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# Application of Support Technology with Step Strengthen Unite for Deep Roadway

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**Abstract:** In order to control the harmful deformation of deep roadway, analysis is made based on the engineering background of haulage rise in one Mine. This roadway is a typical deep rock, of which the surrounding rock becomes extremely unstable, showing strong anti-symmetrical deformation characteristics and high deformation rate after excavation. According to characteristics of great ground pressure, large deform-ation and difficult in supporting deep-seated roadway, this study proposed the surrounding rock control technology of step-by-step strengthen co-supporting and optimize the parameters of roadway support. Field monitoring show that the new method obtained good effect and it's a kind of effective method to controlling large deformation of surrounding rocks of deep roadway.

**Key words:** Deep roadway, roadway deformation, step strengthen unite support, surrounding rock control

## INTRODUCTION

In China coal mines average mining depth will be increased 8~12 m every year, most of existing mines will gradually enter the deep mining, expected within the next 20 years. After entering deep mining, , "three high and one disturbance", the GEO-environment of surrounding rock in deep to shallow great changes have taken place, resulting in mechanical characteristics of surrounding rock of roadway changes. Domestic and foreign scholars and experts from different aspects to be studied and having done a large number of engineering practice makes deep roadway control technology continuously improved and expanded. Fang *et al.* (2012) proposed the secondary support technology to control the roadway deformation with fractured surrounding rock in deep mine. Huang *et al.* (2012) proposed the optimized supporting method was paid great attention to the floor supporting and bottom shearing support. Li *et al.* (2011) put forward a coupling support technology with anchor-net shell lining on the coupling of various supports and the coupling of supports and surrounding rocks to control deformation and damage of the deep soft rock roadway strata. Wang *et al.* (2010) proposed the dynamic superimposed support technology of initial bolting/shotcreting and secondary bolting/grouting support. Wang *et al.* (2011) put forward a rapid excavation technology based on gather-energy blasting of rock, optimizing of support parameters and operation methods (Yang, 2011) put forwarded a support method of anchor nets beam and joint with U steel cable to strengthen the surrounding rock. This research based on existing of theory. According to the surrounding rock characteristics of haulage rise in one Mine, Analysing the causes of instability of surrounding rock, Proposing the new pattern of control surrounding rock with step-by-step strengthen co-supporting, Optimizing the parameters of roadway support, The surrounding rock distortion of roadway is controlled better.

## PROJECT PROFILE

The roadway near the two faults of DF13 and DF64. According to geological data expected, changes in complex geological structure of the region, fault throw greater, lithology is fine sandstone and mudstone fault and mudstone, Construction layer at -748~-470 m. Roadway cross section shape of a semicircleclear width×net height = 3500×3350 mm The initial design of support form: Anchor bolt is lefty twist steel of Φ20×2200 mm and every anchor bolt use two K2950 resin anchoring agent and layout is 700×700 mm. Netting is metal mesh of Φ6-100×100 mm. Cable is Φ17.8×6300 mm of steel, the cable layout is 1500×1500 mm. The length of grouted anchor is 2200 mm and its layout is 1500×1500 mm, Seriflux component by p.o42.5 stage ordinary Portland cement. The design spray thick is 150 mm and the jet concrete strength is C20.

