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Geo-engineering properties of Eemian peats from Radzymin (central Poland) in the light of static cone penetration and dilatometer tests

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A B S T R A C T

The paper presents the results of field studies testing the reaction of Eemian peats on the mechanical effect of standard measurement tools (CPT/CPTU, Marchetti dilatometer). Based on the collected undisturbed samples, macroscopic observations were made and SEM observations were conducted to identify the microstructural features. A fibrous structure and advanced diagenetic changes have been noted in the studied peats despite their relatively young age. These may have resulted from an exceedingly strong structural reinforcement, which causes that the studied sediments cannot be treated as low-bearing soils. Diagenetic processes caused farfetched changes of the mechanical properties, which is reflected e.g. in classification normograms. Standardized diagrams may lead to false conclusions. The presented studies of organic soils are an example of strong influence of structural features and diagenetic phenomena on the results obtained for native soils. At the same time, they imply particular caution in the interpretation of the substratum properties based only on the commonly used in situ tests. The values and variability of the collected parameters have been presented as frequency distributions. Additionally, the apparent character of the properties of preconsolidation parameters (OCR) has been shown.

1. Introduction

Peats are represented by sediments that contain over 20–30% of organic matter (Myślińska, 2003). They belong to strongly deformable soils and are characterized by low strength parameters. Therefore, their identification in profiles is very important.

Peats are represented by sediments that contain over 20–30% of organic matter (Myślińska, 2003). In many cases they belong to strongly deformable soils and are characterized by low strength parameters (Boylan et al., 2011). They are a difficult and uncertain material when built upon. (Hartlén and Wolski, 1996). Therefore, their identification in profiles is very important.

CPT/CPTU cone penetration tests and DMT flat dilatometer tests are used to determine soil parameters in situ (Shahri et al., 2015; Bagińska et al., 2016; Carlsten, 1988; Mayne, 2014; Młynarek and Wierzbicki, 2005; Młynarek and Wierzbicki, 2007; Lechowicz, 1997; Rabarijoely, 2013; Robertson, 2012; Totani et al., 2001; Wierzbicki, 2010). They are also more commonly used in designing foundations (Cai et al., 2009) and in predicting other physical and mechanical properties based on the measured values obtained from these tests. The tests are included in relevant international and Polish standards of research procedures. In Poland, DMT and CPT/CPTU tests have been used for 20 years. Currently, they are regarded as the standard in situ tests in a geotechnical ground investigation. Therefore, collection and exchange of experiments containing the results of such tests seems appropriate. Particularly important are conclusions that induce the development or verify the standing and accepted tests. Consequently, this paper present the features of organic soils with parameters significantly differing from expected.

2. Site characteristics

The survey was conducted near Zwierzyniec, c. 4 km to the north-east of Radzymin and c. 30 km to the north-east of Warsaw (central Poland) (Fig. 1). The study area is located within a central part of vast geomorphological unit known as the Radzymin terrace. It is 50 km long in longitudinal direction and 20 km long in latitudinal direction. Its formation is linked with the Vistulian Glaciation, during which a marginal lake developed in the Warsaw Basin (Karaszewski, 1974). The lake resulting from the damming of water flow by the Scandinavian ice-sheet was subsequently filled with ice-dammed deposits. After the retreat of the ice-sheet, the flat top of the ice-dammed deposits was covered by a thin layer of alluvial sands, which were later subject to eolian processes (Baraniecka and Konecka-Betley, 1987; Sarnacka, 1982). The study area is located at marginal part of the ice-dammed lake. A detailed description of the geomorphology of studied area and

