THE INFLUENCE OF SELECTED WEATHER CONDITIONS ON THE SAFETY OF SLOPES OF POST EXPLOITATION LIGNITE PITS FILLING WITH WATER

WPŁYW WYBRANYCH WARUNKÓW ATMOSFERYCZNYCH NA STATECZNOŚĆ ZBOCZY WYROBISK POEKSPLOATACYJNYCH KOPALŃ WĘGLA BRUNATNEGO WYPEŁNIANYCH WODĄ

Adam Bajcar – „Poltegor Instytut" Instytut Górnictwa Odkrywkowego, Wrocław, Poland

The article describes selected atmospheric factors that may affect the stability of the end slopes of lignite post mining pits during their filling with water. The main factors such as waves, the influence of the ice cover and the wind were characterized.

Keywords: *post-mining opencast pits, slope stability, weather conditions*

W artykule opisano wybrane czynniki atmosferyczne mogące mieć wpływ na stateczność zboczy końcowych wyrobisk poeksploatacyjnych węgla brunatnego podczas wypełniania ich wodą. Scharakteryzowano czynniki takie jak falowanie, wpływ pokrywy lodowej oraz wiatr.

Słowa kluczowe: *odkrywkowe wyrobiska poeksploatacyjne, stateczność zboczy, warunki atmosferyczne*

Introduction

The lignite mining industry in Poland has faced a new problem, accompanying the closure of open pits and resulting from the limitation and necessity of abandoning pit dewatering after the end of coal extraction. The termination of dewatering triggers a number of processes that were not previously present. In the immediate vicinity of the pit, the groundwater table rises back up, which changes the direction of water flow through the rock mass as a result of buoyancy and seepage pressure. The effect of these factors is to change the stresses and stability conditions of the slopes, which can result in increased deformation in the immediate vicinity of the pit.

In addition to the above-mentioned factors, there are also forces acting on the slopes of the water-filled pit, originating partly from natural factors, dependent on weather conditions, such as:

- waves;
- ice covers;
- wind.

Effect of frost heave on slope stability

In slopes constructed by soil subject to frost-heave, where water inflow exists, it is possible for ice pockets to form in the body of the slope. The resulting increase in the moisture content of the slope-building soils during thawing influences a reduction in the value of internal friction and thus a reduction in the safety factor, which can lead to slope liquefaction.

The best method of preventing the above-mentioned phenomenon is to dewater the slope, which for technological reasons is relatively difficult during filling the excavation pit with water. However, it is possible to lower the elevation of the groundwater table, and thus the extent of frost heave, by means of dewatering systems. It should be noted that the majority of the designed slopes have a significant safety factor and there is no need to make additional consideration of this in the calculations.

Impact of ice cover on the slopes of a post-mining pit

The ice cover exerts the following types of forces on the slopes of a water-filled pit:

- horizontal forces - caused by the action of the wind on the ice cover,
- vertical forces - caused by the freezing of the ice cap to the slope of the final reservoir.

Under final reservoir conditions, the possibility of additional stress on the slope by piling up and shoving ice cover on the slope can be ignored. Final reservoirs can be compared to lakes where the problem of ice shoving on shore does not occur.

According to Heuckel [1] the stress of the ice cover on the edges of the reservoir due to wind pressure can be expressed by the following formulae:

a) where the length of the ice cover in the direction of its movement is less than 1200 m:

$$P_n = pB = \left(0{,}3 + \frac{L_L}{1000}\right) v^2 B \qquad (1)$$

where:

B – width of ice cover measured perpendicular to the direction of movement;

v – average wind speed;

p – ice cover pressure [1000 kG/m].

b) where the length of the ice sheet in the direction of its movement is greater than 1200 m:

$$P_n = pB = \left(3 - \frac{1800}{L_L}\right) v^2 B \qquad (2)$$

In the case of the post-mining pits of the Konin Basin, the ice cover causes minor impacts on the slope, which can be ignored during the stability analysis. For the designed large end reservoirs (Bełchatów, Szczerców), these impacts should be taken into account during design work.

Erosive effects of waves

Wave motion is associated with the movement of water molecules along orbits, accompanied by progressive motion, manifested as wave currents [1].

During wave action both water movements have an erosive effect on the reservoir bed and final reservoir slopes. Water velocities in shallow water waves, which occur in post-mining reservoirs, can reach values exceeding the limit velocities at which soil liquefies. The oscillatory character of the waves, mentioned earlier, does not cause displacement of the soil building up the slope, but its erosion in the water-slope contact zone. This phenomenon is dangerous when the erosion of the edge of the slope reaches such a depth that it disturbs the equilibrium conditions of the soil building up the slope.

Rys. 1. Erozyjne skutki falowania
Fig. 1. Erosive effects of waves

The limit velocities are determined empirically. Studies have shown that freshly deposited soils and loose soils are more easily washed out, the finer the grains they are made up of.

For compacted soils, the correlation is reversed. The finer the soil-building material, the more difficult it is to blur.

Forces applied by the waves on the slopes of the final pits

The forces exerted by the waves are, to a small extent, dependent on the soils building up the slope. The greater impact has the inclination of the slope subjected to wave action, the depth of the final reservoir and the wave parameters. Methods for determining the forces applied by the waves on the slopes of the final pit are based primarily on energy and hydrodynamic theories. Ways of determining these forces are given, among others, by Drogosz – Wawrzyniak L. [2] i Saville T. [3].

Another factor affecting the slope stability, and originating from wave action, is the magnification of water buoyancy values. In addition to hydrostatic buoyancy, slopes are affected by an additional, temporary hydrodynamic buoyancy caused by the fluctuation of the water surface in direct contact with the slope. The work, among others Boczar – Karakiewicz B. [4], describes how the hydrodynamic buoyancy caused by wave action is determined.

Summary

The above-described atmospheric factors have a limited effect on the stability of slopes in post-mining pits due to the relatively small size of the currently rehabilitated water-directed post-mining pits of lignite mines. Among these, the exception is wave action, the impact of which is taken into account during design processes [5]. However, it is important to note that the greater the area of the pit, the greater the impact of wave action and ice cover during winter on the slopes. It is therefore important that the factors described in the article are taken into account when planning the filling of pits with a high concentration of mining like Bełchatów i Szczerców.

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