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Investigation of Physical and Mechanical Characteristics of Macro Sample of Water Saturated Peat

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Abstract

The article reports results of laboratory tests of weak water-saturated soils (remoted from day surface) in stress-strain state under influence of compression with double-sided filtration of pore's water. The authors suggested the upgraded assembly scheme of the soil pressure sensors (load cells). The laboratory research of the water-saturated macro peat sample was made in compression conditions with "ground lock" and modeling of the experiment with Plaxis 2D software system. The unit deformation-pressure graph and excessive pore pressure against time in different steps of load graph were built and based on this findings. Authors made the new experimental device for research of the water saturated peat mechanics properties with excessive pore pressure.

Keywords: Weak organo-mineral soil, general and excessive pore pressure, peat macro sample, compression, Plaxis software system.

INTRODUCTION

Nowadays Russia is the first in quantity of marshes. Moreover, it has continued to grow. According the predictions of scientists, the whole territory of West Siberia will be marshed and mucked in the next ten thousand years. It connected with the irreversibility of marsh formation in modern climate conditions. About 0.86 million square kilometers became the marsh areas in the last 500 years. Scientists have proved the fact that growth of the marshes areas and width of the peat deposits make it stable and autonomous as a whole system. High stability of marshes ecosystems makes an irreversibility the marsh formation process and makes the progress in autonomous of marsh formation process in particular territories [1, p.5].

The building of engineering facilities on peaty soils is a complexity process, so in this case, it is necessary to make the constructions more complicate and that leads to price rise. It is very important for development of new effective construction of foundation to explore train-stress distribution and evaluation of mechanical specifications that will fully describe the water-saturated peat as a basis for engineering facilities.

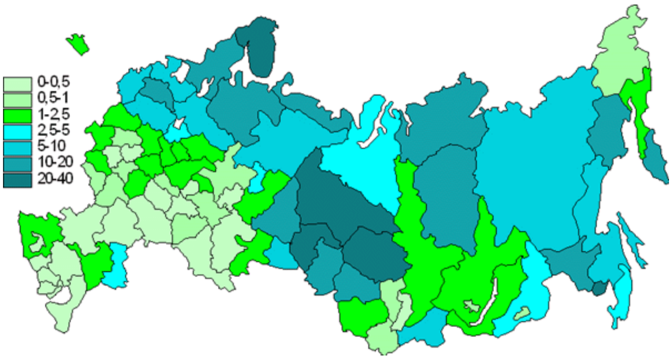

Figure 1: The area of marshes as a percentage of the total area of the subjects of the Russian Federation.

An industrial facilities and civil engineering are very sensitivity to settling. Therefore, peat is non-buildable base and it makes worse the mineral ground soil behavior. [2, p.3]. N. N. Morarescul was the first author who wrote about foundations and grounds of industrial facilities and civil engineering on a peat soils.

The most important thing in evaluation of foundation on peat soils is a peat bedding conditions. There are two types of peat bedding. The first one is opened, the second one is buried. The opened type of bedding uses only for lightweight timber buildings. This type of buildings based on a sand blankets or piles. While as the fundamental structures based on cutting organic soils, sand blankets or piles. The physical mechanical properties of peat have the same standards of evaluation as organic soils.

It is impossible to make analysis of excessive pore pressures influence on physical mechanical properties of sample in the GOST (All-Union State Standard) [3] methods because of a small size of the sample. It is also impossible to apply sensors of soil pore pressures and to measure pore pressures because of sample's height.

By the way, peat properties is different in comparison to organic soils. This is due to property of the peat to keep much more water volume in bounded condition than volume of its particular minerals. The relative degree of humidity of peat in natural conditions of water saturation is more than 96%. It cannot be less than 85% even after the long deep dewatering with filter drain. It connected with the high dispersity level and particular friable fibriform structure of the peat.

