

Study on Grouting Anchor Cable Supporting Technology of Roadway through Extra Large Fault Fracture Zone

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Abstract

Fault fracture zone due to the loose and broken surrounding rock of roadway, tectonic stress, the surrounding rock deformation is hard to control, has been one of the difficulties in roadway support technology research. This paper aim at Xingcun coal mine-1196m level roadway through extra large fault fracture zone, large deformation of surrounding rock and failure supporting project, can't ensure the overall stability of the roadway, put forward the "Bolt-mesh-spurting + prestressed hollow grouting anchor" combination support, effectively control the surrounding rock deformation in the test section of roadway, successfully resolved the problem of long-term stability of the surrounding rock in the fracture zone.

Keywords: Extra large fault fracture zone; Tectonic stress; surrounding rock deformation; Prestressed hollow grouting anchor cable

1. Introduction

Fault fracture zone are two plate of fault relative slip and make the both sides rock wrong extrusion, forming a rock fracture zone of long strip and with the direction of fault plane. Fault fracture zone stress distribution is more complex, easy to form the high concentration area. Surrounding rock is very fragmented and caving extremely easily, and prone to occur rib spalling and roof fall accidents in the process of roadway excavation^[1~3].

Bolt support can improve the stress state of surrounding rock mass, and enhance the rock mass strength and play its bearing capacity of surrounding rock, but in the fractured rock mass of joints and fissures of extraordinary development, roadway surrounding rock can be less anchorage sex, and allowed to control time is very short^[4]; And merely passive support can't control the plastic zone of surrounding rock to deep extension, the actual bearing capacity of the support is quite poor, need to be repaired for many times, and the supporting cost is waste seriously. It is difficult to control the large deformation of roadway surrounding rock in the fault fracture zone^[5].

At present, the technology of the grouting reinforce surrounding rock roadway with more and more widely applied in underground engineering. Grouting reinforcement is the main reinforcement methods of underground broken and soft of surrounding rock roadway^[6]. This paper aims at -1196m level development roadway of Xingcun coal mine, which used the "Bolt-mesh-spurting + U-shaped steel retractable metal stents" supporting programs. It was difficult to meet the long-term stability of roadway support requirements. According to the test section of roadway engineering geological conditions and rock mass conditions, based on the drawing on the original support program fails, the "Bolt-mesh-spurting + prestressed hollow grouting anchor cable" combined support technology succeeded in the test section of

roadway, achieving effective control of roadway surrounding rock deformation in fault fracture zone, successfully solved the problem of the roadway excavation safety.

2. Engineering situation

Xingcun coal mine is located in the east of Yanzhou in Shandong Province and southwest of Qufu, under Qufu's jurisdiction. The west of Xingcun field is the up-plate of Ziyang fault, south to the Ziyang fault and is bounded by Dongtan coal mine and Xing Longzhuang coal mine, north and west to the border mining field, Eastern is bounded by F50 fault and east of Xingcun coal mine, and mining field area is about 36.86 km². The main coal-bearing stratum are Taiyuan group and Shanxi group, and 3-coal of Shanxi group is the main minable seam, average thickness is 7.15 m, the mine geological reserves is 245.72 million tons, recoverable reserves is 67.254 million tons, coal seam dip of western mining field is less than 15°, while coal seam angle of western mining field is more than 15°(Fig.1 is 3-coal seam mining area plan). West wing return-air roadway, material haulage roadway and coal haulage roadway will through the F50 fault fracture zone area, the true thickness of the fault fracture zone is about 250~300m, the total length of three types roadway through the fault will reach 1000m(Fig.2 is F50 fault profile sketch). The maximum horizontal principal stress level (50~68 MPa) is greater than the vertical stress (31.3~31.6 MPa), the maximum principal stress direction is south east—northwest, as a whole, gravity stress and tectonic stress levels of the roadway suffered are relatively high.

