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Research on Roadway Supporting Effect of Different Bolt Parameters under Blasting Dynamic Load

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Abstract: *According to the roadway characteristics and physical properties of rock, calculation model of FLAC2D established, analyzes strain and stress distribution of roadway surrounding rock under static condition and dynamic load of blasting. The results show that, by blasting dynamic loads, stress of surrounding rock will be redistribute, cause displacement increased, and vertical displacement larger than lateral displacement; with the decrease of rock bolt spacing, stress and displacement of surrounding rock under blasting dynamic load decreases, and when the distance is less than a certain value, the influence of blasting dynamic load is smaller. Combined with the results of numerical analysis, gained reasonable supporting parameters, and applied to the engineering practice, has obtained good supporting effect.*

Keywords: *Roadway. Blasting dynamic load. Bolt. Supporting effect*

1. Introduction

With the expansion of coal mining scale, roadway section is more and more big, coupled with the popularization and application of medium-deep hole blasting technique, the total amount and single blasting of explosive in roadway excavation blasting increases, roadway surrounding rock and supporting structure by blasting vibration effect enhanced frequently [1,3,7]. Blasting vibration cause surrounding rock damage and failure, makes fracture of roadway surrounding rock further extending, surrounding rock loose circle increased, even making surrounding rock collapse, affecting roadway stability seriously. In coalmine, stability coefficient *f* of most rock is less than 8, more rock is soft rock, $f<6$, such as mudstone, shale, sandy mudstone; stability coefficient *f* is low, poor entirety, it is easy rupture during blasting vibration load. The current research in this area is few, public documents rarely seen at home and abroad. For tunneling blasting, more use blasting vibration monitoring and analysis of [2,6,8]. Therefore, based on large section roadway blasting vibration monitoring, establishing roadway rock mechanical model, using blasting seismic wave by tested, analyze displacement and stress of roadway rock during different bolt parameters under blasting dynamic load.

2. Calculation model and parameters

2.1. Project Overview

Rail transport roadway in north of a Huaibei coalmine, length is 3080.14m, Horizontal straight roadway, 3 ‰ uphill, elevation is -620 m to -569m. Section of roadway is straight wall with arch, supported by bolting and shotcrete, shotcrete thickness is 150mm, excavation width is 5.3 m, excavation height is 4.45m, excavation area is 20.565m^2. During yard and three roadways construction, igneous rock exposed, lithologic characters is mainly diorite, consistency coefficient *f* is from 9.81 to 11.62.

2.2. Calculation model establishment

From calculation perspective of elasticity mechanics and plasticity mechanics, model size should be3 to 5 times in horizontal direction of project size, and 2 to 3 times in vertical direction, model size is 80m ×50m (horizontal ×vertical direction) finally, mesh size is 0.5m ×0.5m, mesh number is 16000, shown in Fig.1.

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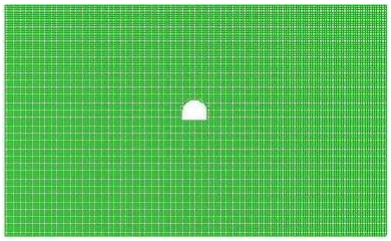

Fig.1: Model and graticule division.

Material model selected Mohr-Coulomb model, rock and bolt mechanics parameters by test shown in Table1, Table2.

Table 1 Testing results of rock mechanics property

Density kg/m^3	Binding power / MPa	Friction angle / °	Tensile strength / MPa	Single axle compressive strength / MPa	Young's modulus / GPa	Bulk modulus / GPa	Poisson's ratio
2725	5.0	35	0.6	124.28	30	8	0.334

Table 2 Parameters of anchor bolt

Diameter/mm	Thickness/mm	Length/m	Tensile strength/MPa	Yield strength /MPa	Tensile rate
18	4	1.8	835	550	≥10

3. Numerical simulations

For analyze stress and deformation of different anchor bolt space under blasting dynamic load, designs four supporting bolt parameters according bolt number for section: 9, 10, 11, 12; corresponding anchor spacing respectively is 1200 mm, 1100 mm, 1000 mm and 900 mm. Numerical calculation is carried out by FLAC2D, static analysis firstly, and then applies dynamic load, dynamic analysis [5].