SUBJECTS AND METHOD

The experimental investigation was made for studying of influence of excessive pore pressures on physical mechanical characteristics of muck foundation. The experiment was conducted in an interdepartmental experimental science lab of TSUACE (Tyumen State University of Architecture and Civil Engineering).

Although, the experimental device (Fig. 2) for investigation of stress-strain state and pore pressures in a water-saturated peat sample with the availability of sand ground compact embankment has been invented [4, 5, 6].

Figure 2: An experimental device.

The experiment includes studying of stress-strain state of a water-saturated macro peat sample with “ground lock” that consists of coarse sand.

The weak organo-mineral soil with disturbed structure (sand-clogged mud-peat) was used for referencing purposes. The samples was taken in Borovskiy village of Tyumen region. During the process of packing the sample was compressed and it has the next characteristics: ρ = 1.23 – 1.31 g/cm^2, W = 181 – 189%, peat decay degree – 45%, ash-content – 67%. Sample proportions: diameter – 510 mm, height – 400 mm. Hs=400 mm. The coarse sand used as a “ground lock”, Hs=400 mm.

Six load cells were put in soil sample at the 20 mm, 200 mm and 380 mm depth. Four for general pressure and two for pores pressure (Fig. 3).

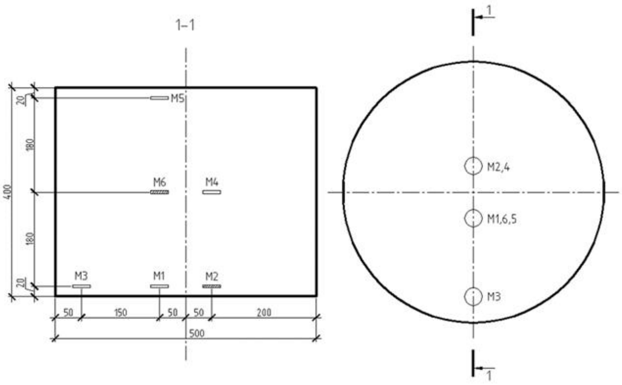

Figure 3: Scheme of the load cells in the soil sample. M 1,3,4,5 for load cells of general pressures. M 2,6 for load cells of pore pressures.

The sensors were calibrated in an aerostatic tank using an air compressor (Fig. 4).

Figure 4: An aerostatic tank with air compressor.

Authors have been elicted the most probable reasons of failure or defective work of the sensors in “classic scheme” that was made by D. S. Baranov [7] and upgraded A. V. Golly. [8]. Here there are:

- Break of the resistive-strain sensor connection;
- Air drain through the wire or place of its hermetic encapsulation;
- Break of the wire;
- Short circuit of resistive-strain sensor on body of the load cell;

- Manufacturing defect.

The Authors have suggested the listed below recommendations of reliability growth:

- The wire rigid fixation inside the load cell with glass-bonded dielectric material (Fig. 5, Fig. 6);
- Using of two-step encapsulation;
- Using the higher quality than twisted-pair wires.

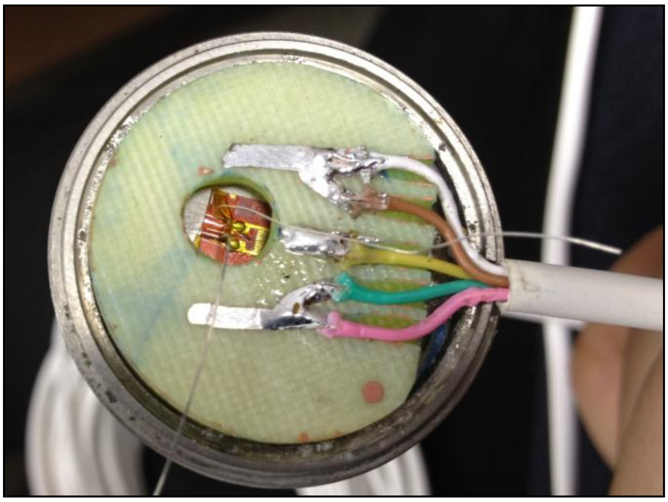

Figure 5: The upgraded load cell.

