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Research on environmental prediction based on linear regression model

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ABSTRACT

Environmental prediction in metal mine has been the main problem which interferes with mining working at depth. And its corresponding formation mechanism is so complicated that the environmental prediction theory cannot come up with the practical engineering research. So it is necessary to establish the corresponding geological structure stress model of the mining area studied, analyze its mechanism and put forward the prediction of environmental prediction location in mining area. Based on the corresponding geological structure stress data of chongqing mine in Sichuan, this paper establishes the three-dimensional finite element modeling with numerical simulation, in order to calculate, analyze and predict the structure stress and the location where the environmental prediction may occur within the range of 3 kilometers in this mine.

Keywords: Metal mine; environmental prediction; linear regression model

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INTRODUCTION

Environmental prediction is a natural disaster which loses dynamic balance. Due to the great geostress, the excavation load leads to the differentiation of stress and the sudden release of the elastic energy in rock mass. Directly affects the working efficiency of the metal mining enterprises, increases its economic costs, and even leads to safety accidents. How to forecast environmental prediction in mining process effectively, has become one of the challenges faced by the underground project worldwide. environmental prediction prediction is mainly based on the forming mechanism of environmental prediction from the qualitative or quantitative analysis of the environmental prediction orientation, and the research methods mainly include the theory analysis and the field measurement method. Currently, a completed and mature set of theory and method has not yet formed either at home or abroad. With the development of computer science and technology, the applications of artificial intelligence, expert system and numerical analysis have become an important direction in environmental prediction prediction [1]. This paper studies the environmental prediction of mining at depth in chongqing mine, Sichuan. The main method is the application of ANSYS finite element analysis simulation tools, setting up the three-dimensional geostress model, analyzing the region stress and local mining roadway by finite element, combined with the corresponding numerical analysis structure, studying its mining energy distribution law of surrounding rocks. Whether the burst would come out or not and the corresponding damage degree are predicted in terms of the related criteria of environmental prediction. Through this method, the environmental prediction position and destruction area can be determined in the practical engineering process of mining at depth, providing the corresponding regional stress field distribution and the corresponding basis for safety production, which guarantees the safety of staff underground as a result.

Analysis of tectonic stress environment of chongqing mine in Sichuan

After 30 years of mining in chongqing mine, the main mining site is deeper than 500m, and the corresponding development engineering has reached the depth of 1100m. According to the relevant engineering experience, the exploit depth has been near the critical point of environmental prediction. Its main feature is the tectonic stress of mining area is very high, and the shallow horizontal stress on the surface is greater than gravity stress. Because of the influence of the corresponding mining work, stress concentration area has emerged in this region, large energy is gathered inside the rock mass, and the condition of environmental prediction has developed. On the basis of geological and stress data until now, the residual tectonic stress on horizontal direction is huge, and two horizontal stress of its weight, have separately become a maximum and minimum principal stress, that is: $\sigma_2' = \sigma_2' = (0.25\sim0.40)\sigma_z$, gravity maximum vertical stress becomes a principal stress stress field under the condition of gravity: $\sigma_2 = \sigma_z$. The east side of chongqing mine: $\sigma_1 = (2.17\sim3.33)\gamma h$, $\sigma_3 = (0.33\sim0.59)\gamma h$; The west side of chongqing mine:$\sigma_1 = (1.27\sim2.16)\gamma h$, $\sigma_3 = (0.27\sim0.59)\gamma h$. The planar projection of the main ore body of chongqing mine is shown in figure 1.

