Research on composite dynamic disaster prevention and control system of mine earthquake and shock in thick and hard rock mines

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Abstract

With the rapid entry into deep mining of coal mines in China, the impact composite dynamic disaster of thick and hard layer mines and mine earthquakes has increasingly become a major disaster that threatens the safe and efficient mining of deep coal. Studying its occurrence mechanism, disaster prevention and control system has become a new major scientific issue in the field of coal mine safety. This paper proposes a framework for a composite dynamic disaster prevention and control system framework for thick and hard rock mines. First, the gravity forms, extents and deformation characteristics of different rock layers of the structural model are analysed, and the expressions of concentrated force and periodic breaking step distance of rock beams in thick and hard rock layers at the fixed support end are deduced. Then, according to the cause of the shock composite dynamic disaster, finally, the specific testing and calculation methods of mine earthquakes in thick hard rock mines are designed. The regional and local measures to manage compound dynamic disasters are put forward. Experiments show that the system is successfully applied to the mining practice of working face, and the results of water conservancy and stress monitoring support the rationality of the system. And through the implementation of impact prevention and control measures, the safety and disaster prevention and control of the working face was finally realised.

Keywords: Coal mining, overlying rock movement, mine earthquake, rockburst, disaster prevention and control

1 Introduction

China has abundant reserves of ultra-thick coal seams, and the fully mechanised caving face mining of ultra-thick coal seams has the characteristics of high output, fast efficiency and significant economic benefits [1, 2]. The mining depth of most underground coal mines in our country is not more than 400–500 m, and the movement range of the roof is mainly 6–8 times the mining height above the coal seam, which is the traditional theory of rock pressure [3, 4]. Key parameters such as mining scale and intensity of longwall panels are constantly being refreshed. The movement range of the overlying rock at the working face increases dramatically, and the evolution law of the mining stress field presents complexity [5, 6]. In the height direction, it has far exceeded the...
‘basic roof’ range, and in the horizontal direction, it has also exceeded the range of the upper and lower lanes on the working surface.

In recent years, domestic scholars have achieved a lot of research results on the characteristics of rock pressure in fully mechanised caving faces of extra-thick coal seams. In view of the research on the failure height of the top coal body in fully mechanised caving mining of extra-thick coal seams, a ‘three-zone’ structural model of the top coal body in fully mechanised caving mining of extra-thick coal seams is proposed, namely ‘scattered body zone’ and ‘block body zone’ from bottom to top ‘Cracked beam belt’ [7–9]. Based on the cantilever beam-masonry beam mechanical structure model of extra-thick coal seam, the mechanical model of the fracture of the cantilever beam structure with the central inclined crack is established, and the expression of the support load is given [10]. The ‘face contact block arch’ model of fully mechanised caving surface of extra-thick coal seam was proposed, the mechanism of top coal arching was studied, and the arching phenomenon that the top coal was easy to form blocking coal caving during the caving process was revealed [11]. Based on the BBR research system, the optimisation of the coal caving method for fully mechanised caving mining in extra-thick coal seams is carried out, and the segmented and large-interval coal caving method is proposed [12]. The research on the mechanism of shock composite dynamic disasters should be strengthened from the following aspects:

1. Make a more scientific classification of the combined dynamic disaster of mine shock and shock in thick and hard rock mines [13];
2. In-depth study of the quantitative mechanical model of shock composite dynamic disasters [14, 15];
3. Consider the research on the disaster mechanism of the mine-seismic composite system in the mine with thick hard rock layer under the stress path that is more in line with the actual conditions of the site [16];
4. Strengthen the role of deep learning and big data technology in the study of the nonlinear mechanism of disasters [17];
5. Continue to increase scientific and technological research efforts [18].

The movement state and stress distribution of the overlying hard rock layers in the stope are the main factors controlling the occurrence of dynamic disasters such as rockbursts. Scholars have carried out a lot of research in related fields [19, 20]. With the continuous depletion of superficial resources in our country and the continuous increase in the depth and intensity of coal mining [21], in recent years, rockburst disasters have occurred frequently, and rockburst has become a typical form of dynamic disasters that affect the safety of coal mine production in China and restrict the harmonious development of mining areas. Rockburst is an induced disaster [22]. The main reason for it is that the stratum structure is damaged or the stress is in an abnormal state in the mining influence range [23]. The motion state of the thick and hard rock layer determines the dynamic appearance and influence scope of the working face, and its buckling motion is the main reason for inducing strong rockbursts [24,25]. Rockburst is usually regarded as a problem related to structural instability of coal and rock mass.

