly produced, max, latent W-F Zone is obviously in form of U-shape. In the range $S_c \leqslant 200$ m, H_{pm} is increasing along with S_c widening; $S_c = 200 \sim 300$ m, H_{pm} keeps unchanged; S_c widens from 300 m to 400 m, H_{pm} decreases gentlely.

According to the criteria, it's known that the W-F Zone occurred can not be beyond the scope of maximally latent W-F Zone. So the later can be considered as the mean to predict the developing of the zone. Based on the variation of H_{pm} versus S_c, the developing form of the zone can be seen that when $S_c \geqslant 200$m, the zone has developed into stabilization stage, and H_{pm} is not increasing anymore, but the location where H_{pm} occurred moves forward along with S_c widening.

Table 1 The mechanical properties of rock and cemented tailings

Sample	Unit Vol. Weight γ /t·m^{-3}	Tensile strength σ_t /MPa	Comp. strength σ_c /MPa	Elastic modul E /10^{4}MPa	Possion ratio μ	Cohesion C /MPa	Inter friction angle φ /(°)
Rock	2.85	4.757	67.76	3.578	0.16	9.11	60.53
1:5 cemented tailings	2.22	0.838	4.54	0.127	0.19	0.98	43.48

Table 2 The max height of W-F Zone

S_c /m	H_{am} /m	H_{pm} /m
100	8	44
200	20	85
300	24	85
400	32	83

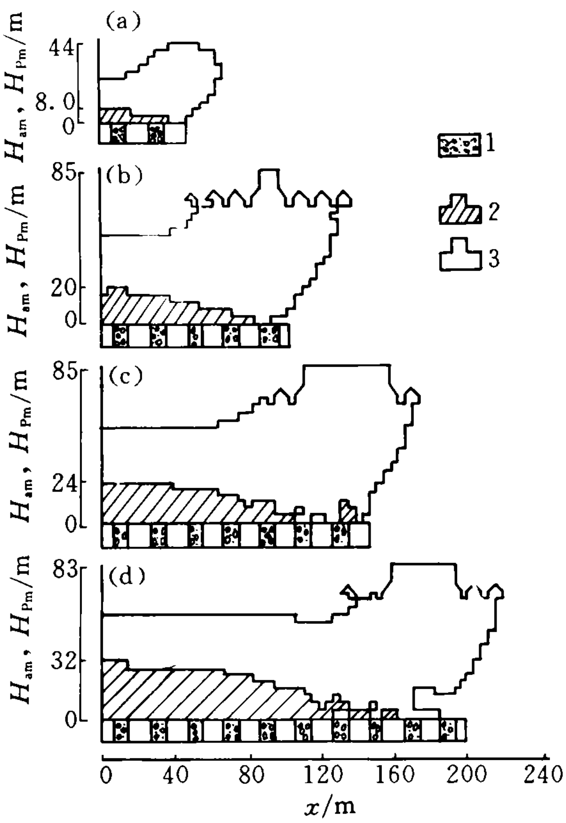

Fig. 2 The developing pattern of W-F Zone in roof

1—artificial pillar; 2— W-F Zone occurred; 3—the maximally latent W-F Zone possibly produced

2.2.2 The varying features of stress state of roof surrounding rock

When S_c is 100 m, 200 m, 300 m, 400 m, the max and min principal stress' variation at level 2 m, 30 m and 62 m above the worked-out area are shown in Figs. 3 and 4, respectively. From the two Figs., it can be found that at the same level y, the σ_3 (or σ_1) is varied in same way in spite of the S_c changing.

At $y = 2$ m level, in whole worked-out area, the σ_3 changing is presented in wavelike form; near the boundary, σ_3 gently compressive stress concentration occurres.

As regard of 30 m $\leqslant y \leqslant$ 62 m, $S_c = 200$ m, 300 m, 400 m, the σ_3 near boundary of worked-out stope is tensile; along with the x extending, the σ_3 will turn to compressive and reach its limit; if the x extends further, the σ_3 will decrease. The σ_3 range mentioned above is defined as σ_3 characterized range, shown as Fig. 3. In the Fig. 3, it is illustrated that as y keeps unchanged, along with S_c widening, the σ_3 characterized range moves forward, and the σ_3, in some field of middle part of roof, turns to compressive from tensile; when S_c is unchanged, in some section of middle field of roof, along with y rising, σ_3 will turn to compressive from tensile.