3.1. Static calculation

Through static analysis, gain stress and deformation of surrounding rock gravity, Sxx, Syy stress of surrounding rock shown in Fig.2, Fig.3, displacement of X direction and Y direction shown in Fig.4, Fig.5.

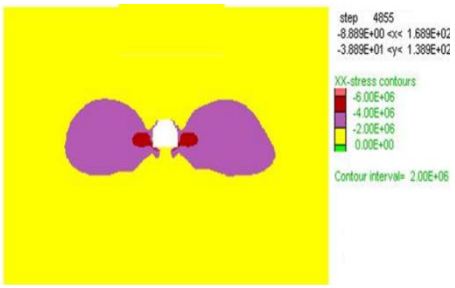

Fig.2 Sxx stress of roadway

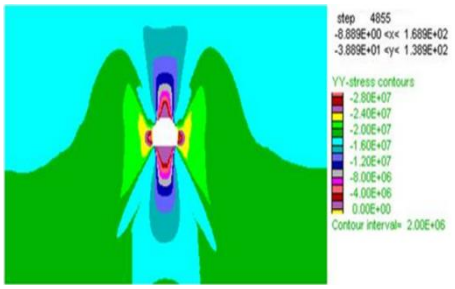

Fig.3 Syy stress of roadway

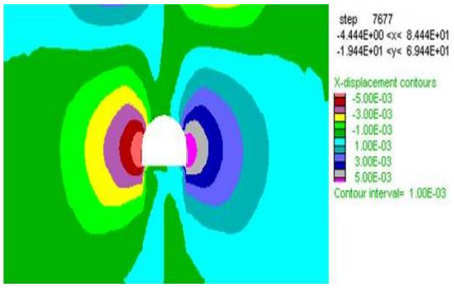

Fig.4 X direction displacement of roadway

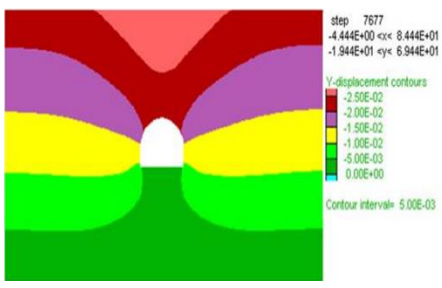

Fig.5 Y direction displacement of roadway

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3.2. Dynamic calculation

For dynamic analysis, based on the static analysis results, using viscous boundary, namely impose viscous boundary in left and right, before and after, bottom boundary, upper boundary as free boundary. Velocity wave transform into stress wave as follow [4]

$$\sigma_n = 2(\rho C_p)v_n \tag{1}$$

$$\sigma_s = 2(\rho C_s)v_s \tag{2}$$

Where, v_n, v_s- normal component and tangential component of velocity in boundary; ρ-density of rock; C_p, C_s- velocity of P wave and S wave, according to the following formula

$$C_p = \sqrt{\frac{K + 4G/3}{\rho}}, \quad C_s = \sqrt{G/\rho}$$

Where, K- bulk modulus; G- shear modulus, according to the following formula

$$K = \frac{E}{3(1-2\mu)}, \quad G = \frac{E}{2(1+\mu)}$$

Velocity wave is obtained by field testing, for the project's main frequency between 100 to 200 Hz, filter the wave below 100Hz, waveform diagram shown in Fig.6, Fig.7.

