Study on Security Appraise Method of Mining under “Three Bodies” in Mining Area

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Abstract: Recently year, the problem of safety mining under buildings, water bodies, and railways and highways is very serious; this paper aims at this problem, and analyses the complexity, diversity and uncertainty of mining damage, at the same time, it bases on the theory of probability and integral and the measure of computer simulation, and sets up the appraise system of mining under surface protection buildings by the main ideology of “‘mining project’ –‘movement and deformation about overburden rock strata’ –‘surface protection buildings’ –‘mining damage and protection’ “, and it has been widely applied. Practices have proved that this appraise system is strong, it is not only one of the credible methods, but it is one of the effective methods about mining industry sustainable development.

Key word: mining under “three bodies”; security; mining damage; environment protection

I. INTRODUCTION

In china, with economy quickly developed, requirement of energy will be quickly increased too, in 2001 output of coal is 1.11 billion ton, but in 2005, it has exceeded 2.0 billion ton. Owing to coal mining has the character of great bound and high intensity, which leads extraction reserves of mine badly lack and mining term shorten. But at present, coal reserves of national mines under buildings, water bodies, railways and highway reach to 13.89 billion ton, how to safety mining under buildings, water bodies, railways and highways (hereinafter shortened form mining under “three bodies”), which is one of the effective pathways about prolonging mine mining term, increasing effective extraction resource ratio and improving mine technique and economy benefit, at the same time, it is one of the important and in dire need of resolving technique difficult problems. Mining subsidence damage is becoming graveres, mostly damages: damage of civilian house, industry buildings and social commonality establishment; damage of infields and vegetation; damage of railways and roadbed and pavement of highways, damage of supplying water, supplying power and communication canals or lines; damage of water bodies and moisture layers; damage of mining area environment. Mining damage has aroused height attention of national correlutive leaders, and society, country has constituted correlutive rules of law, and it emphasizes damage control. Mining damage has been bring into layout of Mine Corporation, which is a important pathway of resolving the mining damage problem, and mining damage control and environment rebuilding have combined into one body, which is the only way of realizing maximum of extraction resource, economy and social benefit, and realizing economy and environment harmonious sustainable development. So studying the model of mine safety control mining, setting up the appraise system about safety mining, which has important theoretical study and practice meaning, it is a must solving important problem of mining industry sustainable development.

II. MINING INFLUENCE OF BUILDINGS OWING TO SURFACE MOVEMENT AND DEFORMATION

Underground mining make overburden rock strata crack, cave, move and deform, it feedbacks to surface, this form is subsidence basin [2]. Owing to the complexity and diversity of mining damage during the process of forming subsidence basin, appraising damage about subsidence basin must depend on the main ideology of “‘mining project’ –‘movement and deformation about overburden rock strata’ –‘surface protection buildings’ –‘mining damage and protection’ “, and at the same time, subsidence (w), incline deformation (i), curvature deformation (K) and horizontal deformation(ε) as bases for appraising.

A. Surface subsidence

- For buildings, if surface odds sinks, the structure of buildings will produce additive stress, and it will make structure to damage; if surface subsidence is large and surface water is high, then the circumstance of groundsill will be changed, the intensity of groundsill will reduce.
- For railways and highways, if surface odds sinks, it will make high speed vehicles empty out and rails hang in the air, when this circs becomes serious, it will bring traffic accidents, at the same time, if surface subsidence is large and surface water is high, the roadbed of railways and highways will be affected, and the cost and difficulty of maintenance will be increased.
- For water bodies, owing to height of mining and quantity of subsidence have direct ratio relation, at the same time, it also has the ratio relation of height on fractured zone, if surface subsidence is large, fractured zone will connect with water bodies, then it can induce serious flooding-well calamity.

B. Incline deformation

Incline can induces structural gravity’s center excursion, and arouses additive overturn moment, and structure produces additive stress, the stress of bearing weight base will redistri-
Incline deformation can be divided into cross incline and longitudinal incline.

- For buildings especially high buildings, if the value of incline deformation is large, then center of gravity will depart buildings, it will make buildings destroy and intimidate people safety. At the same time, it will affect drainage system of buildings.
- For railways and highways, trestle is indispensability, and damage of trestle is obvious. At the same time, cross incline deformation can bring railways landscape orientation movement deformation, two separate or extrusion rails can make high speed trains digression; and bring pavement (rail), roadbed landscape orientation incline, and make center of gravity on vehicle excursion, and destroys the balance state of centrifugal force and centripetal force. Longitudinal incline deformation: surface longitudinal incline deformation make grade of road increase.
- For water bodies, incline deformation make dam and dam groups bear odds force, and brings bursting dam accidents to arise.

C. Curvature deformation

Curvature deformation makes intrinsic buildings plane base, roadbed and pavement of highways, rails of railways become curve, and destroys first balance condition of intrinsic load and reverse force of base soil.

