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Study on Roadway Parameters of Broken Compound Roof of Gently Inclined Thick Coal Seam

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Abstract

This paper through investigation of the geological conditions of Da'Anshan’s coal mine, according to the special of the broken compound roof on inclined thick coal seam, select the anchor suspension theory and composite beam theory, design the roadway support’s anchor parameters, and apply the finite element software ADINA carry out simulation analysis, through the contrast of analysis and engineering data, proved that the design of support parameters is reasonably and practicable. The research has practical value and can guide similar projects.

Keywords: Broken composite; Roof Roadway; Numerical simulation

1. Summary

Roadway support is an important work of mine construction, Support design is an important factor in improving the quality of mine support project, it involves issues like security, cost, high yield and high efficiency, and so on. How to support the roadway to obtain stable work space needs to be solved urgently. Traditional mine support design methods is a serial design patterns, but the major steps of the design programs are the survey the geological conditions, Calculation of roof pressure, and Parameter design. Supporting design process is static. And the whole tunnel is supported with the same bolts, without selecting the right material, size and spacing of bolt according to the stress state of surrounding rock, so we could only make modifications to the design in the construction process. Design and construction process lack information exchange, which leads to a too conservative design and rising

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support costs; Or the design is not proper, and it happens that maintenance follows the excavation, causing great losses to the production. Therefore, selecting the appropriate anchor and taking the correct method for roadway support are very important tasks.

Beijing Haohua group mined 2 slot Coal from the 4th mining area of the west 680m-level Da' Anshan coal mine. The seam is gently inclined coal seam with 4 to 7 meters' thickness. The group intended to mine by using the technology of fully mechanized sublevel caving mining. Fully mechanized top coal caving mining roadway should be along the seam floor. However, since coal is soft, and the cross-section of the comprehensive mining roadway is relatively large, it's hard to retain the top coal. They used to stoping heading along the coal seam roof, leaving the top coal. Under these conditions, the use of fully - mechanized top - coal caving mining will certainly lose a large number of triangle coal in the upper and lower ends. And this way will bring a lot of difficulties to the stoping.

Currently, fully mechanized top coal caving mining technology in China is in the world's leading position. The upper and lower roadways of fully mechanized top coal caving mining face in thick coal seam are arranged along the coal seam floor, however, heading with the roof coal left in soft coal is currently the biggest challenge we're faced with. In order to solve the large-section roadway support in thick coal seam, it is urgent to do the research of supporting parameters of the heading along the upper and lower roadway on the fully mechanized top coal caving mining face in thick coal seam.

2. Geological Situation of Construction

The trend of Da’ Anshan coal mine field is about nine kilometers in length, two or four kilometers in width, 25.5 square kilometers in area, geological structure of mine field is complicated. The research mining face of this paper is the forth of the west mining area with the elevation height +680, up to the axis of Horizontal goaf with the height of +800 and the 800 Horizontal line, down to the 680 Horizontal line, 1200m long and 380m wide. false roof of coal seam is carbonaceous siltstone, with the thickness of 0.3 ~ 0.5 m, and the bedding extremely develop, making it easy to form a thin layer along the bedding and fall off, direct roof is siltstone, with the thickness of 4 ~ 11 m, and bedding develops, the layer partly contains high carbon, and poor Integrity, making it easy to collapse; main roof of coal seam are sandstone and siltstone, with the thickness of 9~14 m, false bottom of the coal seam is tuffaceous siltstone, with the thickness of about 0.3 m, and developed bedding; the direct bottom of coal seam is tuff, with the thickness of 10~20 m. The number of developed large faults in the zone may be 3 to 5, smaller faults also develope.

3. The Bolt Support Design

The roadway cross-section shape and size of Fully Mechanized Caving face be determined by layout of equipment in roadway. The forth west mining area’s roadway cross-section dimensions as shown in Figure 1.
The entire roadway bolting design according to Da’ Anshan coal mine geological conditions, anchor suspension theory and composite beam theory. The up and down roadway’s bolting and rope design parameters as shown in Table1, Table2, Table3, Table4.

Table1. The down roadway bolting design parameters

<table>
<thead>
<tr>
<th>Name of tunnel</th>
<th>The down roadway in the forth west mining area</th>
<th>Angle of corner anchor</th>
<th>75°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-section of tunnel</td>
<td>m2</td>
<td>Steel specification</td>
<td>φ14.24×2600×75</td>
</tr>
<tr>
<td>Length of roof anchor</td>
<td>2000mm</td>
<td>Length of help anchor</td>
<td>2000mm</td>
</tr>
<tr>
<td>Diameter of roof anchor</td>
<td>18mm</td>
<td>Angle of help anchor</td>
<td>0°, -20°</td>
</tr>
<tr>
<td>Row distance between roof anchor</td>
<td>0.8×0.8m</td>
<td>Distance of help anchor between rows</td>
<td>0.8×0.8m</td>
</tr>
</tbody>
</table>

