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Practice and Theoretical Thought on the Supporting for Soft Rock

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Abstract. The support of soft rock roadway is the worldwide problem in Coal resources exploitation, and this problem affect production safety and efficiency of coal mining serious. The surrounding rock of Ronghua coal mine is complex soft rock with expansibility, complex geological structure and deep high stress, large deformation of rocks, floor heave serious , supporting difficulties, frequent overhaul, waste a lot of manpower and material resources, and serious threats to the mine's safety production. After many years of practicing, a new idea of supporting the soft rock in different time periods, which is" avoiding first, then resistance", was propounded. Based on the lithology of surrounding rock and geologic structure, the roadway's length of service, application, and service condition were considered, several pointed support schemes of roadway in -650m level: Super-strong supporting, High-strong supporting, Flexibility combined supporting and Retractable U-shaped supporting were confirmed. A whole soft rock supporting technology system has been formed which effectively solved the difficult problems of soft rock supporting. These achievements can provide useful experience for similar engineering problems.

Introduction

How to support the soft rock is a global tough problem, especially the problem of soft rock supporting is more difficult, which puts back production badly [1-6]. There are more than thirty coal mine areas that have the problem of soft rock supporting. With the increase of mining depth, this problem becomes more and more serious which severely endangers the safety of mine production [7, 8].

The roadway surrounding rock of Ronghua coal mine compound soft rock which has high stress, developing joints and expansion, shorter form HJS soft rock. Along with the increase of mining depth in Ronghua coal mine especially in -650m the deformation and failure significantly increased, the surrounding rock mass deformation control difficulties, the need frequent overhaul, that take up a large manpower, this question restrict deep mining coal mine safety seriously.

The Types of Failure in Soft Rock Roadway

General situations: Vertical shaft development was used in Ronghua coal mine, designed productive capacity is 2.1×106t/a， there is one level development that is -650m; the depth of coal seams mined is 828m below the surface. Semicircle arch is used in shaft bottom and roadway of the first mining area, the roadway had serious failure when anchoring and shotcreting support were used to control the surrounding rock. Later, U-shape set support was used but the effect was not good.

The types of failure in soft rock roadway: Roadway surrounding rock of -650m is mainly made from mudstone and argillaceous sandstone with lots of clay mineral which can be 96 percent of contents of total mineral substance. Under the condition of high stress in deep mining and fault rupture, surrounding rock was squeezed into fragmentation, rock mass structure lose its cementing properties.

Figure.1 Failure in soft rock roadway

Figure.2 Compress-crushed surrounding rock

Roof gradual convergence: The reason of roof gradual convergence is the bolt and anchor cable supporting invalidation. Roof convergence could be 1000mm within ten days, the type of caving roof was like collapse column.

Figure.3 Two sides' convergence

Figure.4 Floor heaves of roadway

Two sides' convergence: Because of the high stress in surrounding rock, two sides of roadway were squeezed into roadway. The two sides' rock has expansibility and the stress transfer from roof into sides after supporting. Resultant force made the serious deformation.

Floor heaves of roadway: Floor heaves of roadway appears universally, the value of floor heave was 60mm within 24 hours in the most serious district. The speed dropped slowly with release of pressure. The floor heave value of East main roadway reached to 1.4m, this roadway has been repaired four times.

Mentality of Soft Rock Roadway Supporting

Based on the lithology of surrounding rock and geologic structure and the roadway's length of service, application, and service condition were considered, support scheme of roadway in -650m level were confirmed.

Super-strong supporting: These support schemes are used to support the roadway whose length of service is long, which have complex geological structures and high stress, such as wellhole, electric power substation, water pump house, and roadway of auxiliary shaft down hole. Use bolt + anchor cable + wire netting as the temporary support, after stress having released rigidity support can be used to support the roadways above to ensure the normal operation.

High-strong supporting: These supports are used to support the roadway and room whose length of service is long, simple geological structures, normal stress, such as east of the electric power substation, tube roadway, and crossheading. Use bolt + anchor cable + wire netting as the temporary support, after stress having released rigidity support can be used to support the roadways above to ensure the normal operation.

Flexibility combined supporting: These supports are used to support the roadway and room whose length of service is long, which are most frequently used, can be repaired, have high stress and serious deformation, such as east and west main roadway, return air main roadway, $7^{\#}$ cross cut, these roadways are support by bolt +anchor cable + wire netting + $H^{\#}$ steel belt + guniting combined supporting.

Retractable U-shaped supporting: This support scheme is used to repair the roadway and room, whose length of service is long and its high stress have released sufficiently, Use combined supporting as the temporary support, after stress having released retractable U-shaped supporting can be used to support the roadways above to ensure the normal operation.

Design and Construction of Soft Rock Roadway Supporting

Super-strong supporting: This scheme uses U29 mine steel support + φ20mm reinforcing steel + concrete enclosed supporting to support the roadway and room which have long length of service, have complex geological structures and high stress.