- For buildings, under positive and negative curvature’s influence, reverse force of base about buildings will redistribute, reverse force of base makes buildings produce additive action of shearing force and resultant moment and makes structure produce converse and correctitude eight-font style crack.
- For highways and railways, surface curvature deformation makes pavement wave gurgitation, high speed vehicles will empty out on this condition, and it will bring traffic accident, at the same time, it accelerates pavement destroy under action of speed vehicles.
- For water bodies, curvature deformation doesn’t obviously affect it.

D. Horizontal deformation

Horizontal deformation can be divided into extension horizontal deformation and condensation horizontal deformation.

- For buildings, owing to the capability of resist tension about structure is farness less than press, surface buildings are easily exposed to destroy by tension.
- For railways and highways, surface longitudinal extension tension by mining can arose roadbed and pavement of highways to craze and destroy, at the same time, it also arose fishplate of join about rails crack, rail slot close and rail longitudinal bend, when theirs value are large, they will induce rail deviate roadbed hang in the air.

- For water bodies, if they were pressed by condensation horizontal deformation, then they not only not to affect safety mining, but benefit for mining under water bodies; but if they were pressed by extension horizontal deformation, then will make water bodies connect with fractured zone, and induce serious flooding-well calamity.

III. MATH MODEL OF SECURITY APPRAISE ON MINING UNDER “THREE BODIES” IN MINING AREA

After random medium theory of mining subsidence is introduced by scholar J. Litwinisz in Poland in 1950s, in1960s, scholar of Liu Bao-chen and Liao Guo-hua in china have triumphantly solved plane prediction problem of underground mining and opencast working base on the random medium theory, and had developed it into prediction system of special surface movement and deformation base on the method of probability integral. At present, the method of probability integral has developed into one of the rather credible and comprehensive prediction theory methods on mining damage. Math model of security appraise on mining under “three bodies” is a polar coordinate close loop integral model (as fig. 1) that bases on the influence function of combining probability integral and Knothe theory, it can rather exactly appraise the security problem of mining under “three bodies”.

\[
D(x,y,z) = \sum_{i=1}^{m} \sum_{j=1}^{l} f_{ij}(R_i, z) f_{ij}(q) dq
\]

(1)

Here: \( (x, y, z) \) —coordinates of calculate point; \( C_i \) —coefficient of time influence; \( m \) —the number of calculation blocks; \( l \) —the number of inflexion about arbitrary calculation mining block; \( q_k \) —clip angle of the line on x-axis and line on calculation point and \( k \) inflexion; \( f_{ij} \) —separate operation function; \( R_i = R_i(q, x, y) \) —radius of polar coordinate.

![Fig1. The integral principle of the polar coordinate](image)
According to the math model in fig. 1, it can educes the forecast formula of subsidence on mining area base on the method of probability integral, it as follow:

\[
 w(x, y, t) = \frac{W_{max}}{2\pi} C_i \sum_{i=1}^{n} \sum_{i=1}^{\infty} \left[ 1 - e^{-\frac{s_i^2}{q_i}} \right] dq
\]  

(2)

According to correlation of surface movement and deformation, it can educes each ponderance of incline \(i_x, i_y\) horizontal movement \(u_x, u_y\) and horizontal deformation \(E_x, E_y\) about surface dynamic subsidence by formula (2).

\[
i_x = \frac{W_{max}}{r^2} \sum_{i=1}^{n} C_i \sum_{i=1}^{\infty} \int_{q_i}^{q_{i+1}} F_i \left( \frac{R_i}{r} \right) \cos q dq
\]  

(3)

\[
i_y = \frac{W_{max}}{r^2} \sum_{i=1}^{n} C_i \sum_{i=1}^{\infty} \int_{q_i}^{q_{i+1}} F_i \left( \frac{R_i}{r} \right) \sin q dq
\]  

(4)

\[
K_x = \frac{W_{max}}{r^2} \sum_{i=1}^{n} C_i \sum_{i=1}^{\infty} (Q_i - Q_s)
\]  

(5)

\[
K_y = \frac{W_{max}}{r^2} \sum_{i=1}^{n} C_i \sum_{i=1}^{\infty} (P_i - Q_s)
\]  

(6)

\[
u_x = \frac{W_{max}}{r^2} \sum_{i=1}^{n} b_i C_i \sum_{i=1}^{\infty} \int_{q_i}^{q_{i+1}} F_i \left( \frac{R_i}{r} \right) \cos q dq
\]  

(7)

\[
u_y = \frac{W_{max}}{r^2} \sum_{i=1}^{n} b_i C_i \sum_{i=1}^{\infty} \int_{q_i}^{q_{i+1}} F_i \left( \frac{R_i}{r} \right) \sin q dq
\]  