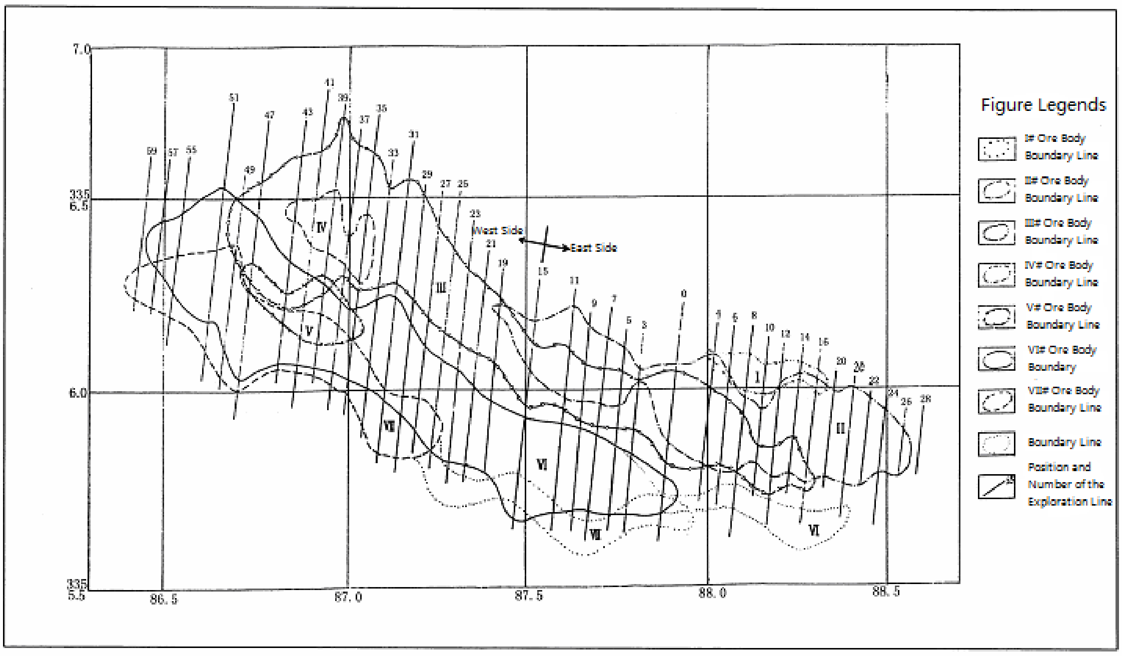

Fig.1 Planar Projection of Ore Body in chongqing Mine

Numerical modeling for chongqing mine

Numerical modeling of finite element. In the process of deep mining, misestimating the stress of the surrounding rock mass will make the environmental prediction suddenly, impacting the production progress and the safety of the staff; Under estimating the strength of the surrounding rock mass will make the mining and project design too conservative, increase the mining cost, which leads to waste the corresponding financial and material resources. Because the analysis of the mine stress field is a complex result combined with multiple factors, the three-dimensional finite element model is chosen for analysis and calculation according to the actual situation of engineering in chongqing mine area. Setting the measured geostress information as the calculation reference points of the finite element numerical simulation method, makes the corresponding structure closer to the actual situation.

The establishment of finite element three-dimensional modeling

The 1:5000 prospecting line section map, 1:5000 present situation map of the mining environment and 1:1000 geographical cross-section diagram between -430m and -640m level are collected as the main geological data of chongqing mine. Taking computer processing speed and accuracy requirements into account, a total range of 3 kilometers is chosen from the mine, east to the production department, and west to Xi Wang Chong. Mining depth selection is mainly based on the following two aspects, one is to assume the coordination of the model size, therefore, -1000m is selected as the altitude; The other is for the reference of related documents and to calculate the structure, only -430m~800m need to be considered. Bottomless sublevel caving mining is applying in chongqing mine. In the modeling process, due to the influence of strata subsidence zone, -428m~150m is approximately set as the subsidence zone, whose upper angle of -430m level is 55° and lower angle 65°. The finite element model of chongqing mining area is shown in figure 2.

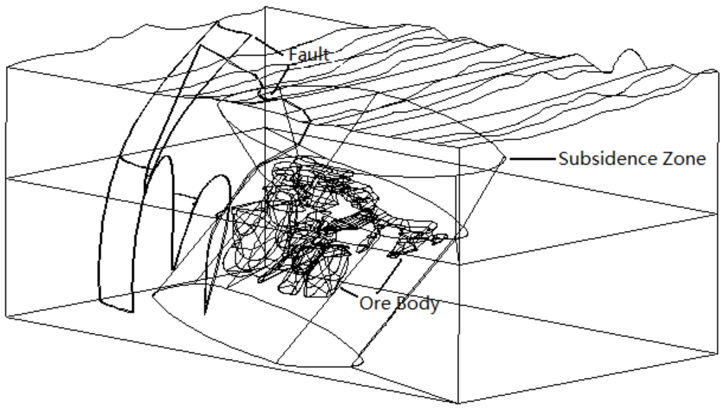

Fig.2 Finite Element Modeling of chongqing Mine

Yield criterion. Mohr-Coulomb yield surface has some defects in practical engineering application. When the stress is located in or near the corners, it is so hard to determine the outer normal derivative of yield function along the surface that the numerical calculation for viscoplastic strain rate cannot be accurate. Drucker-Praher modified it based on Mohr-Coulomb and Mises criteria:

$$f = \alpha I_1 + \sqrt{J_2} - K = 0 \tag{1}$$

In the above formula: I_1 and J_2 are the first constant of stress tensor and the second constant of stress deviator respectively. α and K are internal friction angle of rock and experimental constant of cohesive force respectively:

$$\alpha = \frac{2\sin\varphi}{\sqrt{3}(3-\sin\varphi)} \tag{2}$$

$$K = \frac{6\cos\varphi}{\sqrt{3}(3-\sin\varphi)} \tag{3}$$

Finite element modeling of stress in mining area. The distribution nephograms of vertical maximum principal stress σ_1 both in mining area and ore body are shown in figure 3 and figure 4. After mining at -430m level, large tensile stress exists at -500m level, the maximum stress is 14.5 MPa. The main reason is that influenced by the upper mining and engineering, large mined-out areas or loose covering layers appear and the concentrated underground stress comes out. With the mining depth increasing, the tensile stress changes into compressive stress, and its quantity increases. The three-dimensional simulation results show that there exists a high geostress field in chongqing mining area, whose depth is 1000m and the maximum value 44 MPa.

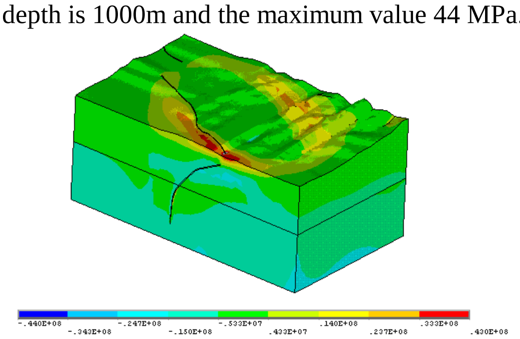

Fig.3 Vertical maximum stress nephogram of the mining area

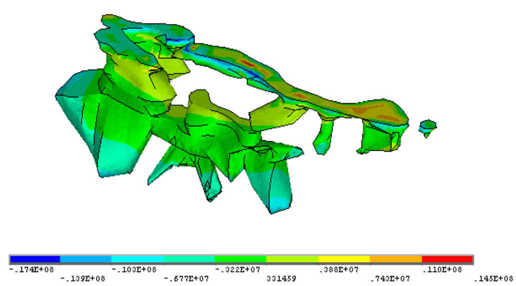

Fig.4 Vertical maximum stress nephogram of the ore body

LINEAR REGRESSION MODEL

The theory-oriented lectures cover single linear regression and multiple linear regressions. Students learn what regression is, how to create its mode, how to estimate the parameters of the model (Estimation Using Least Squares), understanding the assumptions of establishing the conditions for the model, what the regression coefficients are, how to compare the models, and predicting and controlling using regression model. Teachers start theirs lectures with a discussion of simple regression, then, move on to multiple linear regression. This is quite reasonable from a pedagogical point of view, since simple regression has the great advantage of being easy to understand graphically.

Students should place a lot of emphasis on the simple linear regression analysis and understanding its mathematical expressions and be open to more sophisticated concepts. It is difficult for students to study multiple linear regression analysis. However, it is a primary tool in the analysis of real data. Thereby, single linear regression is taught in six sessions, while multiple linear regression requires four sessions. A session is 90 minutes' duration.

Single linear model describes a linear relationship between two variables. One is called the target, response or dependent variable, and is usually represented. Another is called the predicting or independent variables, and is usually represented by x . Given (x1 , x2 ,Λ, xN) , the simple linear regression model is described as:

$$C_{\min} = \sum_{i=1}^{N} \left\{ k_i + C_i X_i + \frac{1}{2}[Y_i(j+1)] \cdot h_i \right\}.$$

$$X_i + Y_i(j) - Y(j+1) - \sum_{i \in R} (1+\delta) q_i = 0,$$

where the data, xi , yi , represent a random sample from a larger population, which consist of n set of observations, the coefficients are unknown parameters, and i are random error or disturbance terms.