Description: Hanging net and playing anchor in Full-face, the bolt use the Rectangular eye arrangement

Table2. The down roadway rope design parameters

<table>
<thead>
<tr>
<th>Length of anchor</th>
<th>5 m</th>
<th>Distance of anchoring cables</th>
<th>3m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row distance of anchor</td>
<td>1.2 m</td>
<td>Anchorage length</td>
<td>2.0 m</td>
</tr>
</tbody>
</table>

Table3. The up roadway bolting design parameters

<table>
<thead>
<tr>
<th>Name of tunnel</th>
<th>The up roadway in the forth west mining area</th>
<th>Angle of corner anchor</th>
<th>75°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-section of tunnel</td>
<td>m2</td>
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<td>Angle of help anchor</td>
<td>0°, -20°</td>
</tr>
</tbody>
</table>
4. Finite Element Simulation of Supporting Structure

In order to verify the supporting program's supporting effect on practical engineering, finite element method is used to simulate the situation and research on compound roof roadway displacement and stress field distribution.

4.1. Modeling and ideas of simulation

First of all, respectively establish the finite element model of the two sections of the upper and lower roadway and the supporting structure, the roadway's cross-section dimensions is as shown in Figure 1. To avoid the simulation of boundary effects, the model boundary is to be three times the width of the roadway section, Establishment of grid figure is as shown in Figure 2, Figure 3. Anchor bolt is simulated by rebar element that ADINA comes with. The model selects level constraints on either side, and fixed constraints at the bottom. Simulation of surrounding rock selects Mohr-Coulomb materials. Material parameters are taken from the experimental data of the project. After integration, it is as shown in table 5. According to the steps of actual construction, stimulate the steps of practical engineering such as excavation and support construction with the element birth and death module of ADINA.

Table 5. Supporting materials and surrounding rock parameters

<table>
<thead>
<tr>
<th>Material</th>
<th>E (Pa)</th>
<th>μ</th>
<th>C/MPa</th>
<th>φ/°</th>
<th>γ/kg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>concrete</td>
<td>21e9</td>
<td>0.2</td>
<td></td>
<td></td>
<td>2.2×10³</td>
</tr>
<tr>
<td>bolt</td>
<td>210e9</td>
<td>0.3</td>
<td></td>
<td></td>
<td>7.8×10³</td>
</tr>
<tr>
<td>surrounding rock</td>
<td>0.932e9</td>
<td>0.2</td>
<td>3.9</td>
<td>40</td>
<td>2.35×10³</td>
</tr>
</tbody>
</table>
4.2. Comparative analysis of simulation results and their actual monitoring

（1）Through analysis, concluding maps of the stress and displacement of the upper and lower roadways after the excavation are as shown in Figure 4, Figure 5, Figure 6 and Figure 7. Based on the graph we can see that, the maximum displacement is up to about 130mm, and stress is small, which shows that Bolt and cable anchor support can meet the requirements, design of support structure is reasonable and practicable.

（2）Comparatively analysis numerical simulation and measured values, Simulate the surrounding rock excavation and formation of bolt and cable anchor support with the element birth and death module of ADINA. Compare the corresponding time with the actual time. After selecting the support form, the actual deformation during construction of the project is as shown in Figure 8 and Figure 9, which shows...
that with the gradual deepening of driving, the vault gradually increases. After supporting according to the initial supporting scheme, upper tunnel vault reaches to the maximum of 110mm, and lower tunnel reaches 105mm, both of them reached stable value. Measured data shows smaller displacement than simulated value, the former is about 60 to 80 percent of the latter, which means that in accordance with the above support method, there is still a certain degree of security reserve, if future conditions allow, we should do further study on broken and composite roof roadway, and determine more precise support parameter.

Fig.8. Section on lane subsidence vault changes with time curve

Fig.9. Lane subsidence under section vault changes with time curve
5. Conclusion

This paper describes a research on the supporting parameters of the Da’ Anshan complex roof tunnel with gently inclined broken and thick coal seam, and also makes a comparative analysis of the practical engineering data, then we get the following conclusions:

(1) Through surveying and analysing the on-site engineering’s geological conditions, stress and the tectonic stress field, determine the size of the cross-section of the roadway;
(2) According to the suspension theory of anchor, and composite beam theory, combine with practical engineering information, and design a roadway anchor, support parameters of the anchor;
(3) Using finite element analysis software ADINA simulates the supporting structure. Through this, structural displacement and stress that originally designed for supporting anchor bolt both can meet the requirements. Compare the simulation results with the experimental results, we can know that the supporting means has enough security reservation, this means that the design of the supporting structure is reasonable and feasible.

This study solved the problems of safety when heading through the roadway under the condition of compound roof, and getting the best performance and quality. At the same time it has a certain implication for other similar coal mining, showing broad application prospects.

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References