In summary, this paper proposes a study on the dynamic hazard system of seismic and shock loads in thick rock mines. The main outstanding work is as follows:

1. Detailed research and discussion on the analysis of the seismic and impact composite dynamics of the thick and hard rock layers;
2. A complete set of disaster prevention and control system is proposed under the combined influence of the combination of earthquake and shock in thick and hard rock layers;
3. Finally, the experimental comparison is carried out, and the experiments are carried out under different vibration degrees. The experimental analysis results show that the system proposed in this paper can pre-analyse disaster prevention and control.
2 Mine earthquake and shock composite dynamic disaster in thick and hard rock mine

2.1 Mine earthquake with thick and hard rock layers

During the fracture movement of the thick and hard rock layer, the bearing stress of the coal body in the working face also undergoes periodic stress changes. The periodic breaking motion of the overlying thick hard rock layer in the stope is the main reason for the concentration and transfer of the advanced bearing stress in the working face. According to the width of the coal pillar and its stress state, the fully elastic state mainly experienced by the coal pillar of the re-mining face during the continuous mining process is obtained [26]. Based on the spatial structure of the thick and hard rock layers and their boundary characteristics, the overhanging thick and hard rock layers are regarded as elastic rock beams, and the coal-rock mass at the stope boundary is regarded as the fixed support end of the stope. The basic morphological characteristics that may appear after the critical layer is broken are as follows:

1. The key layer cantilever beam structure and the masonry beam structure (or hinged structure) are the two types of key layer structures that determine the pressure of the working face and control the type and danger of disasters;

2. The main factor of the shape of the key layer in the stope is the mining height and the height of the key layer from the coal seam, that is, after the key layer is broken, whether the rotation amount of the broken rock block exceeds its maximum rotation amount to maintain a stable structure;

3. After the coal seam is mined, the low-level roof directly collapses layer by layer and fills the goaf, according to Qian Ming et al., as

\[
\begin{align*}
\Delta_J &= m - (K_s - 1)h_L \\
\Delta_{\text{max}} &= h - L\sqrt{2(q_0 + \gamma h)/\sigma}
\end{align*}
\]

Here, the rotation amount \(\Delta_J\) of the broken rock block in the thick and hard rock layer is the maximum rotation amount \(\Delta_{\text{max}}\) required to form the cantilever beam structure. \(m\) is coal seam thickness or mining height. \(K_s\) is a low-level caving rock layer between the top coal (slab) and the bottom of the thick hard rock layer. \(h_L\) is the height of the thick hard rock layer from the coal seam. \(L\) is the breaking step of thick hard rock layers. \(q_0\) is overburden load for thick hard rock beams.

By analysing the thick and hard rock layer-coal pillar structural system and its stress state, the mechanical model of the thick and hard rock layer-coal pillar structure under static conditions is further simplified. In order to facilitate the analysis and calculation, the support force on the fixed end of the cantilever rock beam is approximated as the concentrated force \(F_2\). The transfer body structure composed of the horizontal cantilever rock beam-broken rock block is mainly flexural deformation, and the support structure composed of coal pillar coal mass and rock pillar in the height direction is mainly composed of forced compression deformation:

1. The overhang length of the cantilevered rock beam at the fixed end does not exceed the ultimate breaking step distance under the equilibrium condition of the hinged structure;

2. The stress on the coal pillar at the bottom of the fixed support end is lower than its comprehensive support strength.
2.1.1 Mechanical model building

The model is squeezed by the rock masses on both sides to form horizontal thrusts $T_1$ and $T_2$. The supporting action of contacts and fixed ends in the vertical direction is simplified to concentrated force $F_1$ and $F_2$ as

$$\begin{align*}
\sum F(x) &= 0 \\
\sum F(y) &= 0 \\
\sum M(f) &= 0
\end{align*} \tag{2}$$

Among them, $w$ is the deflection of the cantilever rock beam - the flexural deformation of the fractured rock block structure. The principal vector and principal moment of the force system at any point in the structural system are both zero. The following section focuses on quantitative analysis of the above-mentioned mechanical model, and solves the key parameters.