Supporting parameters and materials:

1) U29 mine steel support: roof beam and upright post are made to lap over each other, The bar lap length shall be 400mm. floor beam uses deflection of elastic thin bending plate, welding δ=10mm steel. The space and array pitch between supports is 0.5m or 1.0m which is selected based on the roadway deformation, surrounding quality and ground stress.
2) φ20mm reinforcing steel: its length is less than 3m. Φ20mm reinforcing steel is colligated on external side of U29 mine steel support. The bar lap length shall be 700mm.
3) Unity gating of concrete in work face, concrete mark is C20 and its thickness is 500mm.
4) The cement is ordinary Portland cement. Grade of cement is P.o32.5.
5) The pebbles are powdered stone whose diameter is smaller than φ25mm.
6) The sand is medium-coarse sand.
7) Construction machinery: JZC350 cylinder mixer, mine concrete conveying pump HBTS-15-6-22K.

High-strong supporting: These supports are used to support the roadway and room whose length of service is long, simple geological structures, normal stress, such as east of the electric power substation, tube roadway, and crossheading.

Supporting parameters and materials:

1) Φ20mm reinforcing steel, its length is less than 3m. Φ20mm reinforcing steel is colligated on external side of U29 mine steel support. The bar lap length shall be 700mm.
2) Unity gating of concrete in work face, concrete mark is C20 and its thickness is 500mm.
3) The cement is ordinary Portland cement. Grade of cement is p.o32.5.
4) The pebbles are powdered stone whose diameter is smaller than φ25mm.
5) Construction machinery: JZC350 cylinder mixer, HBTS-15-6-22K mine concrete conveying pump.

Combined supporting: At present, all the stone roadways are supported by bolt + anchor cable + wire netting + guniting combined supporting. In construction process the application amount of anchor cable is changed by the surrounding quality.

Supporting parameters and materials:

1) The bolt is φ20mm × 2000mm laevorotation deformed steel bars; the space between them is 0.8×0.8mm.
2) The anchor cable is φ17.8mm prestressed cable whose length is 6000mm and anchored force is 20t.
3) Bolt pallet is made of 150×150×8mm steel plate and anchor cable pallet is made of Mine I120-beam whose length is 300mm.
4) Option two resin sticks per bolt and four resin sticks per anchor cable.

5) Option 1000×2000mm wire netting with its mesh 50×50 mm. H steel belt is weld from φ16mm round piece of steel whose length is 4000mm.

6) The thickness of spraying is 150mm, and its strength is C15.

Retractable U-shaped supporting: The scheme, U29 support + metal netting or cement mortar + flexible filling seam, is used to repair the roadway and room, whose length of service is long and its high stress have released sufficiently. Use combined supporting as the temporary support, after stress having released retractable U-shaped supporting can be used to support the roadways above to ensure the normal operation.

Supporting parameters and materials:

1) U29 mine steel support, roof beam and upright post are made to lap over each other, the bar lap length shall be 400mm.

2) Woven bag is filled with mineral waste residue as the filling seam, being put into the space between U29 mine steel support and roadway surrounding rock.

3) Metal netting or cement mortar is also used in the space between U29 mine steel support and roadway surrounding rock.

Roadway floor anchoring: Floor anchor cable and bolt were used to control the floor heave. Because a high proportion of 96% of the rock is expansive mineral, it is very difficult to drill in the floor and the normal bolt and anchor cable can not be installed. So the self-drilling bolt grouting hollow products were used in the pump chamber.

TRZ self-drilling bolt grouting hollow product: In all kinds of underground engineering, due to the existence of the complex geology ,like weak surrounding rock ,fracture zone, the high field stress and large deformation, rock anchor construction has brought great difficulties, especially in serious hole collapsing and needs of the specialty blunder, ordinary bolt is powerless. The TRZ self-drilling bolt grouting hollow product achieve Functional integration of drilling, grouting and anchoring, for advance support in the tunnel, the radial support various types of slope treatment, and high field stress deformation ,it can improve the surrounding rock and achieve the desired supporting effect.

The Structure of TRZ self-drilling bolt:

Nut: Be able to deliver rock stress concentration to the pad

Arched plate: Be able to withstand greater rock stress

Grouting plug: Make sure the grouting to maintain a certain pressure in order to fill the surrounding rock gap fully.

Anchor body: Total length of the waveform with continuous thread, be easy to install drill, connected sets, tighten the nut; and can be cut and connected longer.

Bolt connection sets: Make sure that bolt can drill to side edge and extend to the design depth.

Alloy drill: With a strong penetrating power, so that the bolt can pass through the various types of rock.

Conclusions

The surrounding rock of Ronghua coal mine is complex soft rock with expansibility, complex geological structure and deep high stress, large deformation of rocks, floor heave serious , supporting difficulties, frequent overhaul, waste a lot of manpower and material resources, and serious threats to the mine's safety production. After many years of practicing, a new idea of supporting the soft rock in different time periods, which is" avoiding first, then resistance", was propounded. Based on the lithology of surrounding rock and geologic structure, the roadway's length of service, application, and service condition were considered, several pointed support schemes of roadway in -650m level: Super-strong supporting, High-strong supporting, Flexibility combined supporting and Retractable U-shaped supporting were confirmed. A whole soft rock supporting technology system has been formed which effectively solved the difficult problems of soft rock supporting. These achievements can provide useful experience for similar engineering problems.

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