(8)

\[
\epsilon_x = \frac{W_{max}}{r^2} \sum_{i=1}^{\infty} b_i C_i \sum_{i=1}^{\infty} (P_i - Q_s)
\]  

(9)

\[
\epsilon_y = \frac{W_{max}}{r^2} \sum_{i=1}^{\infty} b_i C_i \sum_{i=1}^{\infty} (P_i + Q_s)
\]  

(10)

Here: \(F_i(s) = se^{-s^2} - \int_0^s e^{-t^2} dt\); \(F_i(s) = \pi^2 e^{-s^2};\)

\(F_3(s) = 1 - e^{-s^2} - \pi^2 e^{-s^2};\) \(P_s = \int_{q_i}^{q_{i+1}} F_i \left( \frac{R_i}{r} \right) dq;\)

\(Q_s = \int_{q_i}^{q_{i+1}} F_i \left( \frac{R_i}{r} \right) \cos q dq\)

IV. COMPUTER SIMULATION AND SECURITY APPRAISE ON MINING UNDER “THREE BODIES”

A. Principle of Safety Mining Under “Three Bodies”

Principle of safety mining under “three bodies”:

- Safety mining under buildings, its aims at reducing or controlling surface movement and deformation to reach to safety mining under buildings by reasonable mining method, mining direction, mining order, and mining time and so on, at the same time setups deformation cushion channel, deformation slot, steel bar, reinforcing steel concrete or contact girder of base and etc to reinforce and defend buildings.

- Safety mining under railways and highways, for railways, mining method must guarantee surface not to appear non-continuous deformation, and roadbed not to appear big crack and incline, and possibly keep consistent on direction of face and extend direction of railways; for highways, especially high class highway, mining method must guarantee surface movement and deformation in the allow range of roadbed and pavement, in a general way, movement and deformation should strictly control in the range of 1 grade damage [6], at the same time, maintenance measure should be set down during the mining process.

- Safety mining under water bodies, mining method should prevent water bodies or mud or sand burst in mine, at the same time, guarantee safety produce not to worsen working condition and leave waterproof coal-rock pillar.

- In environment factor, safety mining under “three bodies” must base on the green mining, and on the precondition of no-damage entironment of mining area.

B. The Flow of Computer Simulation and Security Appraise on Mining Under “Three Bodies”

Aim of safety mining under “three bodies” is to realize much produce coal, reduce cost and mining high efficiency on the precondition of guarantying safety produce [3], so safety credibility, technique reasonable and economy rationality of mining method must be appraised. Engineering practice has proved that systematic science theory and method applied to solve complicated problem is not “ first particular, after whole”, but “ first whole, after particular” [8], this method can abstain antinomy or omit of apiece factors, which has gained a quite rational result.

Owing to appraise method has no uniform mode on artificially appraised on mining project, and at the same time it exists artificial insurmountability disadvantages [9]. For example, artificial appraise even if has experts participate in, and it is hard to avoid omit correlative guidelines; for complicated mine produce process, appraise model on the blob often raise conceptual confusion; and artificial appraise takes time, it is laborious and high cost and so on.

With computer technique developed and extended, in 1990s, safety appraise by computer has come into phase of combing computer assistant, qualitative and quantificationatle dynamic simulate. Computer simulation means changing numeric information into the intuitionistic form of figure and graph chaperonage the progress of time and space [10]. So system of security appraise on mining under “three bodies” must includes as follow embranchments (see fig 2).

According to above frame and objects of mining under “three bodies”, system can calculates weighting value of each influence factors. Mining project may be security appraised by computer simulation, afterwards correlative parameters of mining project can be adjusted, for example, dimension of face and section pillar; mining order and mining direction, and the disposal method of roof and so on. At last, safety, economy and reasonable mining project has been educed.

Authors have proved above methods are safety, economy, in reason and wide applicability by correlative items, problem
study and engineering practice on. For example “study of mining under mountain buildings in Xiao Baoding mine”, “mining under buildings, railroads and water bodies and protected estimating evaluation software”, “prediction evaluation and disposal method of damage degree of gob under Taijiu high class highway” and “the system of prediction evaluation about mining damage”, it is one of effective methods on security appraise of mining under “three bodies” in mining area.

**Fig2. The frame of security appraise of mining project and computer simulation**

V. CONCLUSION

Security appraise and method of computer simulation about mining under “three bodies” in mining area is that quantificational appraise on security, feasibility, economy rationality and entironment of mining project before mining. In order to adopt safety and economy mining project, this method makes people realize the result before mining under “three bodies” by computer simulation’s characters: invest few, cycle short, safety credibility, brief and high efficiency.

So studying the model of mine safety control mining, setting up the appraise system about safety mining, which has important theoretical study and practice meaning, it is a must solving important problem of sustainable development. Practice has proved that this method is one of mining industry safety produce and sustainable development methods.

REFERENCES