In the horizontal direction, the broken rock block squeezes with the adjacent rock beams during the rotational deformation process, thus forming a horizontal thrust. It is not difficult to conclude that $T_1$ and $T_2$ are a pair of action force and reaction force, which satisfies the equilibrium condition:

$$T_1 - T_2 = 0 \tag{3}$$

where the cantilever rock beam and the hinged structure of the broken rock block maintain a balance of gravity, which satisfies the equilibrium condition:

$$F_1 + F_2 = (q_0 + \gamma h)(1 + L) \tag{4}$$

Here, $q_0$ is the load of overlying rock borne by the rock beam, and $\gamma$ and $h$ are the bulk density and thickness of the rock beam, respectively. The hinged rock mass is subjected to horizontal thrust during the slow deformation process. The hinged contact points create internal friction $F_{1\times}$ in the vertical direction. $F_{2\times}$ is equal in size and opposite in direction, which satisfies the condition:

$$\begin{align*}
F_1 + F_{1\times} &= (q_0 + \gamma h)L \\
F_{1\times} - F_{2\times} &= 0
\end{align*} \tag{5}$$

Finally, the expression of the concentrated force $F_2$ at the boundary of the fixed support end of the rock beam is:

$$F_2 = \frac{1}{2} (q_0 + \gamma h) (1 + L) \tag{6}$$

where the concentrated force transmitted by the spatial hinge structure to the coal-rock mass in front of the working face in the thick and hard rock-coal pillar model. The concentrated force belongs to the space transfer load or additional load formed by the mining process.

2.1.2 Periodic motion step of thick and hard rock layers

The basic theory of flexural deformation of rock beam in elastic mechanics, the differential equation of flexural deformation of rock beam is:

$$EI \frac{d^2 y}{dx^2} - M_x = 0 \tag{7}$$

where $M_x$ is the bending moment of the rock beam at any interface along the working face strike, $E$ is the elastic modulus of the rock beam and $I$ is the moment of inertia of the section.

First, according to the moment balance condition, the bending moment $M_x$ of any section of the rock beam is obtained and expressed as:

$$M_x = EI \frac{d^2 y}{dx^2} = \frac{q_0 + \gamma h}{2} (1-x)^2 + F_{2\times}(l-x) \tag{8}$$
where \( x \) is the horizontal distance between the position of the rock beam section and the boundary of the fixed support end.

Then, the maximum bending moment \( M_0 \) of the rock beam at the boundary of the fixed end and the tensile stress \( \sigma_0 \) of the boundary of the fixed end are:

\[
M_0 = M_x|_{x=0} = \frac{q_0 + \gamma h}{2} l^2 + F_2 l
\]

(9)

\[
\sigma_0 = \frac{M_l h}{I} = 3l(l + L) \frac{q_0 + \gamma h}{h^2}
\]

(10)

Finally, if the ultimate tensile strength of the thick hard rock layer is \( \sigma_t = \sigma_0 \), the periodic breaking step of thick and hard rock layers is:

\[
L = \sqrt{\frac{\sigma_t h^2}{6(q_0 + \gamma h)}}
\]

(11)

2.1.3 Evaluation basis and evaluation index of mine earthquake

The shock wave generated by the mine earthquake is similar to the general shock wave. The shock wave can produce strain effects (deformation and vibration) and inertia effects (pressure and tension) on the surrounding medium and surface buildings during the propagation of the medium. Among them, the judgement basis (safe \( Z \) and unsafe \( \overline{Z} \)) operation expressions are:

\[
\begin{align*}
Z &= x_1 \cdot x_2 \cdot x_3 \\
\overline{Z} &= x_1 \cdot x_2 \cdot x_3 = x_1 + x_2 + x_3
\end{align*}
\]

(12)

where ‘−’, ‘+’ and ‘ ’ represent logical operators ‘NOT’, ‘OR’ and ‘AND’, respectively. The specific discrimination results are shown in Table 1.

<table>
<thead>
<tr>
<th>Category</th>
<th>Displacement</th>
<th>Speed</th>
<th>Acceleration</th>
<th>Discrimination result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( x_1 )</td>
<td>( x_2 )</td>
<td>( x_3 )</td>
<td>( Z )</td>
</tr>
<tr>
<td>2</td>
<td>( x_1 )</td>
<td>( x_2 ) + ( x_1 )</td>
<td>( x_3 ) + ( x_1 )</td>
<td>( \overline{Z} )</td>
</tr>
<tr>
<td>3</td>
<td>( x_1 + x_1 )</td>
<td>( x_2 )</td>
<td>( x_3 ) + ( x_1 )</td>
<td>( Z )</td>
</tr>
<tr>
<td>4</td>
<td>( x_1 + x_1 )</td>
<td>( x_2 ) + ( x_1 )</td>
<td>( x_3 )</td>
<td>( \overline{Z} )</td>
</tr>
</tbody>
</table>