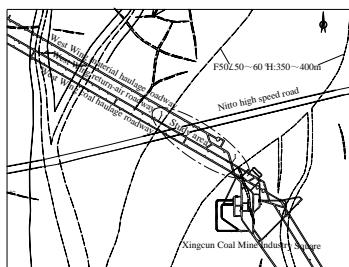


Fig.1 3-coal seam mining area plan

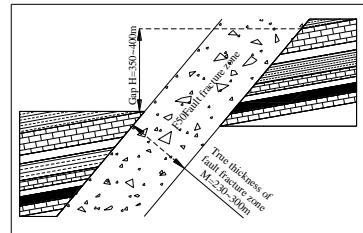


Fig.2 F50 fault profile schematic

3. Support design of roadway through fault fracture zone

3.1 Action mechanism of prestressed hollow grouting anchor cable

On the basis of initial bolt-mesh-spurting support, grouting reinforcement can strengthen the integrity support system and the bearing capacity of surrounding rock, guarantee the stability of the supporting structure. The essence of the prestressed hollow grouting reinforce surrounding rock by prestressed anchor cable, have access to the anchor cable prestressing on the reinforced rock mass, limiting the development of the harmful deformation of rock mass, so as to maintain the stability of rock mass, and grouting reinforcing the surrounding rock, which provides a reliable foundation for efforts on bolts and cables^[7], and avoid further loose of surrounding rock deformation. By grouting reinforcement, on the one hand, the loose and broken surrounding rock will be cemented into a whole, achieving common loading affect with surrounding rock, cooperate with spray the anchor net supporting, which can form an effective combination of multi-arch^[8], improve the bearing capacity and the integrity of the supporting structure, and make the bolts and anchor cables in anchored rock mass convert to full length anchorage. On the other hand, grouting fault fracture zone within a large amount of water flowing fractured channels, effectively preventing expansion and mud phenomenon of surrounding rock encounter water, and thus ensure the long-term stability of roadway surrounding rock and supporting structure.

3.2 Supporting parameters and design of roadway through fault fracture zone

(1)Roadway section design

The section design shape of West wing return-air roadway is straight wall and half closed arch, the section dimensions: roadway width is 4500 mm, arch height is 2750mm, and straight wall height is 1600 mm, straight wall of roadway net width is 4200 mm, net height is 3700 mm, and the wall height is 1600 mm, arch height is 2100mm, sectional area S excavation roadway=15.15 m², S net=13.65 m². Ditch on the right side of roadway floor, below the arch baseline 1600 mm, net width is 300 mm, net deep is 200 mm, ditch wall thickness is 100 mm, bottom thickness is 100 mm, using concrete pouring, the strength grade of concrete is C20.The main track centerline is 300 mm distance from the centerline of the roadway.

(2)The roadway supporting form

Roadway arch and side using “Bolt-mesh-spurting + prestressed hollow grouting anchor” combined supporting form, shown in Fig.3 Arch and side department adopts $\Phi 20 \times 2400$ mm type sinistral longitudinal reinforcement, high strength prestressed anchor to support, inter-row spacing is 800×800 mm, error of ± 100 mm. Anchor cable using the prestressed hollow grouting anchor cable, anchor cable type is $\Phi 22 \times 6000$ mm, inter-row spacing is 1200×1600 mm, error of ± 200 mm, each row set 7 cables (including two for each side near the arch baseline, and showing 20° with the horizontal). Roadway floor using anti-bottom arch support forms, vector height is not less than 800mm, the thickness of concrete laid along the bottom of the arch is 300mm, and mat waste rock or rebound material over the layer of concrete, finally complete a foundation of concrete above the cushion.

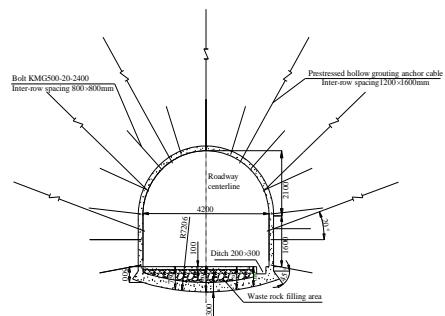


Fig.3 Roadway supporting scheme

4.Monitoring the control effect of roadway surrounding rock deformation

4.1Monitoring station layout

Test section roadway is through layers roadway, the stability of roadway surrounding rock is slightly different from lithology of surrounding rock in various section, Therefore, according to the reveal situation of surrounding rock during the process of excavation, in the test section of roadway specifically set up three station: A, B, C (station location shown in Fig.4), respectively corresponding to the aluminum mudstone section, boackSandstone and gray sandstone section, arrange three monitoring section in each station, set the station location as center cross section, each monitoring section spacing of 5 m.

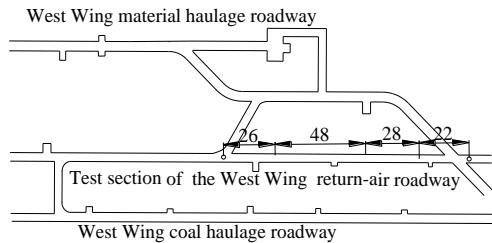


Fig.4 The layout of monitoring station

4.2 Monitoring content

(1)Roadway convergence deformation monitoring

Roadway convergence deformation monitoring include four content: Two sides relative convergence, roof and floor relative convergence, roof subsidence and floor heaves. Roadway surface displacement monitoring using “Ten” distribute points method, when the roadway head-on gradually through the station A, B and C, install monitoring section in time. usually required for embedding and testing initial reading within 12 hours after digging and blasting, each test section under the premise that guarantee monitoring point get effective protection, and should be close to the head, it is better no more than 2 m, and each monitoring section test once a day. Since roadway excavating and blasting, each monitoring station continue monitoring 60 days, record the data once a day. The convergence and deformation of each

monitoring section changed with time shown in Fig.5~6.