**Analysis of surrounding rock deformation characteristics:** Surface displacement of roadway, deep

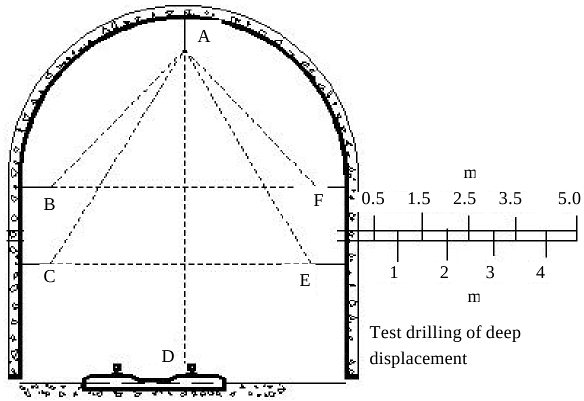


Fig. 1: Surface displacement and deep displacement distribution diagram

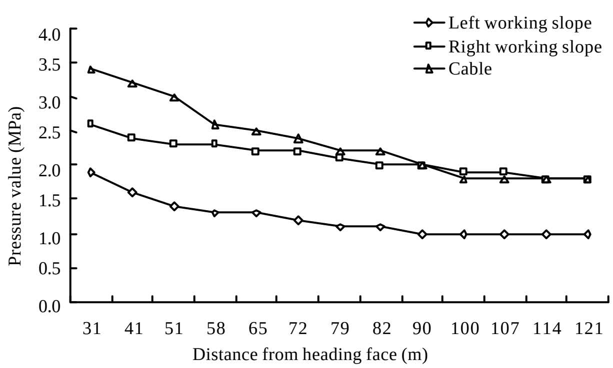


Fig. 2: Anchor bolt force change curve

displacement of surrounding rock and stress on anchor bolt/calbe have been monitored. The layout of surface displacement and deep displacement are shown in Fig. 1.

**Stress analysis of anchor bolt:** Figure 2 shows the anchor force change curve. Following conclusions can be drawn:

- The stress on anchor bolt gradually decreases which indicates the anchor bolt did not reinforce surrounding rocks
- The stress on anchor is merely 1.8Mpa eventually which approximately equals the stress on bolt. Thus, the anchor is not able to reinforce surrounding rocks
- The stress on both side bolt are not even which are 1.8 and 1 Mpa, respectively. Small stress on bolt shows the construction did not meet the design requirements. The construction management and supervision work should be strengthened

**Surface displacement of roadway:** Figure 3 shows the surface displacement change curve. Following conclusions can be drawn:

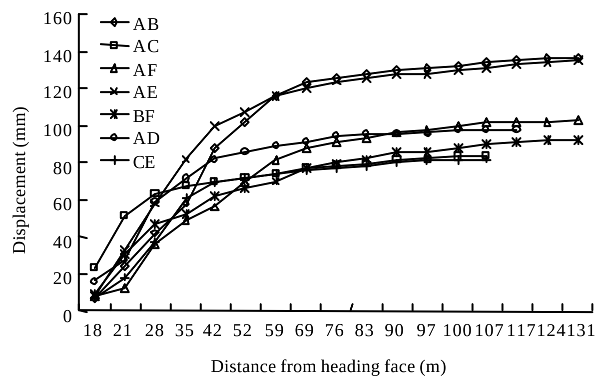


Fig. 3: Aurface displacement change curve

- The surface displacement of roadway gradually increases with the advancing of heading face. It changes dramatically within 69 m from the working face. The surface displacement changes slowly within the scope of 69~107 m and keeps stable 107 m away from outside the working face
- Deformation of BF is 92 mm and deformation of CE is 98 mm. Deformation of AD is 82 mm
- Deformation of roadway is uneven. The difference between AB and AF is 32 mm and the difference between AC and AE is 53 mm

The above analysis shows that with the process of roadway excavation, the deformation of roadway is chronic and uneven in each spot, leading to occurrence of differential deformation around the roadway. This differential deformation further reinforces assemble of stress in roadway and exacerbate deformation of roadway.