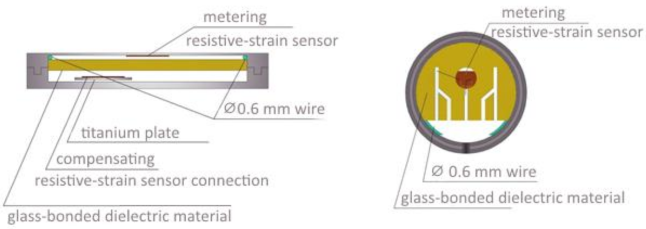

Figure 6: The scheme of upgraded load cell.

The computing simulation of compression was made with Plaxis 2D v.8.2 software system (hereinafter referred to as Plaxis) for identification in patterns of change in stress-strain state of peat soil. The axisymmetric problem was set as initial conditions. The full water saturation was set for peat sample and for the "ground lock" (Fig. 7). Characteristics of soil based on physical mechanical characteristics of soils in lab tests.

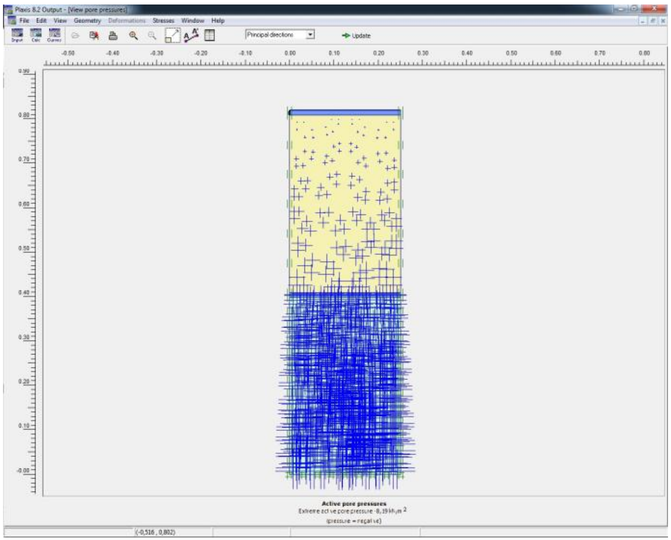

Figure 7: Plaxis: pore pressures.

The grid for peat cluster made smaller because the peat is the main research object.

Author used the elastoplastic model with Mohr-Coulomb yield criterion (hereinafter referred to as Mohr-Coulomb model) for modeling of the process in the Plaxis software system. The model includes five type of characteristics that got with the standard soil tests:

- E is for the Young's modulus (modulus of elasticity).
- ϑ is for the Poisson ratio.
- φ is fot the angle of friction.
- c is for the adhesion.
- ψ is for the angle of dilatancy.

RESULTS

The graph that mentioned bellow were built and based on the results of computing simulation and lab test:

- The graph of unit deformations against pressure (Fig. 8);
- Pore pressure graphs for the first 7 days of the experiment (Fig. 9);
- The graph of excessive pore pressure against pressure on the sample at 20 cm depth (Fig. 10);
- The graph of soil stress against the pressure on the sample at 38 cm depth (Plaxis) (Fig. 11).