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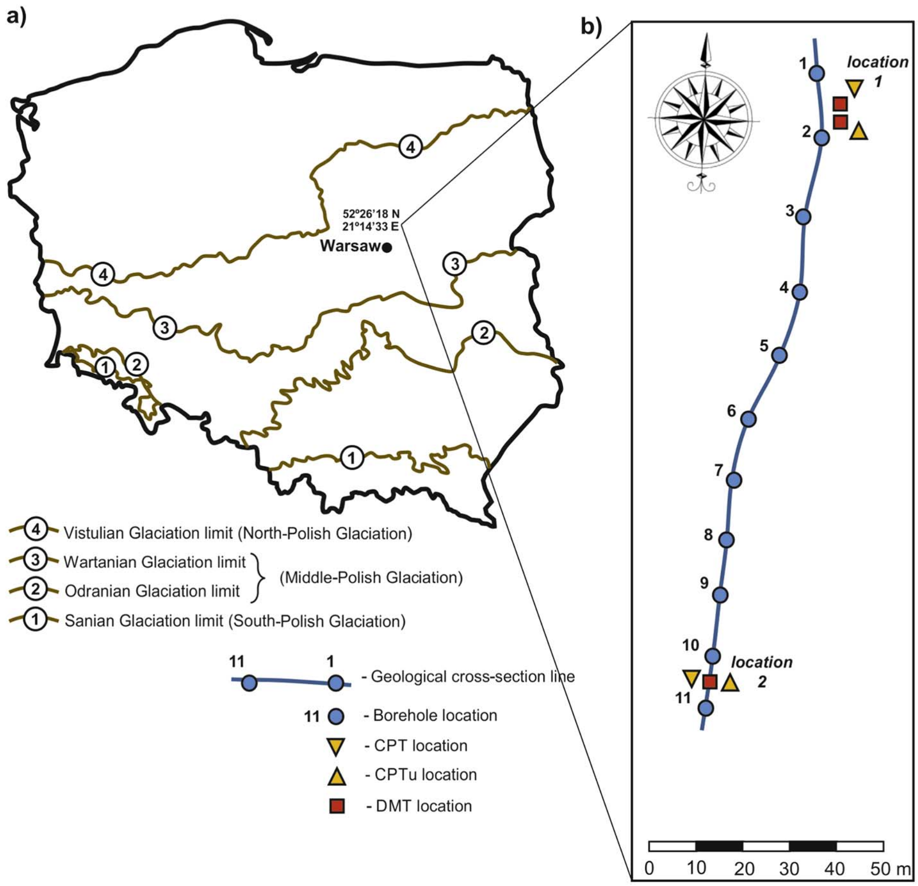

Fig. 1. Location of the study area.

the stratigraphy of quaternary sediments is presented in Kalińska-Nartiša et al. (2016).

Below the ice-dammed deposits occur organic and sandy sediments representing the Eemian Interglacial. The peats studied in this paper occur in the analyzed cross-section as two layers separated by a sand bed with a variable thickness of about 0.5–4 m. The top surfaces of the distinguished peat layers have a diverse morphology, resulting mainly from the erosive effect of a river channel, which is documented by the overlying sands. A layer of coarse material (gravels and pebbles), indicating high-energy flow, is often observed. The distinct general dip of the peat top surfaces towards the north, visible in the cross-section, also reflects the morphology of the sedimentary basin bottom (Kalińska-Nartiša et al., 2016). The lower peat layer is underlain by gyttja. Below the organic deposits occur medium-grained sands of fluvioglacial origin, underlain by glacial deposits of the Middle Polish Glaciations, represented by boulder clays and silts (Fig. 2).

After the retreat of the ice-sheet of the Middle Polish Glaciations, the analyzed area was not covered by a younger ice-sheet (Fig. 1). Both the ice-dammed and the Eemian sediments have not been subject to significant loading in their geological history. The only preconsolidation load could have been caused by dunes passing across the study area in the terminal part of the Pleistocene (Baraniecka and Konecka-Betley, 1987; Dzierżek, 2009; Dzierżek et al., 2015; Kalińska-Nartiša et al., 2016; Kalińska-Nartiša and Nartišs, 2016). There is no evidence of any additional loading of the studied soils.

3. Materials and methods

The applied devices included a CPT static sounder equipped with a mechanical Begemann cone and an electric cone with pore water pressure measurement (piezocone). Another tool was the Marchetti flat dilatometer. Geotech AB hydraulic drive with a maximal strength of 200 kN was used to push the measurement devices into the soil. The tests were conducted in two localities (Fig. 1), with at least one CPT test, one CPT(u) and one DMT test in each of them. The measurement sites within the localities were at distances of about 2–3 m. A total of 7 tests were made. The presented charts refer solely to the layers with Eemian peats. During drilling, peat samples were collected for SEM viewing and macroscopic analyses.

The following parameters were registered during the CPT tests:

- measured cone resistance q_c, sleeve friction f_s – when a mechanical cone was used, with a resolution of 20 cm;
- measured cone resistance q_c, sleeve friction f_s, pore pressure measured behind the cone u_2 – when a piezocone was used, with a resolution of 2 cm.

Every effort was made to achieve the high quality of CPTU results. The final values of the parameters depend on the appropriate measurement of sensor resolution, drift/inertia errors of "0" value due to temperature fluctuations, the type and geometry of cone tips, the extend of their wear, surface roughness, the degree of saturation of the porous filter, proper maintenance of the equipment and the competence of the researchers conducting the test (Sandven, 2010).

During the dilatometer test, pressures p_0 and p_1 were registered every 20 cm in vertical profile.

The procedures of conducting the tests and geometry of the cone tips were according to the requirements of the Technical Committee 16 of International Society for Soil Mechanics and Geotechnical Engineering ISSMGE and international standards (EN ISO 22476-1:2012, 2012; ASTM D3441-16, 2016; ASTM D5778-12, 2012).

Based on the parameters registered in the field, the following values were calculated:

$$q_t = q_c + u_2 * (1 - a), \text{ [MPa]}$$