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Research Article

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The anchor craning beam support technology of the large section roadway with compound roof

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ABSTRACT

The routing of integrated circuits is an important procedure of the physical design after the layout. For this reason, an improved Field Programmable Gate Array (FPGA) routing approach is proposed based on the ant colony optimization. Experimental results suggest that the proposed approach is feasible and correct.

Key words: Field Programmable Gate Array; Routing Method; Ant Colony Optimization

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INTRODUCTION

Much compound roof is composed of multi-thinner rock stratum which is filled with beddings, joints fractured, and this structure of weak coal seam roof in coal-bearing strata is widely distributed [1-2].The compound roof strata has low intensity, poor self-stability, joints fractured, and it contains much montmorillonite, kaolin and other ingredients, leading to water swelling, easily producing plastic deformation, and the physical and mechanical properties of the rock stratum are significantly different between the interlayer , moreover, the contact of the rock interlayer does not close , so the friction of them is small, leading to produce separation easily. In a word, the support of a large section roadway with complex roof is very difficult [3-4]. About more than one-third surrounding rock of coal roadway belongs to the weak compound roof in China, complex roof support is the key problem we facing when extending our coal mining to deep and stopping.

Zhang Lei etc[5] by using "high prestressed anchor cable + cable truss body" jointly controlled the compound mudstone roof to protect the stability of the roof support, and Fan Jian [6] used numerical simulation and field experiments to find that high strength prestressed anchor pole cable support systems can effectively control the complex roof roadway deformation and destruction in high stress deep mine, Yue Zhongwen, etc[7] according to the deformation and failure characteristics of the complex roof of large section roadways conducted similar simulation experiments and found that compound roof's top and bottom angle prone to shear failure, causing the roof to increase the actual span, Bo Jianbiao [8] analyzed the damage characteristics of compound roof in extremely soft rock roadway, and proposed the use of grouting and bolting to control compound roof in extremely soft rock roadway, Gao Feng[9] pointed out that the deformation and failure of compound roofs is mainly associated with lack of bolt (Cable) initial preload, leading to the excessive amount of separation and deformation of the compound roof, He Bingyin[10] analyzed the compound roof anchor breaking conditions and reasons, Zou Hu[11] analyzed the influence of the compound roof span to the surrounding rock stability of coal roadways and proposed high-strength, high preload, high stability support ways, Li Weiteng etc[12] made theoretical and numerical analysis of four different arrangements of the pressure releasing cable box girder, Zhang Yongqing, etc[13] studied the deformation and failure characteristics of compound roof, and analyzed the supporting effect of the truss anchor girder.

Many scholars have done a lot of researches about compound roof deformation mechanism and its supporting

technology, and also achieve fruitful results, but most studies are directed at relatively small sections of roadways, and lack of large roadway section research, especially the research of large roadway section deformation and failure characteristics under the anchor beam supporting. Taking the compound roof of the 11604 cut-hole large section roadway, a coal mine roadway in Guizhou, as the background, we analyse the support mechanism of anchor beam that supporting large section roadway, and apply the anchor beam support way in 11604 roadway. This research has important theoretical and engineering significance.

THE ANALYSIS OF ANCHOR BEAM MECHANISM IN LARGE SECTION WITH COMPOUND ROOF

Anchor cable beam consists of high prestress cable and high stiffness joists, which are squeezed together to form a high strength and stiffness combined rock beam by prestress, so as to effectively control the roadway rock deformation and failure, its supporting schematic diagram shown in Figure 1 .

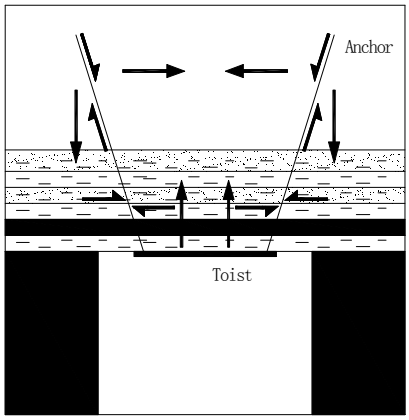


Fig.1 Large section compound roof anchor beam supporting Schematic

(1) Joist squeeze in the upper strata under the action of anchor cable's prestress, which change the roof strata from the unconformity contact rock strata under the unidirectional and bidirectional stress condition into a combination of three-dimensional stress state of the beam, while the horizontal joists anchor squeeze rock beams in horizontal and vertical direction, to increase strength and stiffness of rock beams.

