PORE PRESSURE PROFILING IN SIERCZA LANDSLIDE COLLUVIUM IN THE CARPATHIAN FLYSCH USING CPTU

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Introduction

The pore water pressure provides essential information about the structure, properties, and physical-mechanical processes occurring in the geological medium. One of the possibilities of its measurement, in the form of piezocone pore pressure, is the CPTU test (Zawrzykraj, 2017; Mlynarek et al., 2018). Moreover, analysis of pore pressure changes may be related to the development of the landslide process (Cascini et al., 2013). Studies on this issue have also been conducted in the area of Carpathian flysch (e.g. Zabuski, 2004; Stanisz, 2013; Stanisz and Pilecki, 2018).

The aim of the study is to identify zones with significant changes in piezocone pore water pressure in near surface formation of Carpathian flysch influenced by landslide processes. The study was carried out in the colluvium of the Siercza landslide near Krakow (Wieliczka Foothills) in the southeastern part of Poland. The results of piezocone pore water pressure together with inclinometer measurements and water conditions have been analysed in terms of the identification of potential landslide slip surface.

Methods and/or theory

The Siercza landslide area is approx. 22.75 ha, about 621 m wide and about 590 m long. The landslide has a complex geological structure and it has been classified as slide type. The geological-engineering recognition results have shown that flysch formations are made of shale with inserts of thin-bed sandstones of the Lower Cretaceous and the variegated marls of the Upper Cretaceous. These layers are often folded with black clays of the Chodenice layers (Miocene). The Quaternary is represented by silty clays and dump soils, with diversified thickness from 2.8 to 16.0 m in the upper part of the landslide. The colluvium consists of silty-clay formations with thin sandstone inserts.

The pore water pressure profiling was carried out using the penetrometer with electrical piezocone of NOVA Acoustic of AB Geotech (Sweden). The pore water pressure is measured via a porous element installed at the shoulder between the cone tip and the friction sleeve. Value of the pore water pressure measured in the soil just behind the cone tip can be differed from the pore water pressure in hydrostatic stress conditions. Six field measurements were carried out in the period 2017–2018.. The first three were done in dry conditions – 1 (17.11'17), 2 (8.11'18) and 3 (12.11'18). The next three were carried out under saturated conditions – 4 (20.09'17), 5 (12.07'18) and 6 (2.11'18). A day before no. 4, there was intense rainfall of 336 mm. One day and two days earlier, it was 2 and 7 mm, respectively. Early in the morning of 12.07'18 (no. 5), there was rainfall of 42 mm. The day before it was 46 mm. The last measurement (6) was made when the rainfall was low. On 2.11'18 it was 2.6 mm, while on the previous day it was 0.7 mm.

Due to the specifics of the measurement of piezocone pore water pressure, we expected to obtain information concerning the location of greater saturation zones or water flow paths. The identified zones may be related with the development of slip surfaces in the geological medium.

Examples

The results of the inclinometer measurements made it possible to determine the location of the slip surface. In central part of landslide, evident slip surfaces occur at depths of about 2.5 and 16 m. The largest increases in inclinometer displacements with a maximum value of 1.1 cm occurred at a depth of 2.0 m in the direction of NNE.

In general, the piezocone pore water pressure for all six measurements ranged from -102.2 kPa to 59.7 kPa. The maximum positive value of the pore pressure was registered in the near-surface zone (up to 10 cm) and in the upper part of the geological-engineering I layer. In turn, the maximum negative value was recorded in dry conditions at a depth from 3 to 6 m. In this zone, there are clays or clayey gravel in a semi-solid condition. The greatest values of inclinometer displacement were recorded at a depth of 2 m.
The results of piezocone pore pressure measurements have been analysed for significant positive or negative changes. We assumed, that such anomaly changes may be associated with significant changes in the water presence and may indicate the presence of weak zones.

Conclusions

Based on the piezocone pore pressure and inclinometer displacement measurements in the colluvium of the Siercza landslide, the following conclusions may be formulated:

- CPTU tests enabled pore pressure profiling up to a depth of 6m. In dry conditions, the pore pressure value ranged from -102.2 to 59.7 kPa. For varying water saturated conditions, pore pressure value ranged from -84.2 to 48.5 kPa.
- Five zones of anomalous changes of pore pressure. These zones were partly confirmed by inclinometer displacements occurred up to a depth of 3.5 m with a maximum of about 10 mm at a depth from 1.5 to 2.5 m.
- The changes of both piezocone pore pressure and inclinometer displacement are evident at a depth range from 1.5 to 2.5 m (zone 1, 2 and 3). Two slip surfaces are probable in this section.
- In the remaining sections, characteristic changes in the pore pressure were registered, but no distinct inclinometer displacement occurred. Probably, the deformation process has just started developing in such zones.

The relationship between the change in pore water pressure and the development of landslide processes is complicated. Piezocone pore pressure profiling may be useful in more reliably determining the location of the slip surface. This information can be used in engineering practice for more reliable assessment of slope stability in the Carpathian flysch.
The study provides only qualitative information about this relationship and further research under different Carpathian flysch conditions is required.

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