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EXAMINATION OF AN EARTH SLOPE SETTLEMENT

1. Introduction

The subject of examinations described in the following paper is an embankment dam constructed of mineral soil located on the site of an industrial plant upon Odra river, shown in figure 1. It is situated on the Odra river bank and is used as a soil embankment for a bleaching soil tank. After its collapse in 1997 which was a result of undermining by water from the Odra river and of excessive water saturation of the embankment structure, it was reconstructed in cooperation with the Department of Geotechnics and Geodesy in the same year [2].



Fig. 1. Present view of the embankment dam [5]

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Since then its behaviour resulting from the influence of varying loads has been subject to regular monitoring tests. The monitoring of the structure consists in periodical checks of its external geometry accompanied by survey checks of constant measurement points located on the soil surcharge and on the slope. From the geotechnical side the following are monitored: saturation of the embankment making soil and the condition of the soil and its coherence at the sites of local drops of field on the slope. Location of the embankment on site together with its orientation towards the Odra river has been shown in figure 2.

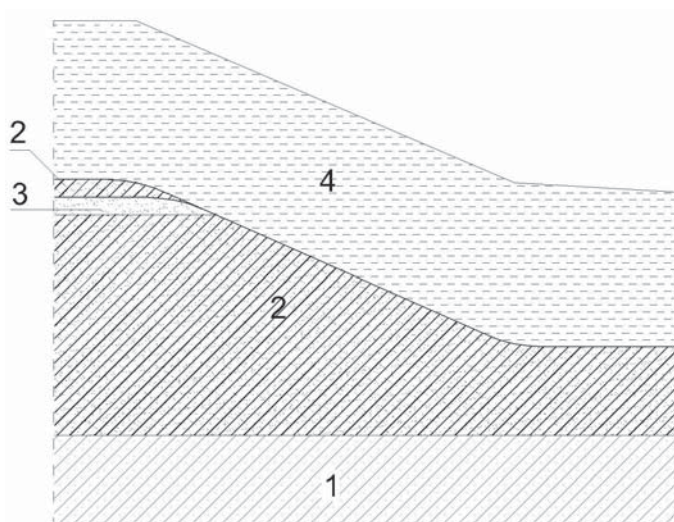


Fig. 2. Geological cross section of the embankment dam: 1 — clay, 2 — sandy loam, 3 — medium sand, 4 — embankment of loamy sand [5]

The following paper presents the results of geotechnical and survey checks carried out from 1997 till 2011. The recorded changes are of numerous geneses, hence the interpretation of them requires the cooperation of an interdisciplinary team.

2. Structure of the embankment

The main body of the structure was build on the existing base which had not been undermined by Odra river waters. The embankment footing is formed of silt existing at a depth of about 14 m below the embankment base. Above it there is a layer of sandy clay, of a thickness ranging from 5 m below the embankment base to 14m below the soil surcharge. In this part of the soil surcharge there is also an interbedding of medium sand, approximately 2 m thick, at the depth of 10 m below the surface of the top of the embankment. The top layer of the slope is made of a fill of clayey sand. The geological cross section of this has been shown in figure 2 [3, 4]. The layout and the shape of the slope on site has been shown in figure 3 [1].

