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INTERDEPENDENCE BETWEEN GROUNDWATER LEVEL AND DISPLACEMENT OF THE LANDSLIDE SLOPE

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Abstract. The paper presents the results obtained in the measurements of groundwater level and displacements during systematic investigations of the landslide slope “Kawiory” in Szymbark in Beskid Niski Mts. As the relations between water depth in the slope and displacement increments are not clear, new variable is elaborated for expressing the water conditions in the slope and then the dependencies between this variable and slope displacements were analysed.

Key words: landslide, groundwater, displacement.

Abstrakt. W artykule przedstawiono wyniki pomiarów poziomu wody podziemnej oraz przemieszczeń, wykonywanych na zboczu osuwiskowym „Kawiory” w Szymbarku (Beskid Niski). Z uwagi na brak logicznych zależności między powyższymi wielkościami, wyznaczono nową zmienną, związaną z warunkami wodnymi w zboczu. Następnie przeanalizowano zależności między tą zmienną a wielkościami przemieszczeń zbocza.

Słowa kluczowe: osuwisko, woda gruntowa, przemieszczenie.

INTRODUCTION

The processes occurring on landslide slope “Kawiory” in Beskid Niski Mts. were investigated in details during over two years (Zabuski *et al*., 2004)[1]. The slope is built of flysch massif, containing cohesive soils and weak clayey rock. Numerous methods have been used in the research allowing for complex description of the landslide behaviour. Special attention was paid to the recognition of the dependencies between water conditions in the slope and the landslide movement.

The movement was measured in four boreholes located on the slope, on the base of systematic inclinometer measurements performed during over two years with the average frequency of 1 series/month. The rate of the displacements changed from few millimetres to few centimetres per year, depending on the borehole.

For determination of the current water conditions, piezometric measurements were systematically carried out with the frequency of 1 series/10 days. Casagrande piezometers were constructed in the boreholes at 3–4 metres depth. The piezometric holes were located in the nearest vicinity of inclinometric boreholes. It provided the “compatibility” and comparativeness of the displacements and the depths of groundwater level (GWL).

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[1] Research has been performed in frames of 5th EC Programme, Project “ALARM” (Assessment of Landslide Risk in Mountain Areas) and in frames of the Polish Committee for Scientific Research (KBN) project (Investigations of the representative landslide process in Carpathian Flysch — experimental landslide in Beskid Niski Mts.)

RESULTS

Figure 1 presents two example curves obtained from the measurements in K3 borehole (see Zabuski, 2004); first of them shows the development of the displacements, second – GWL changes in time. It is clearly seen (arrows) that the GWP lowering is accompanied by acceleration of the displacement process. This observation does not agree with the common knowledge. According to it, the higher water level, the greater displacement rate. More expressive picture of the lack of dependence between displacements and GWL is shown on Figure 2, where correlation between DU and GWL practically does not exist.

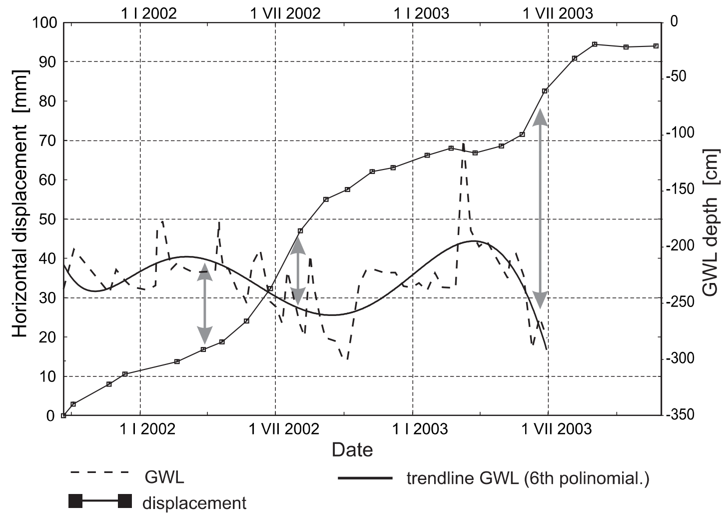

Fig. 1. Curves of displacement and GWL fluctuations in K3 borehole

Due to the above unexpected relationship and the lack of any meaningful dependence between considered variables, it was necessary to explain the phenomenon and to find some other variable, which allows to "connect" the displacement process with water conditions. Many trials were performed, in which different variables were taken into account.

Following combined variable, describing GWL changes was finally established:

$$I(GWL_{cumul}) = [abs\sum_{k=2}^{k=i}(GWL_k - GWL_{k-1})]$$

where:

$I(GWL_{cumul})$ — "cumulated intensity of GWL fluctuations"; it is created as a sum of all absolute values of water fluctuations starting from the beginning of the measurements;

GWL_k — water level in k-th reading;

Index i — the number of the last reading.