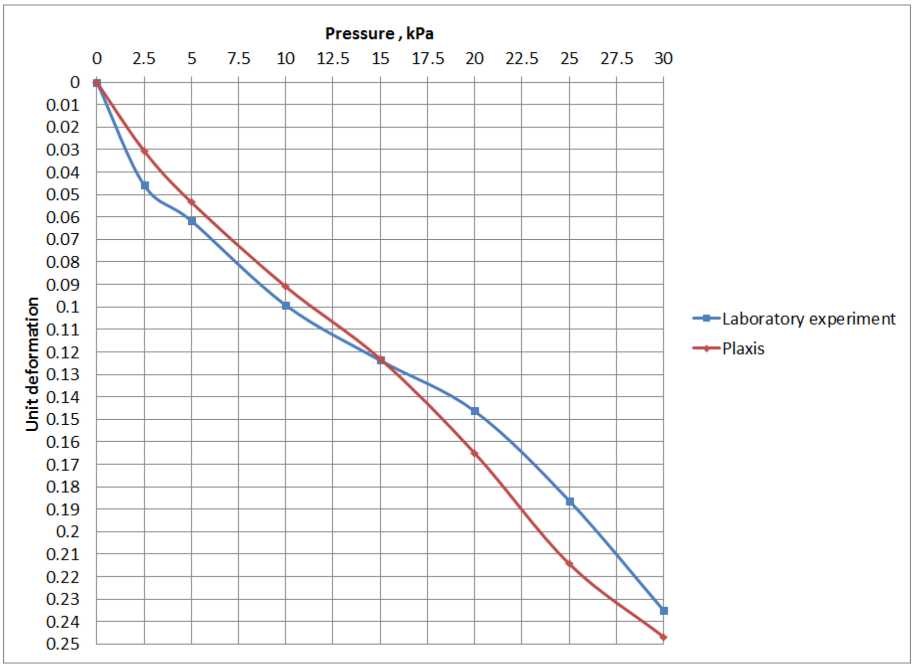

Figure 8: Unit deformation-pressure diagram.

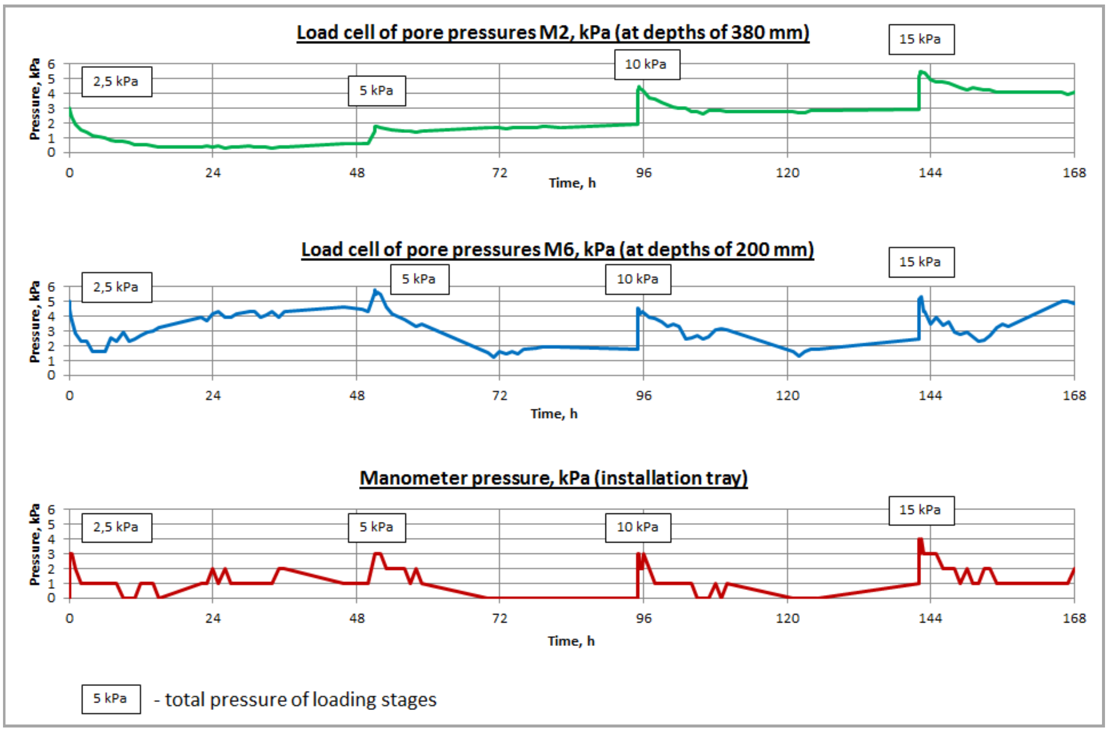

Figure 9: Pore pressure graphs for the first 7 days of the experiment.