FEEDBACK EXERCISES

In the spring semester of the 2012/2013 term, a total of 60 junior students came from two majors, , joined the course at the Xinxiang University, Xinxiang, China. These students already had joined some previous courses, such as mathematical analysis, advanced algebra, probability and statistics, etc [5]. They also demonstrated a certain level of operating computer software capability. A survey questionnaire with six feedback questions was administered to all of these students (shown in Table 1).

Tab.1: Feedback questions

Questions		Majors		Mean
		Computerscience (students30)	Mathematics (students30)	
1	I becameinterestedindataanalysisthroughthisclass.	27 (90%)	28 (93%)	92%
2	I understandtheconceptoflinearregression.	24 (80%)	26 (87%)	83%
3	I performedthelinearregressionusingMATLABprogram.	27 (90%)	26 (87%)	88%
4	I performedthelinearregressionusingMSExcel.	29 (97%)	29 (97%)	97%
5	I thinkthepracticeis usefultounderstandtheconceptof linearregression.	30 (100%)	30 (100%)	100%
6	I canapplymyknowledgeof mathematicsbyperforming theexperiment.	24 (80%)	25 (83%)	82%

There are too many formulations about regression analysis. It is often difficult to understand these concepts of regression analysis, said some students. As can be seen from student feedback, only 80% of computer science students can understand regression, while 87% of mathematics students can do so. However, almost students finished their experiments, and all of them think the practice is very useful to understand those concepts. This information shows that students' interest will be enthused if theory is combined with practice, and as long as theory explanation is not ignored.

Its objective is to strengthen their statistical skills. One of the authors received and accepted the teaching load. Hence, sharing the teaching experience is the objective of this article.

THEORY TEACHING

The theory-oriented lectures cover single linear regression and multiple linear regressions. Students learn what regression is, how to create its mode, how to estimate the parameters of the model (Estimation Using Least Squares), understanding the assumptions of establishing the conditions for the model, what the regression coefficients are, how to compare the models, and predicting and controlling using regression model. Teachers start theirs lectures with a discussion of simple regression, then, move on to multiple linear regression. This is quite reasonable from a pedagogical point of view, since simple regression has the great advantage of being easy to understand graphically.

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SINGLE LINEAR REGRESSION MODEL

Single linear model describes a linear relationship between two variables. One is called the target, response or dependent variable, and is usually represented by y. Another is called the predicting or independent variables, and is usually represented by x. Given $(x_1, x_2 \ldots x_N)$, the simple linear regression model is described as:

$$\begin{cases} y_i = \beta_0 + \beta_1 x_i + \varepsilon_i \\ \varepsilon_i \sim N(0,\sigma^2)\, and\ \operatorname{cov}(\varepsilon_i, \varepsilon_j) = 0\ when\, i \neq j \end{cases} \quad (1)$$

where the data $\{x_i, y_i\}$, represent a random sample from a larger population, which consist of n set of observations, the β coefficients are unknown parameters, and β_i are random error or disturbance terms.

LEAST SQUARE ESTIMATION

A primary goal of a regression analysis is to estimate the relationship between the predictor and the target variables or equivalently, to estimate the unknown parameter β. This requires a data-based rule or criterion that will give a reasonable estimate. The standard approach is least squares regression which is a convex optimisation problem with no constraints. The objective is a sum of squares of terms of the form that are chosen to minimise:

$$\sum_{i=1}^{n} [y_i - (\beta_0 + \beta_1 x_i)]^2 \quad (2)$$

The scatter diagram gives a graphical representation of least squares, which can help students to understand regression graphically. If the fitted regression equation has been obtained, it is a line given by:

$$\hat{E}(y) = \hat{\beta}_0 + \hat{\beta}_1 x \quad (3)$$

Residuals are defined as the difference between the observed value and the fitted value $\hat{y}_i$. Equation (2) minimises the sum of squares of the residuals if the coefficients β take as the fitted coefficient $\hat{\beta}$. By minimising Equation (2), the regression coefficients are obtained by:

$$\begin{cases} \hat{\beta}_0 = \bar{y} - \hat{\beta}_1 \bar{x} \\ \hat{\beta}_1 = S_{xy} / S_{xx} \end{cases} \quad (4)$$

where $\bar{x} = \frac{1}{n}\sum x_i, \bar{y} = \frac{1}{n}\sum y_i, S_{xx} = \sum (x_i - \bar{x})^2, S_{XY} = \sum (x_i - \bar{x})(y_i - \bar{y})$