(2) The joists in anchor beam supporting structure can greatly increase the surface area of the supporting structure, squeeze the compound roof strata under the action of high prestress, eliminate the gap between the support and the surrounding rock, so that the supporting structure can evenly bear deformation pressure of surrounding rock, preventing the support's bearing capacity greatly reducing caused by uneven concentrated loads and eccentric loads, while the anchor can effectively spread in the roof.

(3) Rectangular roadway, especially in the large section roadway with compound roof, prone to shear failure, whose shoulder angle is the shear stress concentration area, and the effect of shoulder angle surrounding rock after destruction supporting roof weakens, causing the roof actual span increases, so that the rectangular roadway prone to cut the top and fall accident. The prestresse applied by Joist anchor that is through the shear stress concentration area, can offset some shear stress of the surrounding rock, and the anchor has a strong shear resistance, and can rock form anti- shear structure with beam, shoulder angle anchor together, which can effectively control shear failure of the shoulder angle.

THE DESIGN AND ANALYSIS OF COMPOUND ROOF SUPPORT PROGRAM IN LARGE SECTION ROADWAY

1 Project Overview

The 11604 working face 16 # coal mining of a coal mine in Guizhou, is relatively stable, and its inclination is 10 ° ~ 17 °, an average of 12 °, and its direct top is compound roof which consist of six layers of shale and coal seam interaction occurrence, with an average thickness of 2.2m; and the roof above the direct top about 4 ~ 6m thick is mudstone or shale sandstone, and thin-bedded, water expansive; the layer above the shale layer, the thickness of 7 ~ 8m, is the aqueous K8 sandstone. The floor is gray fine sandstone, horizontal bedding, clip black mudstone bands, the average thickness is 2.0m. The Cut Coal Lane in 11604 working face is a large section compound roof, measuring 7.0m × 3.2m (width × height). 11604 roadway initial design uses anchor net support, after digging tunnel the roof continues deformation, and appears large sink, block caving phenomenon, and the deformation between two and kick drum is obvious, and there has been part of the anchor bolt pulled off. After the renovation, the support program is still not effectively control the roadway surrounding rock deformation. It causes a serious impact to mine

safety in production.

2 Design of support program

The section shape of 11604 cut-hole compound roof roadway is rectangular, its dimensions are: length × width = 7.0m × 3.2m, twice forming. The first excavation section size is 3.5m × 3.2m (width × height); and the second tunneling section size is 3.5m × 3.2m (width × height). Using anchor beams to support, the parameters are as follows:

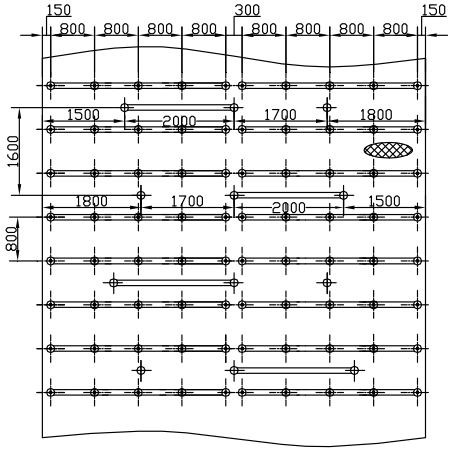


Fig.2 Anchor beam support program

In the roadway roof we arrange 10 φ20mm × 2500mm L no longitudinal reinforcement high-strength steel bolt, the inter-row space is 800mm × 800mm. The roof bolt distance of first tunneling section and the second section is 300mm, and every bolt anchor length is 1600mm, its tightening torque is not less than 140N • m. The angle of the roof corner bolt and the plumb line is 20 °, the rest of the roof bolt arranged vertically. Roof anchor support alternately arranged anchor joists and anchor monomer, the row spacing of anchor is 1.6m. When hitting a row of anchor joists, we hit a row of anchor monomer; the space of adjacent raw is 1.6m, the anchor in the first excavation roadway and the joist anchor in the second excavation roadway display in the same cross-section. Anchor specifications is φ15.24mm × 10400mm, and the anchoring length is 3600mm, and the preload force is not less than 120kN. The distance of the anchor monomer to coal side is 1.8m, and the anchor beam bottom span is 2.0m, the distance of the anchor joists to coal side is 1.5m, the angle between the anchor joists and the vertical line is 20 °, and the angle between the anchor joists close to the roadway middle and the plumb line is 5 °, the joists using 12 # channel steel, the length is 2.0m.

