shoulder are in the strata of pebbled sandstone and glutenite cross, the thickness of which is 20.8 m, hard and compact, and the shell base is in the 5# coal seam. The rock strength of key parts of instability, obtained by experiment of physical and mechanical properties of rock, is compared to the stress of key parts by numerical simulation. The results show that the MSAS firstly causes the tensile instability in shell roof and shell shoulder, and then causes the composite instability in shell base.

<table>
<thead>
<tr>
<th>Instability position</th>
<th>Strata</th>
<th>R/MPa</th>
<th>τ /MPa</th>
<th>R_/MPa</th>
<th>R_/MPa</th>
<th>Instability mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell roof</td>
<td>pebbled sandstone</td>
<td>1.8</td>
<td>9.8</td>
<td>42.5</td>
<td>2.8</td>
<td>tensile instability</td>
</tr>
<tr>
<td>Shell shoulder</td>
<td>pebbled sandstone</td>
<td>1.8</td>
<td>9.8</td>
<td>42.5</td>
<td>2.2</td>
<td>tensile instability</td>
</tr>
<tr>
<td>Shell base</td>
<td>5# coal seam</td>
<td>2.0</td>
<td>1.08</td>
<td>4.9</td>
<td>5.1</td>
<td>Composite instability</td>
</tr>
</tbody>
</table>

6. CONCLUSIONS

Research on fully mechanized longwall mining of steeply dipping seams in China has revealed the distribution of stress and instability mechanism of MSAS, including: (1) the MSAS exists in overlying strata in steeply dipping seam mining, MSAS is a spatial distribution form of intensity envelope line with a strength criterion under the action of rock self-organization after stress distribution. It has the geometry shape asymmetry and stress distribution heterogeneity features. As the face moves forward, MSAS evolution further and tends to achieve relative stabilization due to the rock self-organization. It presents the “instability-stability” process of overburden structure; (2) the analyzing model of MSAS is a symmetrical arch along strike and an asymmetrical arch along inclination. The base of MSAS acts on the peak abutment area of solid coal seam at the front, rear and sides of the face while the roof of MSAS is in the unbroken overburden rock of the upper section of face. Surrounding rock stress distribution in steeply dipping seam mining can be characterized by configuration equation of MSAS. (3) The instability of MSAS is mainly caused by the mining stress concentration over rock mass strength and inclined to start from one key part, such as shell roof, shell shoulder or shell base. The key parts of instability mainly demonstrate three failure forms, which are the tensile instability in shell roof, the compress-shear instability in shell shoulder and the composite instability in shell base. According to the instability process of key parts of MSAS, its instability mode is divided into shell base-roof (shoulder) instability mode and shell roof (shoulder)-base instability mode. (4) Based on the condition of No.25112 working face of steeply dipping seam mining in prime coking coal mine of Xinjiang tar coal group co. ltd, when the No.25112 working face moves forward 50m with the inclination length of face maintained 90m, the MSAS configuration equation of this condition is given by applying the analyzing mode. With the face moves forward, the shell roof (shoulder)-base instability occurs to MSAS, which first causes the tensile instability in shell roof and subsequently causes the composite instability in shell base, leading to the mining fractures and a shift of high stress are to deeper rock where new MSAS is formed.

7. ACKNOWLEDGMENTS

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REFERENCES