(13)

It can be seen from the elastic mechanics reasoning that the additional force caused by the mine earthquake is related to the particle vibration velocity:

\[
\sigma = \frac{E_c}{c}
\]

The equation of motion of an isotropic ideal elastic body is:

\[
\rho \frac{\partial^2 \phi}{\partial t^2} = (\lambda + G) \frac{\partial^2 \phi}{\partial l^2} + G \nabla^2 \phi
\]

(14)

\[
c = \sqrt{\frac{\lambda + 2G}{\rho}}
\]

(15)
where $\sigma$ is the additional stress caused by particle vibration, $c$ is the velocity of the shock wave propagating in the medium, $\varphi$ is the medium displacement function, $\phi$ is the volume deformation function of the medium and $G$ is the volume deformation function of the medium. Finally we obtain the expression:

$$\sigma = v \sqrt{\frac{(1 - \mu)E \rho}{(1 + \mu)(1 + 2\mu)}}$$

(16)

### 2.2 Shock composite dynamic disaster

Aiming at the regular mechanism of shock composite dynamic disaster, the existing research can be summarised into qualitative and preliminary quantitative research as follows. The first category is to combine typical case studies and theoretical analysis to discuss the conditions and characteristics of disaster occurrence, and then to propose a qualitative explanation of the disaster occurrence mechanism. The second type is to use the experimental platform to carry out experimental research from the point of view of the damage and instability induced disasters of gas-bearing coal and rock mass, in order to grasp the occurrence mechanism of compound disasters. The process of composite dynamic disaster must be controlled by the damage and damage of objects and rock medium and its coupling effect with mechanics and seepage behaviour in coal.

Under the condition of deep high stress, rockburst disasters mainly occurred in the coal seam with strong shock tendency and developed into the coal seam with weak shock tendency. Similarly, the increase of stress, gas content and gas pressure led to coal and gas outburst from soft coal to medium hard coal. Coal development is shown in Figure 1. Therefore, many deep mining mines face the threat of rockburst and gas outburst dynamic disaster at the same time, and some mines even have a composite dynamic disaster in which the impact and outburst are mutually induced.

![Fig. 1 Shock – changing trend of the dangerous range of prominent dynamic disasters with mining depth](image)

The use of microseismic monitoring technology to study composite dynamic disasters is an interdisciplinary subject, involving the knowledge of many basic disciplines such as geology, rock (damage, fracture) mechanics, dynamic signal testing and analysis. The essence of a microseismic event is the manifestation of a series of dynamic evolution processes such as stress, strain, deformation, cracking, instability and failure of the surrounding rock. Because the microseismic monitoring technology can describe the movement and failure of rock formations in an all-round way in space stress drop and its failure size and failure mode, so it has unique advantages over traditional methods.
At present, the main technical measures for pressure relief and outburst elimination of coal seam roadway excavation working face include mining protective layer, regional gas pre-drainage, advanced drilling, deep hole water injection, hydraulic punching, hydraulic cutting, deep hole loosening blasting and deep hole drilling controlled blasting and so on.

3 Prevention and control system of mine earthquake and impact composite dynamic disaster based on thick and hard rock layer mine

The rupture of thick and hard rock layers can induce strong mine earthquakes and cause different degrees of vibration damage to the ground. According to the conditions of strong mine shocks induced by the rupture of thick and hard rock layers, the idea of a shock composite dynamic disaster prevention and control system is proposed to change the conditions of mine shocks and reduce the energy released by mine shocks, as shown in Figure 2. Changing the conditions of mine shock can be based on mining technology, where the purpose is to reduce the height of the fracture of the thick hard rock layer and maintain the structural stability of the thick hard rock layer. Among these, reducing the energy released by the mine shock mainly controls the splitting scale of the thick and hard rock layers and the scale of the movement of the thick and hard rock layers.

[Diagram: Countermeasures for reducing vibration damage of mining surface]

Mining protective layer and regional gas pre-draining have been widely used in China and abroad as regional technologies for preventing and controlling mine gas dynamic disasters. In view of the characteristics of poor gas permeability and soft coal quality of prominent dangerous coal seams in China, enhanced drainage technologies such as hydraulic hole reaming, wind-driven slag discharge and other drilling construction technologies along the coal seam have been studied, and good application results have been achieved. However, the short-range lower protective layer mining technology and regional gas pre-extraction and anti-outburst affect the evaluation system as follows:

1. Mining of protective layers between coal groups in mines. At present, most mines adopt the downward
mining sequence of coal groups. The mining practice of some mines has proved that the upward mining between groups has a good protective effect on the coal of the upper group.