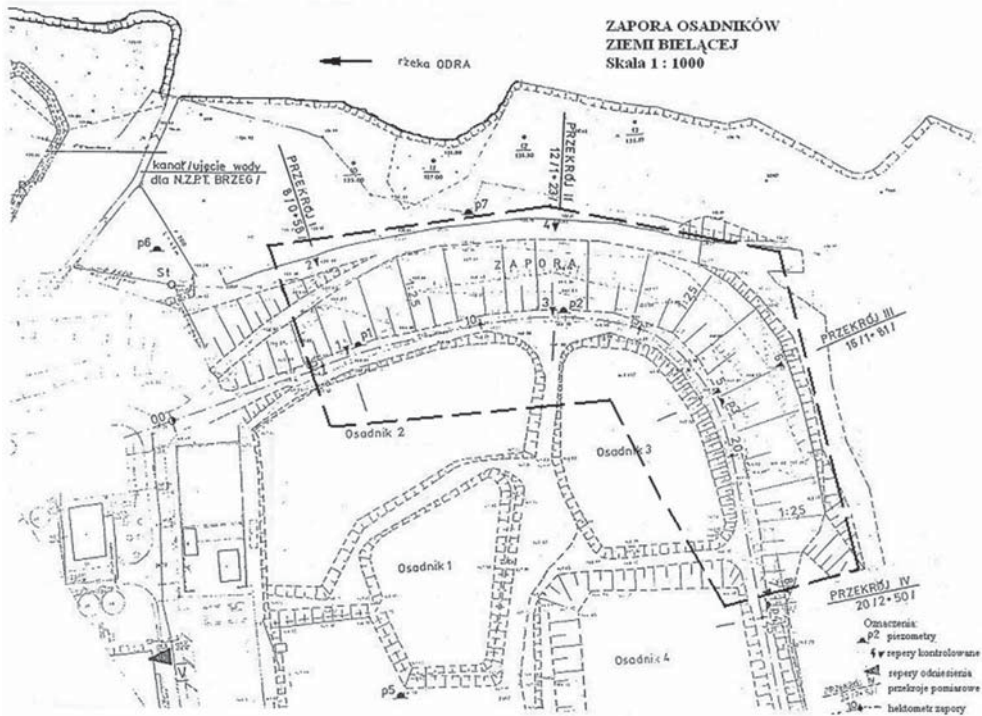


Fig. 3. Location of the embankment dam on site [2]

The embankment in section II has the following dimensions [2]:

- height: 9.5 m,
- length: 23.6 m,
- angle of slope 22°.

In the course of long-term observations, the second section appeared to be the most susceptible to settlement and local landslips. During the course of the examination additional measurement points were installed in this section.

At present the slope has a modified structure, because the settling tanks constructed above were reclaimed in the years 2007–2008. Thanks to that, the height of the slope soil surcharge could be partially reduced. The angle of the slope did not change.

3. Survey checks

Vertical checks were carried out using the geometric levelling method of increased accuracy. The typical observation error amounted at ± 0.15 mm. The measurement was carried out with a precise digital level NA 3003 and with the use of precise invar staffs (Fig. 4). Prior to measurement, the level was checked and rectified in accordance with PN-ISO 17123-2:2005. (Optics and optical instruments — Field procedures for testing geodetic and surveying instruments — Part 2: Levels). The Kronsztad vertical system of coordinates was accepted.



Fig. 4. The precise digital level NA 3003 during use

Figure 5 presents the settlement of the no 9 bench mark located on the slope, in section II, about 1.5 m below the soil surcharge of the embankment. This bench mark is settling in a steady way, and its total settlement amounts at 45 mm within 15 years. It is located in a place where a local landslip was observed. The behaviour of the bench mark indicates that this landslip has stabilised. In relation to the settlement of the neighbouring marks, this one does not show any increased vertical dislocation.

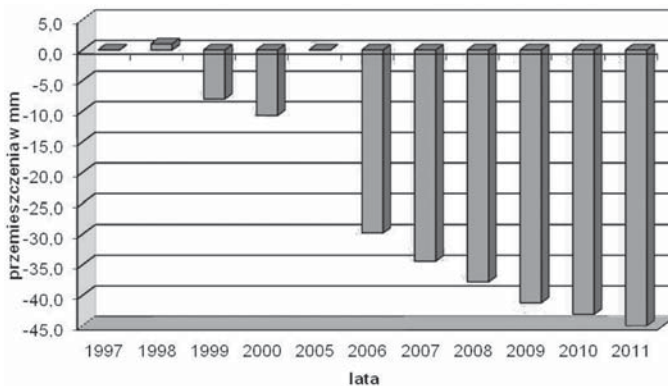


Fig. 5. The settlements of benchmark no. 9 in the period of 1997–2011

4. Summary

On the basis of tests carried out on the soil embankment dam held in the period of 1997–2011, it has been stated that the present condition of the soil embankment dam of the bleaching soil settlement tanks is good and that it does not threaten any possible instability.

The slight changes in geometry revealed as a result of yearly survey checks do not jeopardize stability of the structure. Some local, movement has already been stabilized. Landslips of a relatively thin slip surface were recorded. Geotechnical ground tests at the sites of the local landslips did not reveal any increased saturation of the embankment. In the case of any worsening of soil parameters at the sites of local landslips, it would be advantageous to recreate the slope down to the depth of the slide surface. There is a need to monitor the embankment over the next years. Checks of local landslips should also be carried out on a regular basis and the dam needs to remain under observation at the time of reclamation works.

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