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Top coal caving mining technique in thick coal seam beneath the earth dam

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ABSTRACT

It is important to study the mining technology under structures for raising the coal resources recovery ratio. Based on the geological and mining conditions, the top coal caving harmonic mining technique in thick coal seam beneath the earth dam was put forward and studied. The 5 factors such as the panel mining direction, panel size, panel location, panel mining sequence and panel advance velocity were taken into account in this technique. The dam movement and deformation were predicted after the thick coal seam mining and the effects of mining on the dam were studied. By setting up the surveying stations on the dam, the movement and deformation of the dam were observed during mining. By taking some protective measures on the dam, the top coal caving mining technique in thick coal seam beneath the earth dam was carried out successfully. The study demonstrates that harmonic mining in thick coal seam is feasible under the dam. The safety of the earth dam after mining was ensured and the coal resources recovery ratio was improved.

1. Introduction

The surface movement and deformation caused by coal mining not only influence the ecology environment in the mining area, but damage the surface structures such as buildings, railroads, highways, water bodies and dams [1–3]. The movement of strata and surface caused by mining had disturbed various aspects of industrial and agriculture productions in the mining area [4]. The earth dam is a very important water retaining structures, so it must makes sure the safety of dam if mining under it. Therefore, to study the effect of mining on dam and control measures to ensure safety of mining under the dam are important factors for improving the mining recovery ratio, reliving the mining continuity, preventing or reducing damage to the dam [5–7].

By means of the harmonic mining technology, theoretical analysis and field observation, the mining method under an earth dam and the mining influences were studied and analyzed in this paper [8]. The mining of a thick coal seam under the dam was carried out safely and successfully.

2. Harmonic mining technique under an earth dam

Coal mining under the dam damages it and affects its normal usage. Once it becomes unstable and fails, it seriously threatens life and properties downstream. So it's essential to make sure the dam is safe [9–13]. Earth dam is one of the widely used types of dams. It is a water reservoir made of local soils, rocks or combined materials by roller compaction and filling. In order to reduce the damages to dam caused by undermining, based on the physical and mechanical properties of materials used to build the dam, the harmonic mining principle was confirmed as follows:

(1) Properly determination of the panel direction

To avoid or reduce the tensile cracks on the dam, the dam should not stretch over the panel. So the long axis of the dam should be parallel to the panel advance direction (Fig. 1). In this case, the dam is only influenced by dynamic deformation and the influence of mining on the dam is very small.

(2) Properly determination of the panel size

Based on the surface movement and deformation characteristics of subcritical or ultra subcritical mining condition, the width of panel is adjusted in order to reduce the effects of undermining

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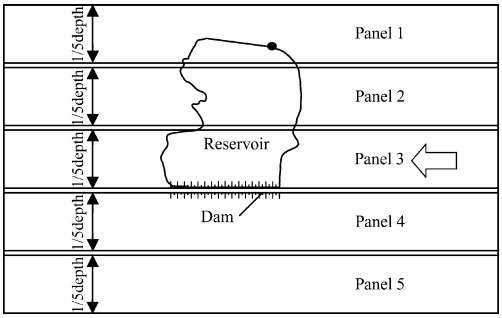

Fig. 1. Mining direction parallel to the long axis of the dam.

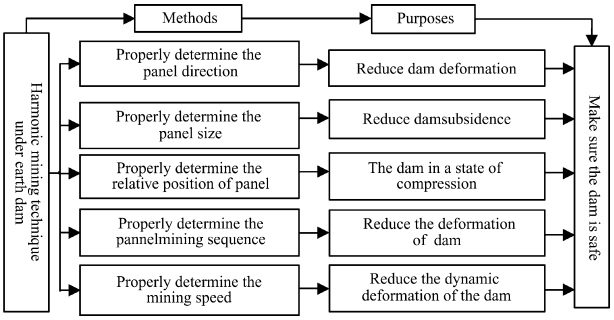

Fig. 3. Harmonic mining principle of the "5 factors" under earth dam.

the dam [14,15]. According to the design requirements of strip pillar mining, the surface movement and deformation are smooth and uniform when the panel width is 1/4–1/10 of mining depth. Based on the mining and geological conditions and mining efficiency, the panel width under the dam is less than 1/5 of mining depth.