2. Mining of protective layers within coal seam groups of mines. When mining within the group, give priority to mining the protective layer within the group and liberate other coal seams.

3. Preventive measures for excavation face. Under the condition of no protective layer mining, the gob-side roadway technology is preferentially used for the coal roadway driving face with the risk of composite dynamic disaster in each mine. The coal seam extraction measures shall be implemented in the gob-side roadway to protect the roadway excavation of the adjacent outburst coal seam.

4. Outburst prevention measures at coal mining face. The coal mining face generally adopts the measures of transportation, long-draining along the layer of the return air lane, shallow-draining in the working face, and drilling through the layer in the high (low) level roadway. After the effectiveness of the measures exceeds the standard, take supplementary measures for shallow hole pressure relief and drainage in the area exceeding the standard.

4 Experimental results and analysis

4.1 Experimental data

In the northwestern part of a mining area, the main mining thick hard rock layers are mines, with an average coal thickness of 9.43 m and a coal burial depth of 800–1000 m. Since the coal mine was opened in July 2019, the phenomenon of impact composite dynamic has occurred many times during the excavation of the main road and after the formation of the roadway with the thick and hard rock layers. During the period, the coal-rock mass fracture-induced shock composite dynamic appears in the coal pillar area of a typical deep-buried mine. This section selects 8 dynamic manifestation events and 58 mine earthquake events that occurred in the Northwest Mine Coal Mine from August to December 2019 as the research objects, and explores the mechanism law of mine earthquake and shock composite dynamic disaster prevention and control system in deep hard rock mines.

4.2 Experimental methods and evaluation criteria

4.2.1 Calculation of fracture parameters of high-level thick hard rock

The width of the working face is first divided into 175 m, according to the actual mining experience in the west area. The three options are as follows:

1. When the working face is preferentially mined, the overlying thick hard rock can be broken, and the sum of the width of the working face and the adjacent goaf is about 545 m;
2. The sum of the width of adjacent goaf is about 535 m in priority;
3. The sum of the width of the joint working face and the adjacent goaf is about 715 m.

Here, the ratio of goaf width and rock thickness in different schemes is (535−715)/110 = 4.86−6.45. Therefore, referring to the research results of the thin plate theory, the rock fracture law is analysed as:

\[
\begin{align*}
    a_1 &= \frac{b}{l_m} \sqrt{b^2 - \sqrt{b^2 - 2l_m^2}} \left(b \geq \sqrt{2l_m}\right) \\
    a_2 &= \frac{h}{\sqrt{2l_m}} \sqrt{b^2 - \sqrt{b^2 - 2l_m^2}} \left(b \geq \sqrt{2l_m}\right)
\end{align*}
\]

(17)

where \(a_1\) and \(a_2\) are the step distance of the first broken rock under the condition of three-side fixed support, one side simply supported and four-side fixed support. \(h\) is the rock thickness, and \(l_m\) is the limit span of rock under...
infinite length condition for working face propelling as:

\[ l_m = \frac{h}{1-u^2} \sqrt{\frac{2\sigma_t}{q}} \]  

(18)

where \( \sigma_t \) is the ultimate tensile strength of rock, \( q \) is the load of thick hard rock, \( u \) represents the Poisson’s ratio and \( b \) indicates the overhang width of the rock bottom. For the case of narrow coal pillars:

\[ b = b_0 - nh_1 \cot \theta \]  

(19)

where when the four-side fixed support condition is taken as \( n = 2 \). Three sides are fixed on one side and one side is simply supported or the conditions of the adjacent goaf are taken as \( n = 1 \), where \( b_0 \) is the gob width.

4.2.2 Overall stability analysis of working face

According to the mining geological data, the goaf width on one side of the incomplete mining area is 360 m. Take the average bulk density of the overlying rock as \( y = 25 \text{ Kn/m}^3 \). The uniaxial compressive strength of the medium is 18.5 MPa. Considering the complex and changeable spatial structure of the overlying hard rock in the mining face, and the violent movement of the roof, The dynamic load effect varies greatly under different mining intensities. Take the dynamic load factor as \( K = 0 \) (complete static stress state), 0.5 and 0.8 times.