Using φ20mm × 2500mm high strength steel bolt without longitudinal reinforcement support the roadway two left-handed, anchoring length is 1.2m, tightening torque is not less than 100N • m, the row space between each anchor raw is 800mm × 800mm, and the distance of the upper side anchor to the roof is 400mm, and the angle between the upper side anchor and the horizontal direction is 10 °, the remaining three bolt arrange into a horizontal layout. The lower side anchor to the bottom is 400mm, the steel pallet specifications is 180mm × 180mm × 8mm (length × width × thickness), and using diamond wire mesh support surrounding rock, the metal mesh specifications is: length × width = 11m × 0.85m. Steel ladder beams is welded by φ14mm steel bars, width 80mm and length 3.0m.

3 Numerical analysis of the support program

To analyze the supporting effect of anchor beam supporting to the large section compound roof, we establish the numerical model of the anchor beams support and the original anchor net support, the model is showed in Figure 3, the size of the numerical calculation model is 90m × 60m, and the rock constitutive relations uses Mohr - Coulomb model; the model upper boundary conditions is the stress boundary conditions, the stress is uniform load: q = 5.886MPa, and the lower boundary, the L-boundary and R-boundary conditions are displacement boundary conditions. The rock physical and mechanical parameters of the model are displayed in the following table. In this numerical calculation model, the bolt length is 2.5m, and the anchor length is 10.4m, Table 1-2 shows the physical and mechanical parameters of every rock stratum and bolt, anchor mechanical parameters.

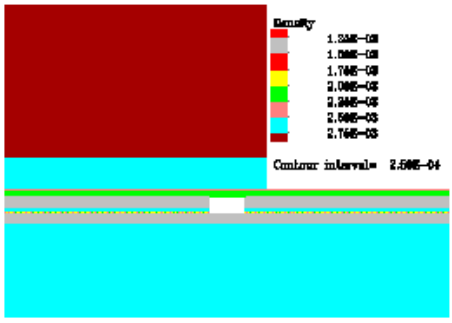


Fig.3 Rock stratum distribution in the model

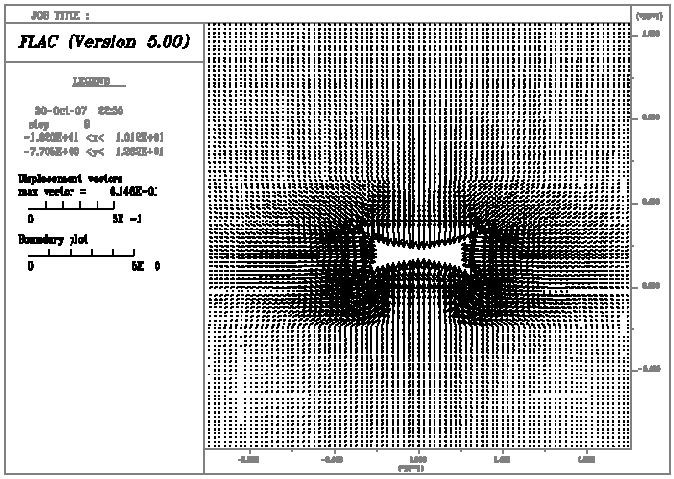
Table.1 Coal and rock mechanical parameters

Lithology	Density g/cm³	Shear modulus /GPa	Bulk modulus /GPa	Bond force /MPa	Internal friction angle /(°)	Tensile strength /MPa
Medium sandstone	2.63	12.5	16.5	14.15	31	9.1
Fine sandstone	2.60	11.1	14.7	8.58	30	3.53
Shaly sand	2.57	20.3	27.1	4.52	29	2.24
Mudstone	2.50	10.2	17.0	2.34	29	1.05
Coal	1.40	7.5	16.3	2.52	28	0.81

