Experimental Study on Zonal Disintegration Phenomenon in Deep Rock Mass under Blasting Excavation

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1 Introduction

2 3D Geomechanical Model Experiments

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5 Conclusions
Nowadays, deep exploitation is becoming a common practice in China. Deep rock masses are in the complex and special engineering environment, such as high geostress, high geothermal temperature, high seepage pressure and blasting disturbance. Then, a series of unique and new geological hazards are presented. **Zonal disintegration phenomenon** is such a unique geological hazards in high axial geostress condition.

It was defined as “alternated regions of fractured and relatively intact rock mass appearing around or in front of the working stope”.
1 Introduction

Fig.1 Schematic diagram of Zonal disintegration phenomenon

Interval distribution of fractured and relatively intact rock mass around deep tunnel

Fracture Zone

Unfracture Zone

Fig.1 Schematic diagram of Zonal disintegration phenomenon
1 Introduction

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At present, Deep underground engineering are mainly constructed by drilling and blasting method.

To investigate the effect of blasting load on zonal disintegration phenomenon in deep rock mass, 3D geomechanical model experiments in high axial geostress and blasting excavation are carried out by "capacity of deep rock breakage mechanics and supporting technique model test" in State Key Laboratory of Deep Coal Mining and Environment Protection.
2 3D Geomechanical Model Experiments

Fig.2 Capacity of deep rock breakage mechanics and supporting technique model test
Dingji Coalmine in Huainan mine area, where zonal disintegration phenomenon has been observed, is taking as engineering prototype.

According to similarity theory, the geometric similar coefficient is 1:25, the stress similar coefficient is 1:36.

Cemented sand similar maertial is used to simulate the deep rock mass. The compressive strength of intact rock is chosen as 88.55 MPa. Therefore, the compressive strength of cemented sand similar material is 2.48 MPa.
2 3D Geomechanical Model Experiments

Fig. 3 Cemented sand model
(Size: 1000 × 1000 × 400 mm)
2 3D Geomechanical Model Experiments

![Diagram of measuring points arrangement in cemented sand model](Image)

*Fig. 4 Measuring points arrangement in cemented sand model (Unit: mm)*
Fig. 4 Measuring points arrangement in cemented sand model
Table 1 Test Scheme of 3D geomechanical model experiments

<table>
<thead>
<tr>
<th>Number</th>
<th>Excavation method</th>
<th>Support condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZD-1</td>
<td>Static</td>
<td>No</td>
</tr>
<tr>
<td>ZD-2</td>
<td>Blasting</td>
<td>No</td>
</tr>
<tr>
<td>ZD-3</td>
<td>Blasting</td>
<td>anchor bolt + anchor cable</td>
</tr>
</tbody>
</table>

The experiment procedure is “first loading, then excavation, last overloading”.

The cemented sand model is firstly loaded at the initial geostress condition.

During experiments, only axial direction is overloaded.
3 Blasting Load Effect Analyses

Fig. 5 Schematic diagram of design loading curve for model test
3 Blasting Load Effect Analyses

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Fig. 6 Blasting excavation in 3D geomechanical model experiments
3 Blasting Load Effect Analyses

Fig. 7 Blasting vibration signals in three directions
3 Blasting Load Effect Analyses

Radial Direction

Tangential direction

Fig. 8 Actual measured explosive strain waves
3 Blasting Load Effect Analyses

Fig.9 Radial strain distribution around tunnel after overload $1.5\sigma_c$
Blasting load produces some micro-cracks on similar materials nearby the boundary of model tunnel with deterioration of its mechanical properties and damage to its integrity.

Under high axial load, micro-cracks caused by blasting load propagate and connect to form a macro fractured zone. After quantitative analysis of fracture zone distribution under blasting load, the radius of next fracture zone is about 1.28 times bigger than that of former fracture zone.
Fig. 10 Macro fracture mode of model ZD-2
4 Anchorage support effect analyses

Fig. 11 Layout of model support materials
(anchor bolt + anchor cable)
4 Anchorage support effect analyses

Fig. 12 Radial strain distribution around tunnel after overloading
Fig. 13 Macro fracture mode of model ZD-2 and ZD-3 after overloading
Compared the results with no anchorage support, there is no zonal disintegration phenomenon in anchorage positions of model tunnel.

The combination of anchor bolt and anchor cable can transfer and redistribute the stress of surrounding rock.

Therefore, the combination of anchor bolt and anchor cable presents a good inhibition effect of zonal disintegration phenomenon.
5 Conclusions

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5 Conclusions

(1) Blasting loads during blasting excavation will not only deteriorate the mechanical properties of surrounding rock, but also reduce its integrity. High axial geostress intensifies the fracture level and extends the fracture zone.

(2) After quantitative analysis of fracture zone distribution in blasting excavation, the radius of next fracture zone is about 1.28 times bigger than that of former fracture zone.

(3) The combination of anchor bolt and anchor cable can transfer and redistribute the stress field of surrounding rock. And it presents a good inhibition effect of zonal disintegration phenomenon.
Thanks for your attention!