4.3 Experimental results and analysis

Figure 3 shows that the average support strength of coal mines increases with the increase in working face width and tends to be stable. When the working face width is less than the limit width (about 80 m), there is a possibility of ‘static instability’. The theoretical estimate of the limit width of the working face is about 145 m. In order to meet the height safety requirements of rockburst working face, factors such as roadway, section coal pillar arrangement and safety factor are considered. The actual working face layout width should be greater than 175 m. According to the analysis, scheme 3 is the best for the prevention and control of rockburst.

![Fig. 3 Disaster risk of working face under different widths](image)

In addition to considering the overall stability of the working face, there are important water conservancy facilities on the stope ground. Assess the vibration damage effect of mine earthquakes on water conservancy facilities. Find mining options that reduce vibration damage. According to the three schemes, the total lengths \( L_G \) of the clamped edge at the initial fracture of rock and rock are 1370 m, 1790 m and 1838 m, respectively. Without considering other factors, the total elastic energy released by the rock for the first time for different schemes \( U \approx 1.6 \times 10^{10}J, 1.3 \times 10^{11}J, \) and \( 1.6 \times 10^{11}J \) are estimated according to the evaluation criteria. According to the research method, the vibration velocity of the surface water conservancy facilities caused by the mine earthquake induced by the release of elastic energy is estimated, and the calculation and analysis results are as shown in Table 2.
Table 2 Mine seismic analysis results

<table>
<thead>
<tr>
<th>Vibration effect (%)</th>
<th>Vibration speed v/cm s⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model-1</td>
</tr>
<tr>
<td></td>
<td>U ≈ 1.6 × 10¹⁰J</td>
</tr>
<tr>
<td>1</td>
<td>0.12</td>
</tr>
<tr>
<td>2</td>
<td>0.19</td>
</tr>
<tr>
<td>3</td>
<td>0.23</td>
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<td>7</td>
<td>0.48</td>
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<tr>
<td>8</td>
<td>0.49</td>
</tr>
<tr>
<td>9</td>
<td>0.58</td>
</tr>
<tr>
<td>10</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Table 2 shows that the vibration velocity \( v \) of the surface water conservancy facilities caused by the mine earthquake is different under different mining schemes and vibration efficiency. Mine earthquakes have different effects on the vibration of surface water conservancy facilities. Among them, Model 1, mining of thick hard rock, breaks the particle vibration velocity of water conservancy facilities in the range of 0.03–0.17 cm/s. Compared with Model 1, the vibration velocity of water conservancy facility particles caused by mining earthquakes in Models 2 and 3 is significantly larger, where the safe allowable particle vibration speed is 0.5–0.9 cm/s. The experimental results also show that, under the same vibration efficiency, the vibration velocity of the particles of the water conservancy facilities caused by the mining earthquake of Model 1 is generally lower than the national safety standard. Models 2 and 3 mining caused by mine shock caused the particle vibration speed of water conservancy facilities to be relatively large, and the maximum vibration speed was close to the safety standard. However, it takes a period of time for the micro-cracks to develop, merge and gradually form macro-cracks before the high-level thick and hard rock layers are broken. Under normal circumstances, the overall structure of the thick hard rock roof will not break down instantaneously. Finally, for the sake of security, the parameters selected for calculation are also too large. Therefore, the possibility of damage to the surface water conservancy facilities caused by the mine shock induced by the rock formation is extremely small. Analysis of experimental results can provide important support for mining plan optimisation and selection.

5 Conclusion

The motion state of the thick and hard rock strata determines the dynamic appearance degree and influence range of the working face, and its instability motion is the main reason for the strong rockburst disaster. Rockburst is usually regarded as a problem related to structural instability of coal and rock mass. This paper proposes a framework of a composite dynamic disaster prevention and control system framework for thick and hard rock mines. First, the gravity forms, extents and deformation characteristics of different rock layers of the structural model are analysed, and the expressions of concentrated force and periodic breaking step distance of rock beams in thick and hard rock layers at the fixed support end are deduced, based on this. Then, according to the cause of the shock composite dynamic disaster, finally, the specific testing and calculation methods of mine earthquakes in thick hard rock mines are designed. The regional and local measures to manage compound dynamic disasters are put forward. Experiments show that the system is successfully applied to the mining practice of working face, and the results of water conservancy and stress monitoring support the rationality of the system. However, the mines discussed are still relatively simple, and there are no comparative experiments with multiple mines. In the future work, the multidimensional mine seismic data will be compared horizontally.
References