Pit walls stability calculation in the cracks field of undermined Kryvbas massif

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Abstract
The technique of pit walls stability calculations in the cracks field of undermined Kryvbas massif, which considers the stress-deformed state, structural features, strength characteristics of rock formations, and also forces operating in a pit wall sliding wedge is given.
Keywords: PIT WALL, MASSIF, STRESS-DEFORMED STATE, SLIDING WEDGE

Placement of pit walls in this part the rock massif is the most reliable in terms of stability in comparison with the areas of collapse and shifts of rocks. In the course of displacement, as determined by studies the rocks undergo only minor changes in the conditions of bedding. Based on studies, it is established that in this part of massif the strength characteristics of rock formations and a stressed state of pits walls are slightly decreases. For the rock formations bedding modes in Kryvbas [1, 2, 8-12], which considered in pits the main surfaces of massif weakening, which influencing on pit walls stability are contacts of rocky layers, as well the systems of the back-falling cracks (Fig. 1). For the pits over 150m in depth the inter-ramp angle can be no more than 35°. Therefore the inter-ramp angle will be less than incidence angle of rocky layers, i.e. α <β. The sliding surface in this case is dated for surfaces of rock formations massif weakening [4]. For the conditions of the untreated massif the sliding surface passes under the bedding in the top part, and the in the bottom - crosses the layers and also has a circular cylindrical or a flat shape [5, 6]. In this case, except of layering the cracks of back-falling system, which in certain conditions can affect the stability of the pit walls should be considered. In homogeneous isotropic medium at a limit stressed state in each point there are two sliding surfaces, which are intersect at an angle of (90-φ)[6].

The values of the angle (90-φ) is the boundary condition for the sliding surfaces position with the known direction of the principal stresses, which acting on these surfaces.

In a layered medium the possibility of weakening surfaces influence on the pit walls stability is determined by the angle 0_{kr} = (90-φ)[6], where - φ- is the friction angle by secants to weakening surfaces. If the weakening surfaces incidence angle is less than a size of 0_{kp}, then they will affect the stability of the pit walls because the rocks may shift by them [4].

Therefore, the probability of sliding wedge shear by back-falling system cracks is determined from the condition

$$\beta \leq 90°-\varphi, \qquad (1)$$

where β-is an incidence angle of the cracks back-falling system; φ - an angle of internal friction on the cracks surfaces.

Since the strength characteristics of the weakening surfaces is much less than the same characteristics of the rock massif, the sliding surface will have a complex form: the top part is flat - by contact of rock layers and the bottom is stepline - by back-falling system cracks and contact rock layers if the condition is met (Figure 1) or the circular cylindrical - at the turn of the structural blocks (Figure 2). According to possible forms of sliding surfaces of pits walls let's consider the following calculation schemes.

The angle of pit wall slope is less than rock layers incident angle (α <δ). The bottom of a sliding surface has a stepline form (Fig. 2). In a pit wall sliding wedge it is possible to allocate an active pressure wedge - I and a horh wedge - 2.

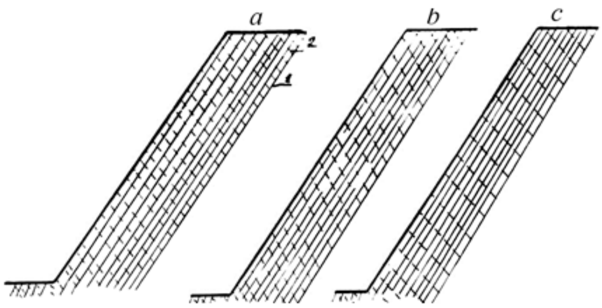

Figure 1. Weakening surfaces position:
a) - "Northern" pit; b) - "Southern" pit of JSC Arselor Mittal Kryvyi Rih mine office; c) - East pit wall of Central Mining and Processing Complex; 1 - bedding; 2 - cracks back-falling systems

Let's determine the force, which acting on each wedge. On the wedge of active pressure the power of the rocks weight (P1), which can be determined by the formula [7], reaction of an active pressure (R1) wedge basis and reaction of horh wedge (R2), which can be determined by formulas in [7] are acting. The horn wedge weight (P2) and the value of the basis (R3) reaction are also determined by the corresponding formulas [7].