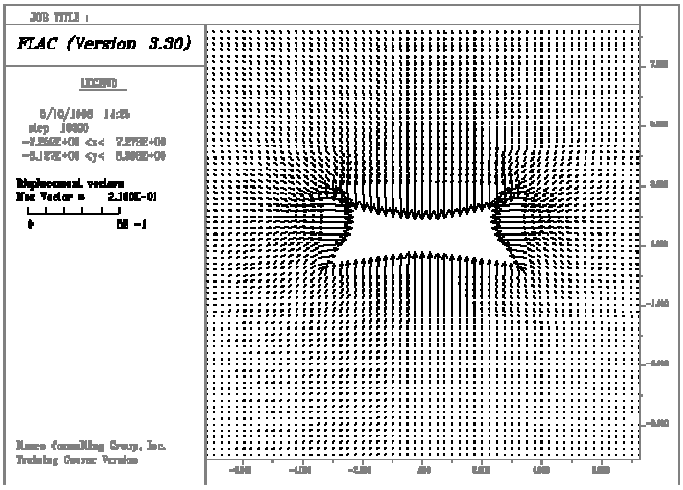
Table.2 Anchor and bolt mechanical parameters

Mechanical parameters	Bolt	Anchor
Elastic modulus	98.6GPa	150GPa
Tensile strength	600MPa	900MPa
Compressive strength	600MPa	900MPa
Resin stiffness	19MPa	19MPa
Resin cohesion	35MPa	35MPa

As shows in the roadway displacement vector figure 4 of the former anchor net support and the anchor beam support, the roof support is the difficult and key problem in the large section compound roof. The fastest roadway surface deformation rate often appears in the middle of the roadway roof, and the roadway surface deformation rate under the anchor beam support is 35.1 percent of the original anchor net support, and the maximum deformation of roadway roof under the former and the latter support is 432mm and 142mm, obviously after the roof subsidence decreases 67.1% after using the anchor beam support, and the roadway roof sink is controlled effectively. Using anchor joists reinforce the surrounding rock at the roadway shoulder, the failure caused by excessive deformation get better control, and two coal sides deformation is also significantly reduced, floor heave also decreased, as shown in Figure 5. The roadway surface deformation is significantly lower under the anchor beam support than the original anchor net support.



(a) Vector displacement of the anchor net support



(b) Vector displacement of the anchor beam support

Fig.4 Vector displacement of the roadway

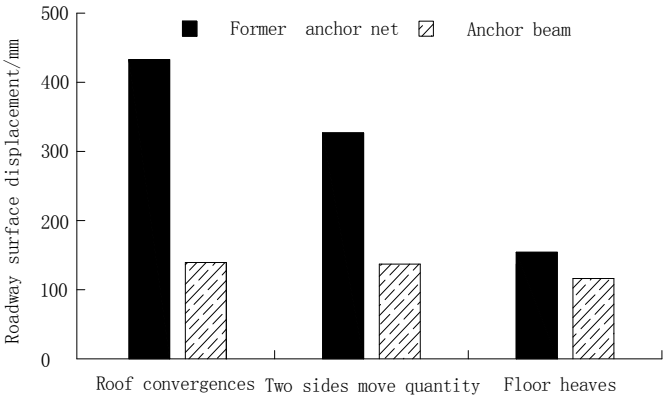
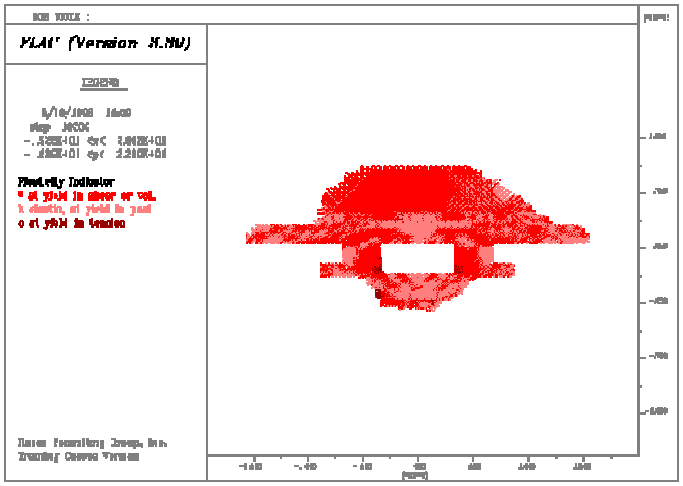
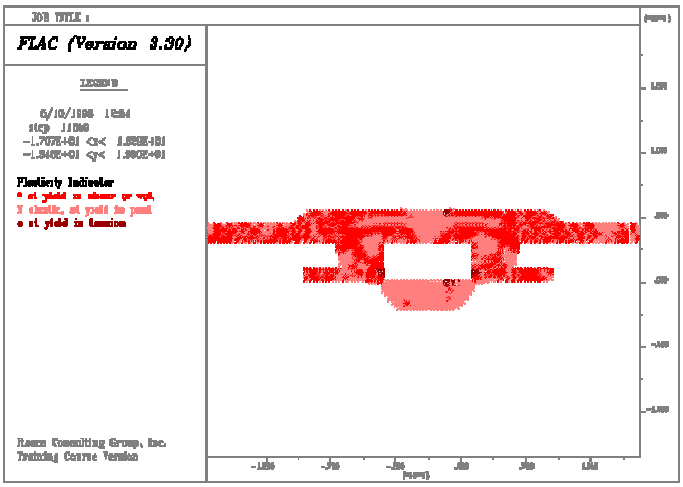