Evaluation of environmental prediction

Sufficient and necessary conditions of environmental prediction in mines are as follows. Firstly, the rock itself can store a lot of elastic strain energy; secondly, there exists the related environment to produce high stress and accumulate energy. Based on the finite element calculation and analysis, the distribution features and quantity of the elastic strain energy in surrounding rocks after deep mining can be obtained, the calculation formula is:

$$W_e = (\sigma_1 \omega_1 + \sigma_2 \omega_2 + \sigma_3 \omega_3)/2 \quad (4)$$

In the above formula: σ_1, ε_1, σ_2, ε_2, σ_3, ε_3 are the principal stress and strain of rock unit respectively. Related researches at home and abroad as well as the field monitoring show that, if the internal elastic energy of rock mass reaches or exceeds $1.0\times10^5 J\cdot m^3$, corresponding impact ground pressure and environmental prediction will happen. Figure 5 is the elastic strain energy distribution nephogram of mining area at -430m level, and the related calculation results show that the rock mass has high horizontal elastic energy at -500m, as shown in figure 6. When mining below -500m, there will be the phenomenon of environmental prediction and ejection.

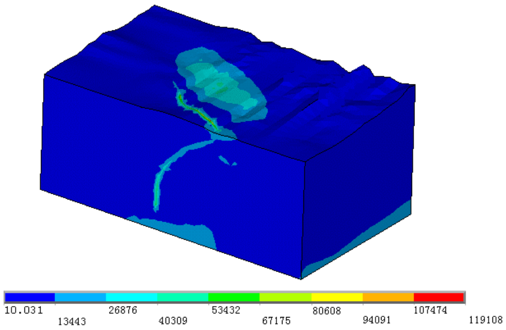

Fig.5 Variation nephogram of elastic energy in -430m mine area

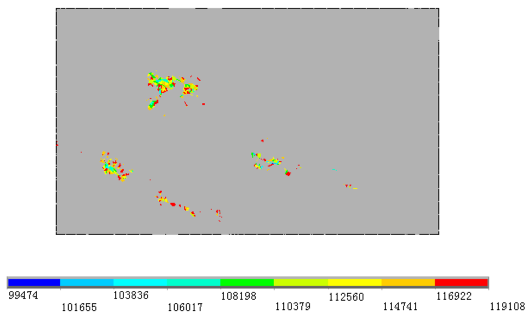

Fig.6 Variation nephogram of elastic energy in -500m mine area

CONCLUSION

Aiming at the structure stress circumstances of chongqing mining area, applying numerical simulation of finite element method, establishing the three-dimensional finite element model of chongqing mine, setting the corresponding yield criterion, the experimental results show that the maximum tensile stress is 44 MPa at -1000m in chongqing mine. On this basis, this paper studies the location where the environmental prediction may occur in the mine area. Through the corresponding judging criteria of environmental prediction, continual mining under -500m in the mine area will lead to environmental prediction or rock ejection for sure.

REFERENCES

[1] Guo Li. The model to dynamically predict environmental prediction proneness of hard rock at depth and its application, D. Central South University, Changsha. (**2009**) 1-2.
[2] Gu De-sheng, Li Xi-bin. Science problems and research state of deep mining in metal and nonferrous mines, C. The fifth academic annual conference papers of China Nonferrous Metal Institute. Mining research and development magazine, Changsha. (**2010**) 1-4.
[3] He Man-chao, Xie He-ping, Peng Su-ping. *J. Chinese Journal of Rock Mechanics and Engineering*. 24 (**2009**) 2803-2813.
[4] Miu Xiao-jun, Wu Ji-min, Li Jing-bo. Causes of environmental prediction in circular chambers and its geological disaster analysis, J. Journal of Hohai University (Natural Sciences). 30 (**2011**) 37-40.
[5] Zhu Qi-hu, Lu Wen-bo, Sun Jin-shan. *J. Engineering Journal of Wuhan University*. 40 (**2007**) 84-87.