The Roof Support Load Analysis for Pre-Driven Recovery Room Parameters Design

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Abstract. Submitted by generalized experience entry longwall into pre-driven recovery room (PDRR) in foreign and Russian mine. Submitted by research characteristic state parameters of the roof at failed entry. Give a classification of roof collapse at the entrance longwall into PDRR. On the example of longwall panel 5a-10-18 mine Rapsadskaya reviewed formation process of stress-strain condition in area for PDRR. Has been modeled process of entry longwall into PDRR in the conditions of heavy roof. Determine the expected load on the anchor and standing support, installed in the PDRR. Assessed the load on the longwall shield. When calculating the loads was taken into account the following parameters: width pre-driven recovery room, number of standing support in the PDRR and especially its placement, the rate of entry longwall into PDRR.

1 Introduction

Recovery longwall equipment is always an operation requiring careful engineering and planning. The alternative method is pre-driven recovery room. The main advantage of this method is that the standing and anchor support is installed in normal conditions, under the protection of temporary support. However, in some cases, at the entrance to the pre-driven recovery room there were failures [1, 2].

2 Results

An analysis of Russian and foreign entry accidents allowed them to be typified. The first type is associated with the collapse of a weak immediate roof in front of roof shields (fig. 1). The second type is associated with the influence of a heavy roof with a relatively weak immediate roof (fig. 2). It was established that collapse according to the first type occurs when rocks with low strength characteristics are in the roof, and the density and the bearing capacity of the anchor support installed in the pre-driven recovery room are not enough to compensate for the increase in the span of the pre-driven recovery room, the width of the bearing barrier pillar of the lost bearing capacity [3].

Collapse and failure entry of the second type occurs when the detached blocks of the main and immediate roofs move together relative to the point of rotation located above the outby pillar. The load from the detached roof blocks exceeds the bearing capacity of the mechanized roof support section and breaks them. At the same time, the load on the roof shield does not depend on the density of the installation and the bearing capacity of the anchor support installed in the pre-driven recovery room, because the anchor support moves with the roof units.

Based on the generalized experience of entry into pre-driven recovery room in various mining and geological conditions, presents a scatter plot of the distribution of entrances to the pre-driven recovery room depending on the depth and type index of the roof (fig. 3). Two areas are highlighted on the graph in which the maximum number of failure entries occurred. The first area (A) is typical for depths of up to 300 meters and in areas with hard-to-control roofs – 42.1% of the total. The second (B) for depths over 600 meters and two types of hard-to-control and medium-controlled roofs – 50% of the total. From the graph, conclusions can be drawn about the boundaries of the application of technology and the likelihood of accidents.

Fig. 1. The first type of roof failure at the entrance of a longwall into pre-driven recovery room.

Fig. 2. The second type of roof failure at the entrance of a longwall into pre-driven recovery room.

Fig. 3. Scatter plot of the entrances to the pre-driven recovery room depending on the depth and roof type index (CMRR).

3 Discussion

The process of the formation of a stress-strain state near pre-driven recovery room at the entrance moment is considered below using a longwall panel 5a-10-18 Rapsadskaya coal mine. Entrance period is longwall panel mining process when the distance to pre-driven recovery room equally the of lengths bearing pressure zone L_{bp} (fig. 4).

Fig. 4. The initial longwall entrance period into pre-driven recovery room.

Convergence between roof and floor in pre-driven recovery room is rising up when the distance from face to pre-driven recovery room is decreasing. It caused by overlay of stresses from face σ_{m1} and σ_{m2} from pre-driven recovery room. In a conditions of seam 10 of Rapsadskaya coal mine on the depths of 330 m the convergence value (h) relate to width bearing barrier pillar (L) using exponential distribution law:

$$h = 562 \cdot (L)^{-1.09} \tag{1}$$

in type: L – the distance from face to pre-driven recovery room, m.

Fig. 5. Relation curve between distance from face to pre-driven recovery room and convergence into pre-driven recovery room.

There are two types failures entry. Both of them connected with the end stage of entering when bearing barrier pillar lost their bearing capacity. According to practical and theoretical research [5] has be established into the bearing barrier pillar appear the field with over boundary state stress. This field named as the pillar core. The pillar core is stable until the moment side force from the bearing barrier pillar walls equal horizontal stress into the pillar. The width of the bearing barrier pillar (x) lost its bearing capacity can be expressed through the formula:

$$x = 0,5 \cdot (x_{m1} + x_{m2}) \tag{2}$$

in type: x_{m1} , x_{m2} , – distances to the maximums of the bearing pressure from the longwall face and pre-driven recovery room, respectively, m.

Fig. 6. a – Scheme of pillar core formation into the bearing barrier pillar; b – The design scheme for determining the load on the support pre-driven recovery room (Q), at the time of the compression failure of the bearing barrier pillar between the pre-driven recovery room and the longwall face.