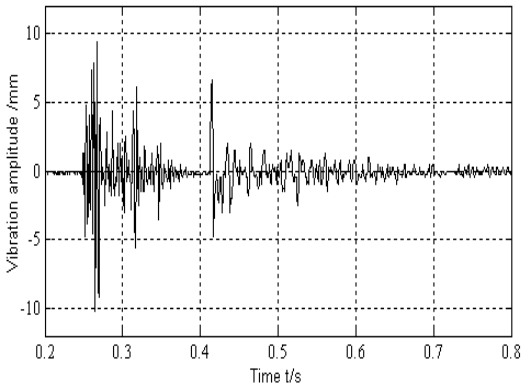

Fig.6 Velocity temporal curve input from X direction

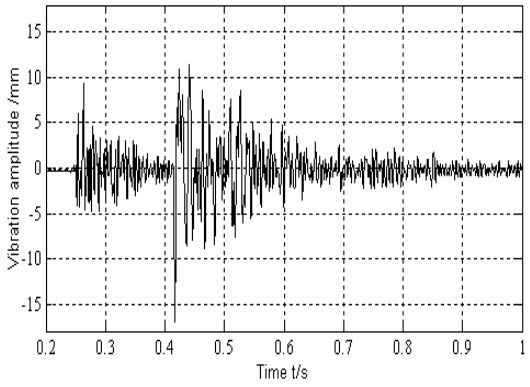

Fig.7 Velocity temporal curve input from Y direction

It is too far to establish blasting zone and roadway in model directly, using applied velocity wave to roadway, apply method as fulmar (1) and (2), similar to the apply method of natural seismic wave. Applying blasting dynamic load and dynamic boundary conditions, gain Sxx, Syy stress of stable roadway rock in effect of blasting dynamic load, shown in Fig.8, Fig.9. Surrounding rock displacement of X and Y directional shown in Fig.10, Fig.11.

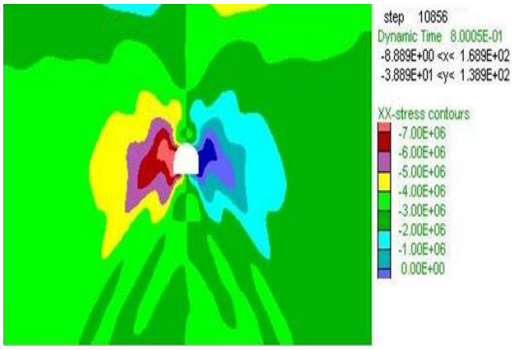

Fig.8 Sxx stress of during dynamic loaded roadway

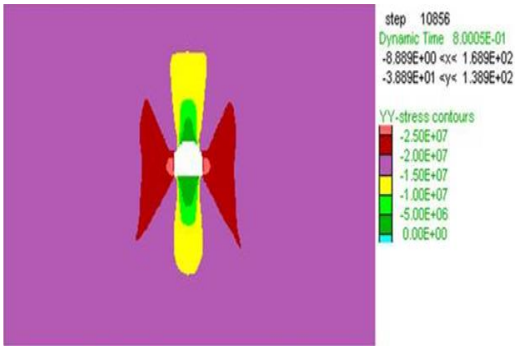

Fig.9 Syy stress map of dynamic loaded roadway

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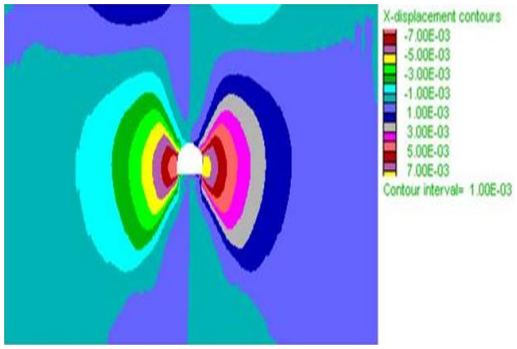