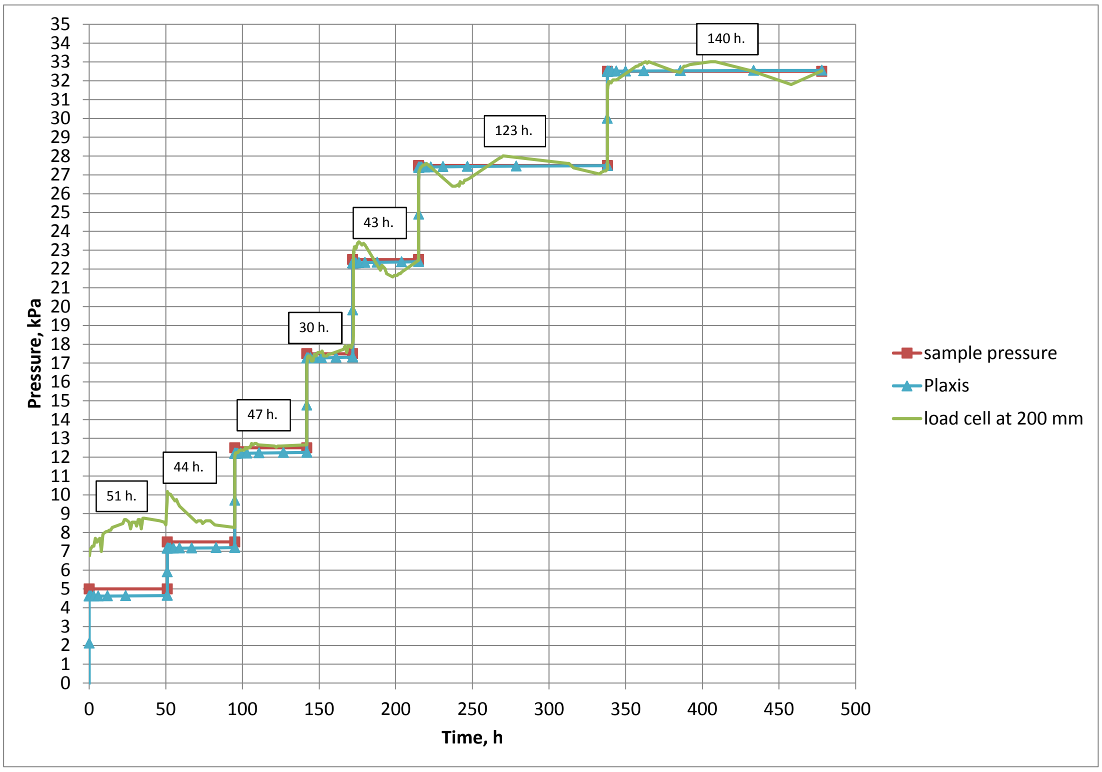

Figure 10: Graph of the stresses in soil against the sample pressure at depths of 200 mm.