**Displacement of deep surrounding rock:** Figure 4 shows displacement of deep surrounding rock curve, from which following conclusions can be drawn:

- Displacement of deep surrounding rock changes dramatically within 127 m from the working face and and keeps stable 127 m away from outside the working face
- In the early process of excavation, displacement is not obvious. Once the working face move forward about 40 m, no mutation of displacement happens 2.5 m within surrounding rock. However, within the scope between 2.5 and 3.0 m, displacement increases to 11 mm and take little change outside 3.0 m, indicating the whole surrounding rock shift out in the range of 2.5 m and rock become loose between 2.5 and 3.0 m and range of surrounding rock loose

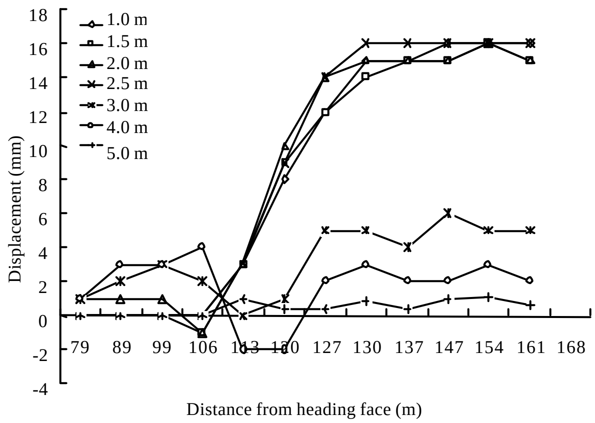


Fig. 4: Deep displacement change curve

circle is between 2.5 and 3.0 m. According to on-site monitoring results, the bolts are too short to reinforce the surrounding rock. The proper lagged time for grouting is as soon as displacement occurs. Yet, it is postponed to 50~80 m form working face in order not to affect the construction.

## ANALYSIS OF INSTABILITY IN ROADWAY

**Poor integrity of roadway surrounding rock:** The roadway construction has been completed by 500 and 700 m or so remain underconstruction. Geological conditions in this area are complicated. A number of associated and derived small faults will occur due to the faults in the construction. Lithological character is relatively fragmental in faults and fractured sections. Lithological character of roadway surrounding rock are mainly fine sandstone and sandy mudstone. The strength of rock block is relative taller than the rock strength because of the influence of internal structure. The integrity of rock is not good as well as overall stability. The broken rock zones of surrounding rock become larger and easier to deform under complex stress. The broken rock zones are even larger after excavation. The deformation last longer and the floor heave is severe

**Unreasonable supporting design:** Using engineering analogy method, the original support design did not choose the right supporting shape and the right time according to the geological conditions and stress properties of surrounding rock. The bolt is designed too short and the intensity of supporting system is inadequate. Lacking of theoretical basis, the floor heave control is ineffective

**Construction quality:** Since, this roadway is relatively high, procedures like roof controllng, drilling, installing anchor and bolt are difficult to deal with. Some leaky sections require high level of operational ability, construction quality and on-site management. According to on-site monitoring results, initial anchor-hold of the bolt is not adequate which weaken the load capacity of surrounding rock. So, the deformation coordination requirements between suporting system and surrounding rock are hard to achieve.

## SUPPORTING PRINCIPLES AND CONTROL MODEL OF SURROUNDING ROCK

**Supporting principles:** According to the depth and complex geological structure of this roadway, the following supporting principles are accepted:

- Active supporting principle.The rock is reinforced by high intensity cable anchor.Self load-bearing capacity of surrounding rock is fully exerted
- Timely supporting principle. Once excavated, the roadway should be supported prior to the deformation of surrounding rock so as to ensure the integrity of surrounding rock and the formation of load bearing structure as soon as possible
- Effective supporting principle. Ensure the quality of the project so that every bolt is intact and effective. Bolt should be strengthened when it fractureed or became invalid to ensure the overall effectiveness of roadway supporting.
- Process control principle. In the early stages of roayway excavation, surrounding rocks are mainly destroyed by tensile-shear complex unloading. Two main reasons account for its intensity weakening: (1) Stress state converts from three dimension to two dimension and (2) Excavation lead to surrounding stress concentration.Relatively large stress deviator is generated in the process of unloading pressure and main stress adjustment, resulting in shear fracture loops in the shallow surrounding rock gradually. In the following period, surrounding rock continue deformating in a relatively stable equilibrium. After a period of deformation accumulation, the balance of supporting surrounding rock structures tends to ultimate state. Affected by the environment, the intensity of surrounding rock further reduced. Stress perturbation generated at the same time the excavation works, direct impact of mining and other factors undermine the relative balance of the second phase, resulting in accelerating deformation of surrounding rock until the supporting