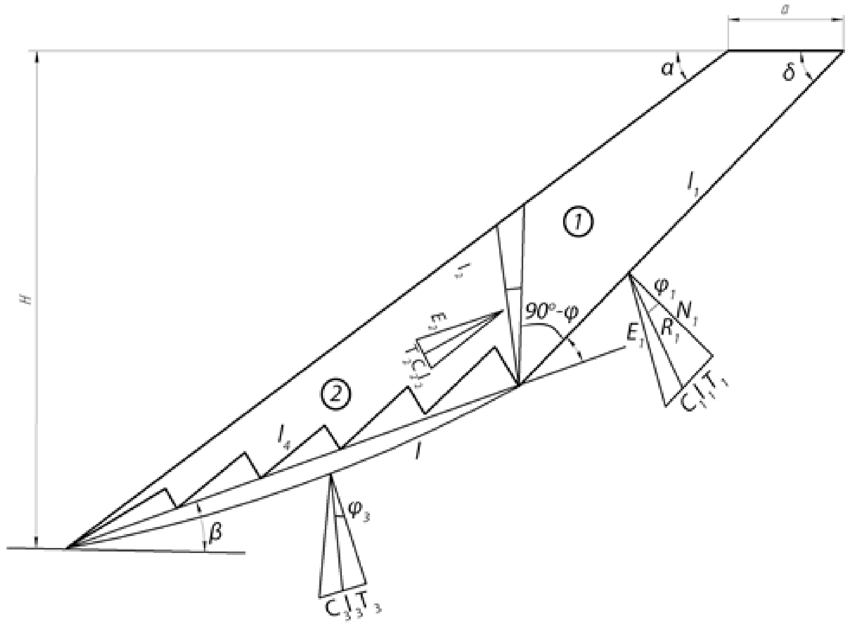

Figure 2. The calculation scheme of pit wall stability with a sliding surface stepline form in the bottom of sliding wedge.

The size of tangents and normal forces of a wedge (2) is defined considering the designations on Fig. 2 from following expressions

$$T = P_2(\sin\delta + \sin\beta) \quad (2)$$

$$N = P_2(\cos\delta - \cos\beta) \quad (3)$$

Size of tangents and normal components of reaction (R)

$$R_N = R_3(\cos\varphi 1 - \cos\varphi_3) \quad (4)$$

$$R_T = R_3(\sin\varphi 1 - \sin\varphi_3) \quad (5)$$

where φ_1 and φ_3 – are the internal friction angles by contact of rock layers and cracks rupture.

Considering the expressions (2-5), the pit wall stability margin coefficient is determined from the expression

$$\eta = \frac{P_1\cos\delta * tg_1 + c_1 l_1 + P_2(\cos\beta + \cos\delta)(tg\varphi_1 + tg\varphi_3) + c_3 l_3 + R_1\cos\delta * tg\varphi_1 + + R_2\cos\xi * tg\varphi_2 + R_3(\cos\varphi_1 + \cos\varphi_3)(tg\varphi_1 + tg\varphi_3)}{P_1\sin\delta + P_2(\sin\delta + \sin\beta) + R_1\sin\delta + + R_2\sin\zeta + R_3(\sin\varphi_1 + \sin\varphi_3)} \quad (6)$$

where φ_2-an angle of internal friction on the surface, which separating the wedges (1) and (2).

Expression (5) allows to determine the pits walls stability in the field of rock formations cracks, considering the sliding wedge shift by the cracks backfalling systems. The pit wall stability calculation with a circular-cylindrical form of the bottom of a sliding surface is made by the technique given in [7].

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