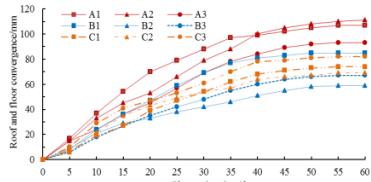


Fig.5 Roof and floor convergence

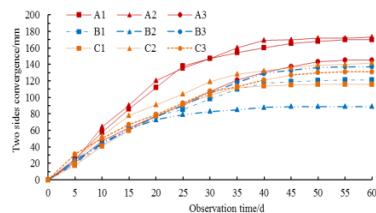


Fig.6 Two sides convergence

From Fig.5~6, you can see roadway deformation regularity can be divided into three stages:

The first stage: Intense deformation stage of roadway support beginning. For 15~20 days, and the roadway excavating and unloading disturb the broken surrounding rock mass. The stability of roadway surrounding rock is bad, and should adopt “Bolt-mesh-spouting + prestressed hollow grouting anchor” combined support measures in time. In the period of initial support, stress of roadway surrounding rock in a dramatic adjustment, strength of slurry strengthen stone in fractured surrounding rock is low, anchor cable and bolt supporting structure not fully play a supporting role, making the roadway deformation rate greater and the accumulative deformation of surrounding rock also bigger. Roof and floor of roadway maximum convergence rate is 3.5 mm/d, average convergence rate is 2.29 mm/d; Two sides maximum convergence rate is 6 mm/d, average convergence rate is 4.35 mm/d.

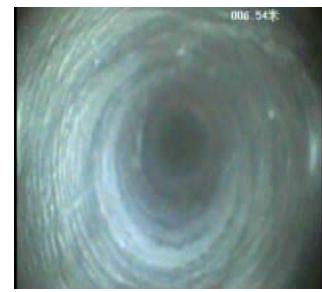
The second stage: Slow deformation stage. This phase mainly occur in applying supporting body in 20 days to 35 days, stress redistribution of surrounding rock tends to be stable, which gives full play to bolt-mesh-spouting and prestressed hollow grouting anchor cable active supporting role, converts the load

of surrounding rock into carriers, and limits the speed of deformation of surrounding rock. Roof and floor maximum convergence rate is 2.33 mm/d, average convergence rate is 1.61 mm/d; Two sides maximum convergence rate is 2.93 mm/d, average convergence rate is 2.35 mm/d. Compared with the first stage, roof and floor, the two sides convergence rate are significantly reduced.

The third stage: Stable stage. Support system impose about 40 days, roof and floor convergence rate and both two sides convergence rate tend to zero, the surrounding rock of roadway in a stable condition

(2)Drilling TV monitoring of the broken surrounding rock grouting reinforcement effect

To check the slurry filling effect in fractured rock mass, probe drillings are respectively arranged in the arch baseline of each centered monitoring station of the vault and side, drilling diameter is 32mm, and hole depth is 10m. Limited by the condition of the instrument itself, the actual probing depth is 9m, and the two observation results of roadway vault drilling video image in white sandstone monitoring station shown in Fig.7.



6.54m from the orifice



7.33m from the orifice

Fig.7 Drilling screenshots of gray sandstone in trial roadway after grouting

According to the design scheme, the prestressed hollow grouting anchor cable length is 6 m. removing the end anchorage segment, the actual grouting bond length is 5 m. According to the observation results, hole wall of the probe section 0~6.54 m from the orifice is integral, and fissure surface filled by cement slurry can be seen from part of the picture. Hole wall of the probe section after 7.33 m from the orifice is developing fissure, broken surrounding rock, and appearing seriously collapse phenomenon. Therefore, Anchor grouting cable can make the broken surrounding rock mass into a whole within the scope of the anchor cable length, combined with other support structure, forming a compound arch of effective multilayer in the deep roadway surrounding rock, and achieving the long-term stability of the roadway surrounding rock fault fracture zone.

5. Conclusions

(1)The new prestressed hollow grouting anchor cable use the technology of “outer anchor inner grunt”, and combine the function of anchor cable supporting and grouting reinforcement. They are together working on roadway surrounding rock, succeed in controlling roadway deformation and instability of fault fracture zone. Slurry in the upper part of the anchor cable can permeate into the deep rock fracture zone and strengthen the broken rock mass, making this part of the broken rock mass effectively form carriers. Combined with bolts, give full play to its anchorage effect, and thus effectively control the large deformation of roadway surrounding rock.

(2)The monitoring analysis of roadway control effect shows that: According to Xingcun coal mine roadway through extra large fault fracture zone, the proposed “bolt-mesh-spurting + prestressed hollow grouting anchor cable” combined support system, obviously improve the stress of roadway rock and the whole carrying capacity, and effectively control the deformation of roadway surrounding rock. It ensure

the roadway long-term stability and security, and the supporting effect is remarkable.

6. References

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