Fig.5 Surface displacement of the roadway



(a) Former anchor net support



(b) Anchor beam support

Fig.6 Roadway plastic zone distribution

11604 cutting whole compound roof is composed of six mudstone and coal seam which is interactive occurrence, its strength is low, its span is large, and its overall stability is poor, and under the original anchor net support the roadway severely damages, as shown in Figure 6 (a). The numerical simulation results show that the greatest damage depth of the roof rock is 8.4m. After using the anchor beam support, the joists of the anchor beam increases the surface area of the support structure, so the Pre - tightening Force of the preload anchor in the roof get effective diffusion, effectively reducing the roadway roof rock tensile stress, and reducing the roadway roof strata damage extent, while the roadway compound roof in the anchoring range squeezed into a large rock beam which have large strength and stiffness, thus effectively controlling the roof deformation failure, as shown in 6 (b). The numerical simulation results show that under the anchor beam support the roof destruction depth reduced to 3.2m; as joists anchor pass through the roadway shoulder which is shear stress concentration area, the prestressing force the joists anchor produces can offset some of the rock shear stress, meanwhile the anchor has a strong shear resistance, so it can effectively control the shoulder shear failure, leading to reduce the plastic zone of the roadway two sides.

SITE MONITORING

In order to observe the supporting effect of the anchor beams in cut roadway with the large section roadway compound roof, Surface displacement monitoring section is set using cross distribution point method (as shown in Figure 7) and three stations are set in cut roadway with the large section roadway compound roof, the upper station is 35m away from the track crossheading, while the lower is 35m away from the transportation crossheading, the central station is located in the middle position of the cut roadway, the monitoring of changes in the roadway surface displacement as shown in Figure 8.

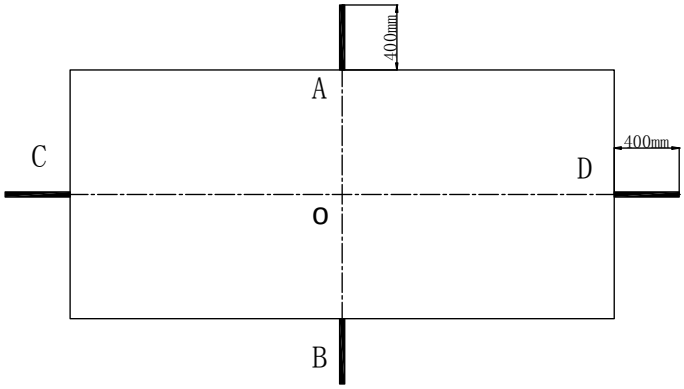
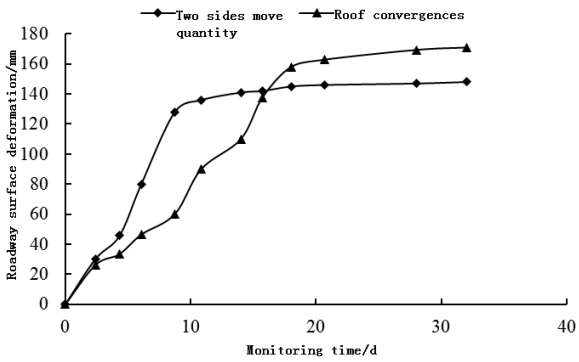
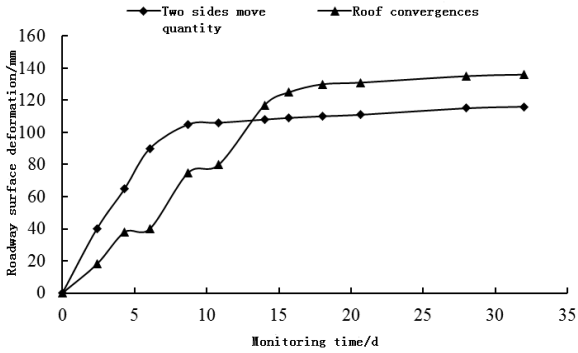