The variation of σ_1 in roof rock is charac-

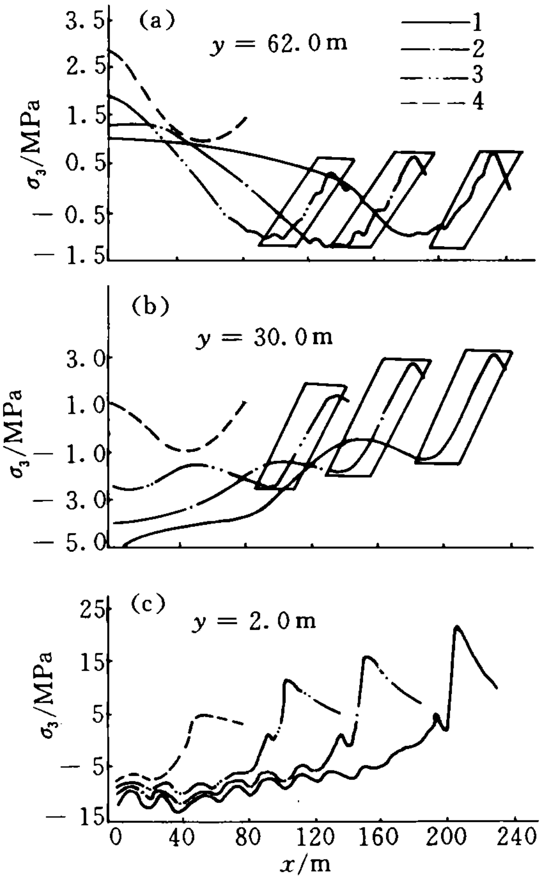

Fig. 3 The variation of σ_3 at different levels

1— S_c = 400 m; 2— S_c = 300 m; 3— S_c = 200 m; 4— S_c = 100 m terized by the occurrence of compressive stress concentration near the boundary of worked-out area. When the y keeps unchanged, the compressive stress concentration strengthens gentlely as S_c widens. However, when S_c is unchanged, the compressive stress concentration weakens obviously along with y rising.

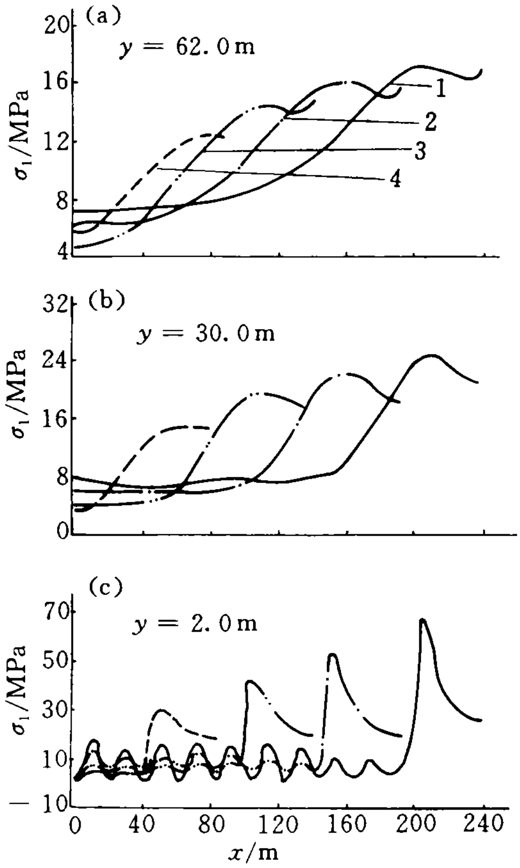

Fig. 4 The variation of σ_1 at different levels

1— S_c = 400 m; 2 S_c = 300 m; 3— S_c = 200 m; 4— S_c = 100 m

Sum up the results as following: as the artificial pillars and filling with tailings act together, the stress state in roof rock has been improved, and compressive stress concentration occurring near the boundary of worked-out area has got controlled. When $S_c \geqslant 200$ m, the σ_3 characterized range moves forward, but the highest point where σ_3 is tensile will not rise as S_c widens. It is obvious that when y keeps unchanged, in some field of middle part of roof, σ_3 turns to compressive from tensile along with S_c widening.

2. 3 *The Relationship Between Roof Surrounding Rock Stress and Developing of W-F Zone*

Both the fracture caused by tension and damage caused by shear stress, where compressive stress concentration occurres, are the two main reasons resulting in developing of W-F Zone. Actually, when the two-steps mining method is adopted the artificial pillars and filled tailings can support the roof effectively, limit the deformation and subsidence of roof, and may lead the stress concentration to be under control. Under the simulated conditions, no shear failure can be found. In other words, the developing of W-F Zone is controlled by the distribution of tension. In the paper, when $S_c \geqslant 200$ m, the changing pattern of H_{pm} virsus S_c and σ_3 virsus S_c is similar to each other, and it proves the view mentioned above.

3 CONCLUSIONS

(1) When two-steps mining is adopted, the developing pattern of W-F Zone in roof rock is dominated by tensile stress.

(2) Under the simulated range, i. e. when $S_c \geqslant 200$ m, the developing of W-F Zone is in stable state. H_{pm} stops increasing, but its location removes forward as S_c widens.

(3) The numerical simulation can be used to predict the developing of W-F Zone resulting from back filling so long as the S_c is beyond a given range, otherwise, the result is not credible, for example, in the paper, $S_c \geqslant$ 200 m.

REFERENCES

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2 Xu Guoyuan *et al*. Nonferrous Metals (in Chinese), 1990, 42(4): 18—24.

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