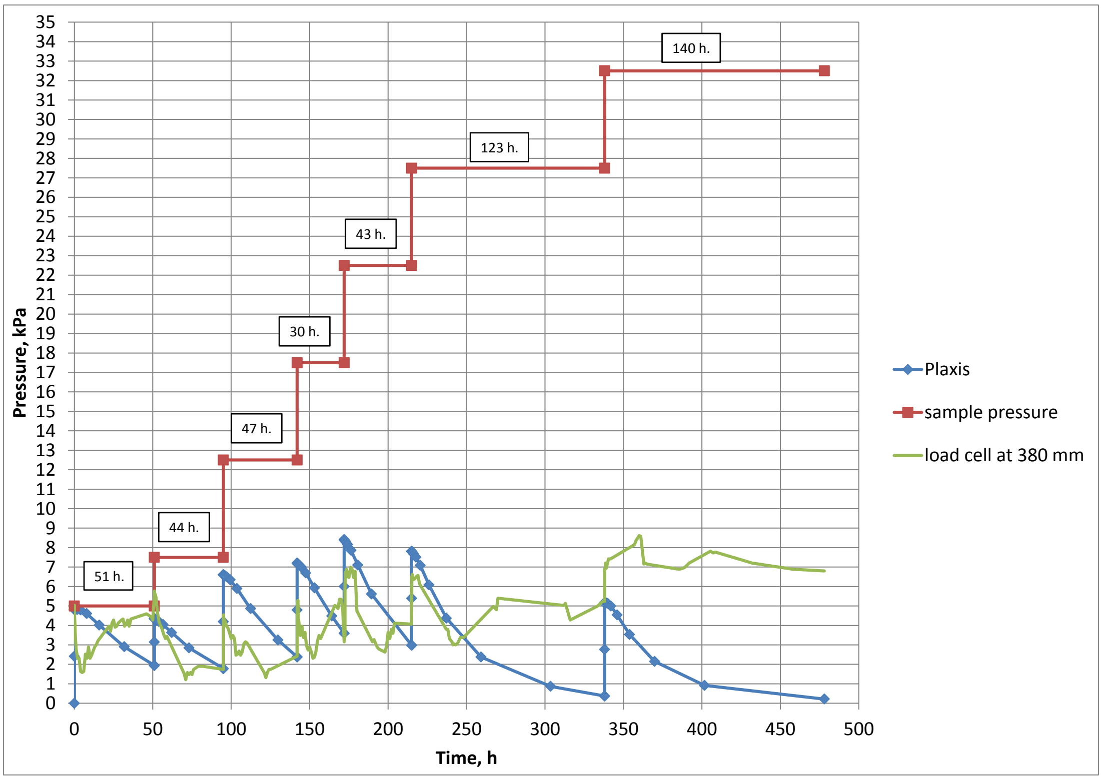

Figure 11: Graph of the excessive pore pressure against sample pressure at depths of 380 mm.

CONCLUSIONS

1) Nowadays Russia is the first in quantity of peat soils. Moreover, in Tyumen region it is more than 15% of a whole territory of region. The experience in design and construction of linear engineering constructions suggests that it is necessary to spot the mechanical characteristics of water saturated peat to reduce the errors in designing.

2) Existing methods for determination of physical mechanical characteristics of peat soils does not provide for the possibility of taking into account the influence of the excessive pore pressure on the mechanical characteristics (e.g. peat humidity can be more than 2000%).

3) Results of the lab tests: the unit deformation of testing sample is 0.235; the modulus of deformation E = 0,16 MPa; the excessive pore pressure, measured with load cell at depth of 200 and 380 mm(in last step moment) has become 28 and 33% from the pressure on the sample; the residual excessive pore pressure, measured with load cell at depth of 200 and 380 mm has become 16 and 22% from the pressure after 30 days pass the last step.

4) Matching the values of general pressures that measured with load cell under press tool with the strain shows the 4% error (in 10-30 kPa range).It means that created assembling and connecting of load cells technology is efficient .Moreover, load cells have not been crashing during all the experiment.

5) Plaxis 2D v.8.2 software system is a good tool for displaying and modeling of the total pressing in soil. Nevertheless, differences in pore pressures indicate that chosen elastoplastic model with Mohr-Coulomb yield criterion does not show the real picture. Further, it is necessary to spot the soil characteristics that make possible to use other models of Plaxis software system.

6) The new experimental device for research of water saturated peat mechanics properties with taking into account excessive pore pressures was made and based on experimental research and analysis of the literature sources.

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