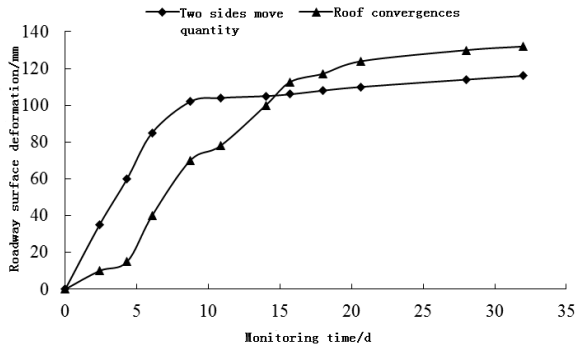
Fig.7 Roadway surface displacement monitoring sections arranged



(a) Station 1



(b) Station 2



(c) Station 3

Fig. 8 Station roadway surface displacement

The change curve of the amount of roadway roof subsidence and side wall is divided into two stages in figure. Roof moves down on average at the rate of 7 ~ 8 mm/d in the initial roadway excavation and the roof goes into a stable deformation stage after 20 days, roof subsidence speed gradually reduces to 0.5mm/d, at this time the roof subsidence is 171mm; while two sides of roadway, on average, move at a speed of 15 mm/d early in the excavation, the deformation is gradually into the stable period after 12 days, and the speed of two walls closer is reduced to 0.5mm/d, at this time the amount of two walls closer is 148mm. Roadway surrounding rock control effect is better.

CONCLUSION

1) The view of controlling compound roof of roadway deformation is put forward by using anchor beam supporting technology from the perspective of improving strength and stiffness of surrounding rock, and from prestress diffusion, the formation of high strength and high stiffness YanLiang, shoulder Angle shear structure point of view, the mechanism of controlling compound roof roadway deformation and failure is analyzed by anchor beam supporting.

2) The support scheme is designed under the conditions of the anchor cable beam supporting combined with 11604 engineering geological conditions of the large section cut roadway with compound roof, and the characteristics of roadway deformation and failure are analyzed contrasting the anchor cable beam supporting with the original anchor wire rope supporting, using the method of numerical simulation. The results show that, roadway roof subsidence is reduced by 67.13% and the amount of two walls nearer is reduced by 58.72% under the condition of the anchor cable beam supporting.

3) Anchorage beam support technology is successfully applied in 11604the large section cut roadway with compound roof. The two sides and floor tends to be stable after roadway digging around ten days, while the roof is stable after 20 days later. The roadway roof subsidence is 171 mm, the amount of two walls nearer is 148 mm.

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REFERENCES

[1] Xue Yadong, Kang Tianhe. *Journal of China Coal Society*,**2000**,25(12):97-101.
[2] Fang Bocheng. *Coal Science and Technology*,**2007**,35(7):8-12.
[3] Zhang Bin, Ren Yongjie, Han Xuefeng. *Mine pressure and roof management* **2002**,2:81-84.
[4] Su Xuegui, Li Yanbin, Li Haochun. *Journal of Taiyuan University of Technology* (Social Sciences Edition), **2011**,42(6):628-629.
[5] Zhang Lei,Zhang Zhiming,Zhai Ji, Etc. *Coal Engineering*, **2014**,46(4):80-82.
[6] Fan Mingjian. *Coal Engineering*, **2013**, 11:30-33.
[7] Yue Zhongwen,Yang Renshu,Yan Zhendong, Etc. *Journal of China Coal Society*, **2006**, 36:47-52.
[8] Bai Jianbiao, Hou Chaojiong, Du Mumin, Etc. *Chinese Journal of Rock Mechanics and Engineering* [J].**2001**,20(1):53-56.
[9] Yang Feng, Wang Lianguo, He Anmin, Etc. [J]. *Journal of Mining & Safety Engineering*, **2008**,25(3):286-289.
[10] He Bingyin. *Coal Engineering*, **2007**,4:62-64.
[11] Zou Hu. *Coal*, **2013**,22(9):45-47.
[12] Li Weiteng,Li Zhi,Li Shucai, Etc. *Journal of Mining & Safety Engineering*, **2013**,30(4):475-482.
[13] Zhang Yongqing,Wang Weijun,Jiang Yi, Etc. *Mineral Engineering Research*, **2011**, 26(4):10-14.