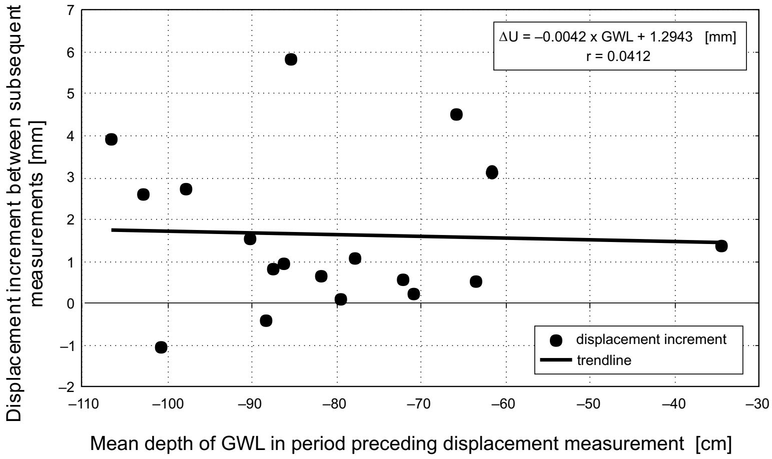

Fig. 2. Displacement increments versus mean GWL in K1 borehole

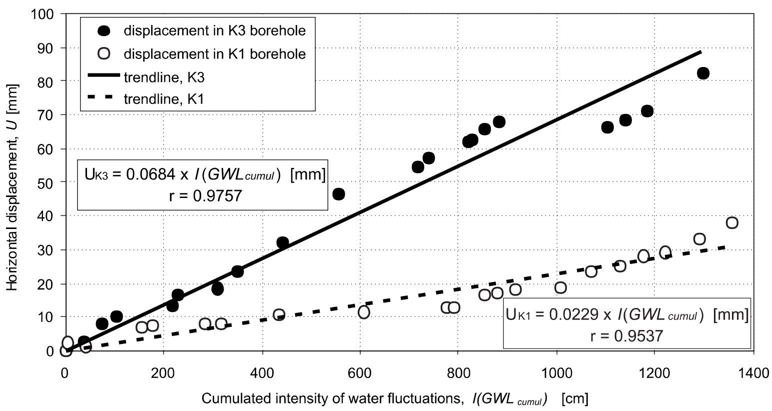

Fig. 3. Horizontal displacement of K1 and K3 boreholes in function of I(GWL_{cumul})

Relation between displacements measured and I(GWL_{cumul}) variable shows a good agreement. The example is shown in Figure 3 where displacements of K1 and K3 boreholes are drawn versus I(GWL_{cumul}). Linear trendlines approximating above relations prove high correlations between the variables, with correlation coefficients higher than 0.95.

It is seen now, that the more intensive fluctuations of the water in the slope, the higher displacement rate. If these two quantities are considered together as processes, it is seen that both develop similarly in time (Fig. 4). The curves are almost parallel proving their direct proportionality of above processes.

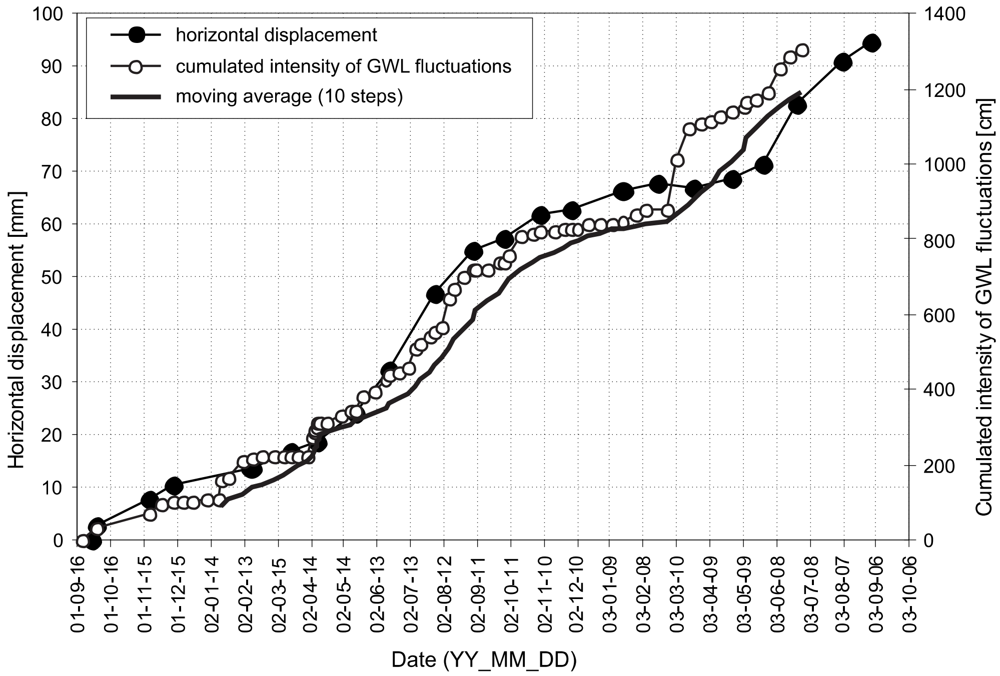

Fig. 4. Displacement and I(GWL_{cumul}) changes in time; K3 borehole

FINAL REMARKS

It was shown on the base of the results obtained in direct measurements that dependence between landslide deformation and groundwater level does not exist. Moreover, measurement results indicate inverse proportionality between GWL and displacement rate. The nature and reason of such unexpected effect is not clear; it seems, that some physic-chemical microprocesses occur in soil lying in the shallow slip zones due to its alternate drying and wetting.

Results confirming possibility of the generalisation of above conclusion are not numerous. It seems however, that this observation can have a more general character. The fatigue mechanism in soil could really weaken this material.

It is necessary to test in the future similar relations between GWL and deformations considering also the results reported in the paper.

REFERENCES

ZABUSKI L., 2004 — Prediction of the slope movements on the base of inclinometric measurements and numerical calculations, *In*: Proceedings of the Conference “Risks caused by the geodynamic phenomena in Europe” (ed. M. Graniczny *et al.*). *Pol. Geol. Inst. Sp. Papers*., **15**: 29–38.

ZABUSKI L., GIL E., RĄCZKOWSKI W., WÓJCIK A. , 2004 — Investigations of the representative landslide process in Carpathian flysch – experimental landslide slope in Low Beskid Mts.), IBW PAN Gdańsk, Project KBN, final raport (unpublished).