become invalid. Thus, a good roadway supporting should be strengthened step by step according the cause of its damage and intensity weakening: (1) Timely close the surrounding rock and compensate radial resistant force while excavating, (2) Surrounding rock deformate severely once excavated. The destruction of the shallow rock is mainly shear stress produced during stress adjustment. In this dynamic adjustment process, provide shearing resistance across structure face to prevent damage from occurring and timely improve the shear intensity of surrounding rock and (3) After the formation of fracture loops, surrounding rock stay in the fractureing state. A large number of macro-fractures appear and the intensity of rock decreases comprehensively. At this stage, the intensity of surruonding rock needs enhancing to improve the mechanical properties of rupture surface. Key damaged place should be reinforced to enhance the stability of its load bearing structure over a long period of time

**Control model of surrounding rock:** According to the surrounding rock conditions and underground pressure monitored, an ideal supporting program for this roadway is stepwise unit reinforcement supporting including bolt-mesh-spurting first, then cable bolting and grouting. In the fracture zone of roadway, the supporting program includes erecting shed and cable bolting and grouting. As is shown in Fig. 5. The optimized supporting parameters is as follows:

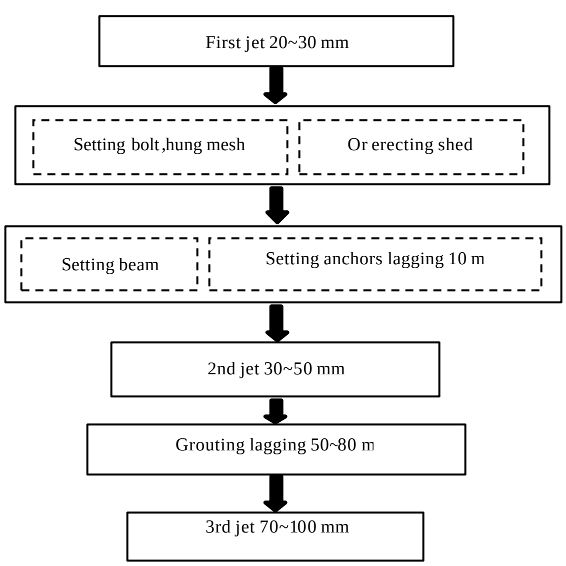


Fig. 5: stepwise unit reinforcement supporting flow chart

**Primary support:** The bolt is lefty twist steel of Φ20×2400 mm and the layout is 800×800 mm and every anchor bolt use two K2950 rapid resin anchoring agent.

**Secondary support:** the supporting technology is combined support with cable bolt wire mesh shotcrete and groutting. Cable is steel strands of Φ17.8×6300 mm and its array pitch is 2400 mm and 5 cables evenly distributed in every row. The length of grout bolt is 2200 mm and the layout is 1600×1600 mm.

**Analysis of roadway support effect after support parameter optimized:** The results of surface displacement shows that: (1) Roadway deformation is small, the biggest change of roadway surface displacement is 10 mm, (2) Roadway deformation uniformity, Overall stability of roadway and (3) Roadway deformation effects in short time, for the heading face within 50 m stabilization of the roadway in the context of the basic.

## CONCLUSION

- The influence of roadway fault crevice, the strength of roadway surrounding rock reduce, surrounding rock deformation large, the roadway surrounding rock deformation effect for a long time and the periphery of roadway deformation nonuniform
- The stress of anchor stock and anchor rope slants small, illustrate anchor stock and anchor rope didn't have effect of reinforcement surrounding rock, therefore, must strengthen construction management and supervisory activities, insure construction quality, enhance timbering effect
- Need more optimization design timbering parameter, choose rational support form and opportunity, optimized design the supporting parameters, through industrial practice has shown good bolting support results

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