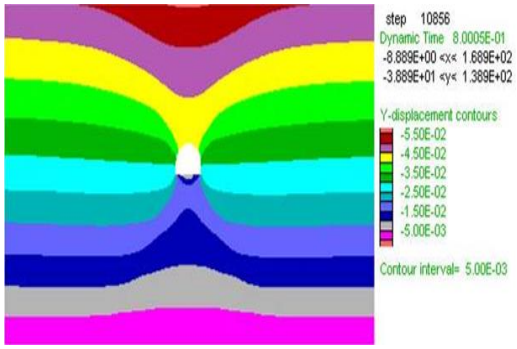
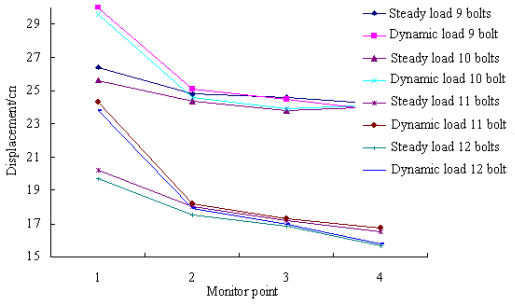


Fig.10 X direction displacement of dynamic load *Fig.11 Ydirection displacement of dynamic load*

Fig.2~Fig.5, Fig.8~Fig.11 are stress and displacement of 9 bolts the stress and displacement, simulation method for 10, 11, 12 bolts are similar, doesn't shown every pictures of stress and displacement. In order to compare the surrounding rock stress and displacement of different situation during blasting dynamic load, selected four monitoring points, distance to blasting face respectively is 3m, 5m, 8m, 10m. Maximum displacement and stress of various measuring points for different number of anchor are shown in Fig.12 and Fig.13.



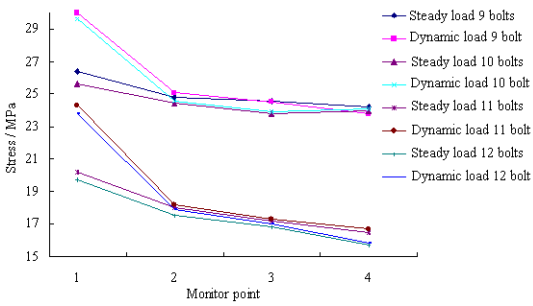


Fig.12 Maximum displacement of different bolt number *Fig.13 Maximum stress of different bolt number*

3.3. Results analysis

Fig.2 to Fig.5 shows that stress value in top and bottom of roadway changes large, stress value of the two sides changes small, and surrounding rock stress concentration appears around anchor bolt, namely, bolt parameters too large without blasting dynamic load. Through bolt parameters adjustment, surrounding rock stress around bolt improved significantly, guarantees safe and reliable.

By Fig.2 to Fig.5 and Fig.8 to Fig.11, after applying blasting dynamic load, displacement of surrounding rock increased, X direction displacement from 5 mm to 7 mm, Y direction displacement from 25 mm to 55 mm, amplification is 40% and 120% respectively, its shows that vertical displacement influenced by blasting dynamic load is bigger than lateral displacement. But before and after apply blasting dynamic load, stress changes small, it is because surrounding rock stress redistribution caused the increase of surrounding rock displacement.

Fig.12 and Fig.13 show that for large bolt spacing (9 anchor bolts), stress around anchor is greater and improved not obviously, displacement and stress variation can be large while apply blasting loading, from four monitor points can be see that displacement and stress variation with small changes of 9 or 10 anchor bolts, when 11 and 12 anchor bolts displacement and stress without change basically. After adjusting parameters, influence of blasting dynamic load on supporting effect much smaller.

4. Conclusions

Through simulation analysis, supporting effect is greatly influenced by blasting dynamic load when support 9 anchor bolts (space 1200 mm). And variation is very small of 10(space 1100 mm) and 11 and 12 anchor bolts. Take economy into consider, choosing anchor bolt row spacing 1000 mm, specifications M20-Φ18-2000 mm, mating 130 ×130 mm square sphere tray; and then spray 150 mm concrete, strength C20, achieved good supporting effect.

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