Using the PDRR technology the tasks of determining stress-strain state of rock massive and loading values support pre-driven recovery room, and shields roof support should be solved. The solution to this problem is to eliminate the possibility of roof collapse in the pre-driven recovery room of the first and second type (fig. 1, 2).

The pressure load of anchor support can be determined using the pressure arch theory [6]. It is required to determine the load on the support pre-driven recovery room Q kN/m², located near longwall face taking into account loose parts (x) over bearing barrier pillar that lost bearing strength (fig. 6 b). The load on the support pre-driven recovery room is transferred not from the pressure arch, but only from parts of the false, immediate and main roof with technogenic fracture in longwall face area.

If there are rocks in the roof that belong to the group of heavy loads[7], then in the calculation take the total thickness of the false Z_f , immediate Z_i and parts of the main roof with a technogenic fracture h_m (weak strata). For medium and light roof types, only the total thickness of the false roof Z_f is taken into account and parts of the immediate roof subject to technogenic fracturing h_i (weak strata).

In the calculations, the roof of the pre-driven recovery room was presented, according to the unified industry classification of roofs, by three types according to load properties: light, medium and heavy. The estimated width of the pre-driven recovery room was in the range from 3 to 12 m, the calculation was carried out in increments of 1 m. The range of the width of the room was selected in accordance with domestic and foreign experience in applying the technology of entry into pre-driven recovery room.

According to the results of the study, a graph of the expected load on the pre-driven recovery room is constructed depending on the roof characteristics and the width of the pre-driven recovery room (fig. 7). The graph shows that:

- with an increase in the width of the pre-driven recovery room, the load on the anchor support decreases. Reduce the load on the pre-driven recovery room support due to the unsupported distance (x) located over bearing barrier pillar in the moment of losing their bearing capacity. The greater the width of the pre-driven recovery room, the smaller the degree of influence, since the unsupported distance (x), under these conditions, the value is constant;
- the expected roof support load of the pre-driven recovery room for an easily-controlled roof is 20-25% higher than that of the average roof, this is due to the fact that in the case of a light roof, its structure contains a larger volume of rocks with low strength characteristics, which increases the pressure arch.

Fig. 7. The expected load on the anchor support pre-driven recovery room Q depending on the characteristics of the roof and the width of the pre-driven recovery room.

To determine the expected roof shield load, need to determine the load on the roof shields at the beginning and end of the entry process. At the initial stage of entry, which is located at a considerable distance from the pre-driven recovery room, only the blocks of the main and immediate roofs have the main loading effect P_{step} kN/m² on the roof shields with

the periodic collapse step R_p^m and R_p^i , respectively [8]. However, at the final stage of entry, with the loss of the bearing capacity of the bearing barrier pillar, the roof shields perceive an additional load source P_d kN/m² this is the load from the detached flight blocks above the pre-driven recovery room of the main and immediate roofs moving together relative to the rotation point located above the outby pillar.

Fig. 8. Calculation scheme for determining the load on the roof shield and standing support at the entrance of the longwall face complex to the pre-driven recovery room.

Summing up the received loads P_{step} and P_{dis} from two load sources, we get the desired value P_t of the expected load on the sections of the roof shields

$$P_t = P_{step} + P_{dis} \quad (3)$$

in type: P_t – total design load on the roof shield, kN/m²; P_{step} – the expected load from the blocks of the main and immediate roof with a periodic step of collapse, kN/m²; P_{dis} – the expected load from detached roof blocks unsupported distance located over bearing barrier pillar, kN/m²

The condition for successful entry can be expressed as:

$$P_t < P_{sup} \quad (4)$$

где P_{sup} – roof shield resistance, kN/m².

The design scheme for determining P_{step} and P_{dis} is presented on fig. 8. In this scheme, the roof, between the entire bearing and the face, is represented by a multi-distance continuous beam.

4 Conclusion

The result of calculating the total load P_t on the roof shields for heavy roofing has been shown in fig. 9. According to the graph presented fig. 9 a (heavy roofing, standing support was not installed) then resistance of the roof shield P_k 1100 kN/m², accident-free entry into the pre-driven recovery room possible if it width varies from 3 to 5 m with face movement speed $V=0,8$ m/day. These entry parameters shows that using technology in heavy roof conditions without installation of additional supports for standing support is practically impossible.

The graphs of the expected roof shields load (fig. 9 b and 9 c) shows that the accident-free entry parameters are almost identical in case of standing support installation into pre-driven recovery room. Failure-free entry, with the face speed movement up to $V=2,4$ m/day

is ensured by the width of pre-driven recovery room from 3 to 12 m. Moreover, from the point of view of smooth bearing pressure distribution on installed standing support in pre-driven recovery room with a width of more than 5 m, the option with two installed standing supports is more preferable.

Fig. 9. Graph of the expected load on the roof shield P_t on the width of the pre-driven recovery room and the speed of movement of the longwall face with a heavy roof, a - standing support is not installed; b – one leg standing support; c – two legs standing support.

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