(3) Properly determination of the relative position of panel

Based on the previous studies, the dam, made of loess and ashlars, will not be subjected to tensile deformation and cracks under compression [16]. And the permeability of dam will not be increased, thereby ensuring dam stability. Based on the location of the dam on the surface, the center position of panel is determined by the angle of maximum subsidence (Fig. 2). Under this condition, the subsidence of dam is larger, while the dam is in the horizontal compressive zone, which is good for the stability of the dam.

(4) Properly determination of the panel mining subsequence

By adjusting the panel mining sequence, the tensile and compressive deformation caused by adjacent panels mining could be offset to some extent, and the deformation on the dam can be minimized. Simultaneously, the mining effects on dam can be reduced by "skip-mining" because of subcritical mining of each small panel.

(5) Properly determination of the mining speed

A proper mining speed could minimize the dynamic deformation on the dam. Avoiding the face being advanced too slow or too fast; too slow speed will cause boundary effect in front of the face, while too fast speed will cause the deformation rate of dam to accelerate. Previous studies showed that the maximum subsidence velocity is related to the mining advance speed. So it's essential to determine a proper face advance speed and keep it uniform based on the geological and mining conditions.

Based on the previous studies, the maximum subsidence velocity increases linearly with the advancing speed of the mining face [17].

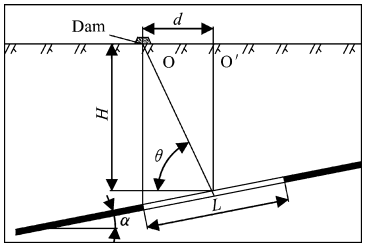

Fig. 2. Panel position determination.

$$V_{\mathrm{fm}} = K\frac{CW_{\mathrm{fm}}}{H_o}$$

where V_{fm} is the maximum subsidence velocity, m; K the subsidence velocity factor; C the advancing speed of working face, m/d; W_{fm} the maximum subsidence, mm; and H_o the mining depth, m.

In order to fulfill the safety of mining under the dam and ensure the stability of the dam, the above five factors should be considered all together in subsidence design. This is called "the harmonic mining method" (Fig. 3).

3. A case study

3.1. Geological and mining conditions

Micun Coal Mine, with 1.5 Mt/a production capacity, is located in Henan province, China. The longwall mining method was used and the whole seam thickness was mined by top coal caving method. The mining depth was 300–390 m. Coal mined in the area was No. 21 coal seam, 1.7–12.31 m thick. The average thickness was 4.65 m. The average dip angle was 10°. The recoverable reserves were 2190 thousand tons.

3.2. The earth dam conditions

The earth dam was located to the south of No. 26 enlarged area and was made of local soils and rocks. There was a paved road 8 m wide on the top. The dam surface was 3 m above the reservoir surface. The dam length was about 114 m, the angle of upstream slope was 40–50° and the slope length was 10–16 m. Fig. 4 shows the earth dam.

3.3. Determination of the harmonic mining scheme

Based on the principle of minimum mining damage to the dam, the panel width is 60–78 m, approximately 1/5 of mining depth. The panel advance direction should be parallel to the long axis of the dam and advancing speed should be uniform. Panels advance speed should be kept at 2.5–3.0 m/d.

Based on the results predicted of the surface movement and deformation, the panel 260061 was mined first and the deformation on the dam was compressive. The width of first panel was less than the 1/5 of its depth, and this is called subcritical mining. Because of the compressive deformation, fissures did not appear on the dam. And the dam was influenced by the dynamic deformation only.

To reduce the adverse influence on the dam, the skip-mining method was used. The second panel mined was panel 26071. This layout was similar to the wide strip skip-mining, and the movement and deformation was largely reduced [19]. Simultaneously, the compressive deformation on the dam caused by the first panel