International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 16 (2017) pp. 6071-6075

The Findings of Laboratory and Computational Investigations of Water Saturated Peat with Taking into Account Excessive Pore Pressures

Aleksandr Vladimirovich Kulikov[1] and Aleksey Nikolaevich Kraev[2]

[1,2]Department of research and development activity, Industrial University of Tyumen
38, Volodarskogo str., Tyumen 625000, Russian Federation.

[1]Orcid: 0000-0001-5844-3531, [2]0000-0003-2316-246X,

Vyacheslav Viktorovich Vorontsov[3]

[3]Department of Education, Tyumen City Administration, 17, Respubliki str., Tyumen 625000, Russian Federation

[3]Orcid: 0000-0002-0141-7452

Abstract

The article reports results of laboratory tests of stress-strain state weak organo-mineral water-saturated soils (remoted from day surface) under influence of compression with double-sided filtration of pore water and modeling of this experiment in Plaxis software system. The experimental device with console-lever system of load transfer and potential of double-sided filtration was made for current research. The compression specification was controlled with the strain gauge sensor element of general pressure (i.e. the load cell). The deformation in sample were measured with the motion detecting transducer that based on indicating gage. The excessive pore pressure were measured with strain gauge sensor elements and digital manometer. Also the plots of compression deformation against pressure and changes of excessive pore pressure during the time on different load degrees were drawn.

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

INTRODUCTION

There are a lot of territories with peaty high water table soils in Russia. Nowadays Russia took the first position in swamp areas quantity [1]. The peculiarity of south of Tyumen region is that spread of peaty soils more than 15% of whole territory.

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.

Soviet scientists made the important contribution in question of organo-mineral soils. Especially, the research of compression tests of peat made by L. S. Amaryan and written in his monographs [2, 3]. Also V. D. Kazarnovskij and I. E. Evgenev [4, 5] presented the full classification of boggy grounds and the methods of engineering of line structures on a peaty moors.

N.N. Morareskul due to extended compression tests determinated K coefficient that show the conversion from 1-day unit deformation to 2 years tests [6].

One of the basic methods of building of engineering facilities on peaty soils is a surcharging with a well filtrate artificial basis made of medium, coarse or gravel type of sand. If the region is poor for such sand, then low filtering ability materials will be also applicable. P. A. Konovalov and S. Ya. Kushnir were made the large-scale set of experiments for studying of influence of filtration properties of filled-up grounds on a consolidation process of peat mass [7].

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).

SUBJECTS AND METHOD

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

The height of the peat sample was set as 400 mm for comparison of characteristics between standard methods that not consider remoting from the day surface and the considerations about importance of smaller samples that not only a point-counter value and can characterize system as a whole [2]. In addition, during the tests of standard samples (from 40 to 80 mm in diameter and from 20 to 30 mm in height) after 75-95 minutes the odometer reading in a clay soils became zero because of small height of samples [8]. For peat soils, this process passes faster.

The experimental device (Fig. 1) for investigation of stress-strain state and pore pressures in a water-saturated peat sample has been invented in interdepartmental experimental science lab in TSUACE.

Experimental device is a steel pipe with hard sidewalls, it has a diameter - 510 mm and height - 1020 mm. Above the sample of peat (with the 400 mm of height) has made a solid of coarse sand that simulate overlying soils. Perforated slab has set at the bottom of tray for drainage of water into pallet that connected with digital manometer. The load on a sample transfers through the round perforated press-tool #1. Press-tool #2 was made heavier for combined settlement and prevention of sand catching. In this case, load transfers through the console-lever system. Easy-deformable plastic membrane has set on a pipe's sidewalls, solid oil has used as a grease between them. Membrane have used for friction of reduction between soils and the sidewalls of device.

Experimental device is described in detail in the article "The findings of laboratory tests of macro sample of water saturated peat with simulation remote from day surface" [9, 10].

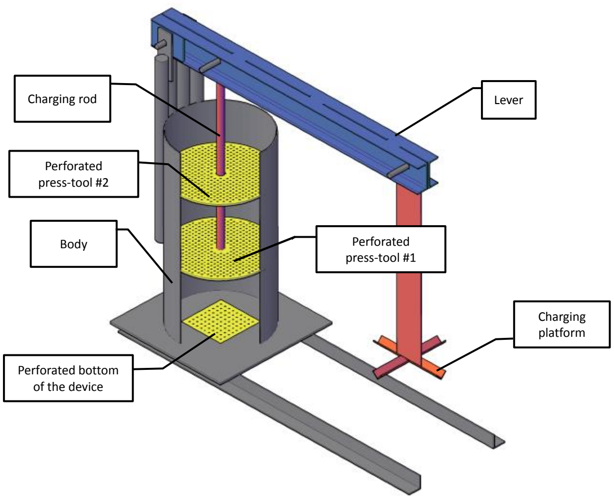

Figure 1: An experimental device: 3d-model.

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 (Fig. 2). The axisymmetric problem was set as initial conditions. The full water saturation was set for peat sample and for the "ground lock" (Fig. 3). Characteristics of soil based on physical mechanical characteristics of soils in lab tests.

Author used the elastoplastic model with Mohr-Coulomb yield criterion (hereinafter referred to as Mohr-Coulomb model) for modeling of the process.

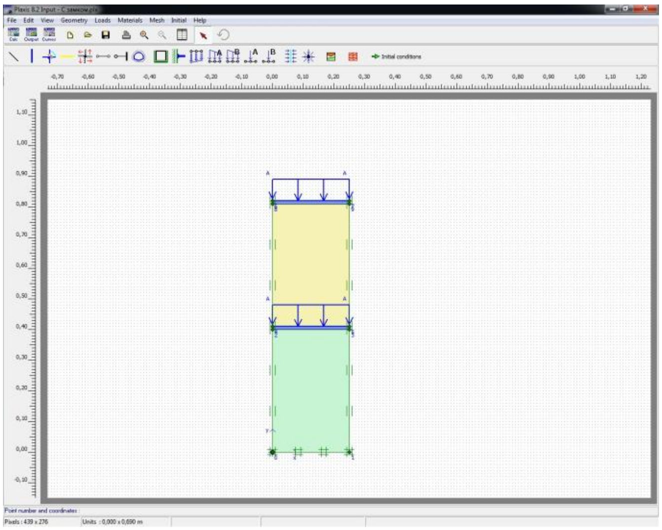

Figure 2: Plaxis: initial conditions.

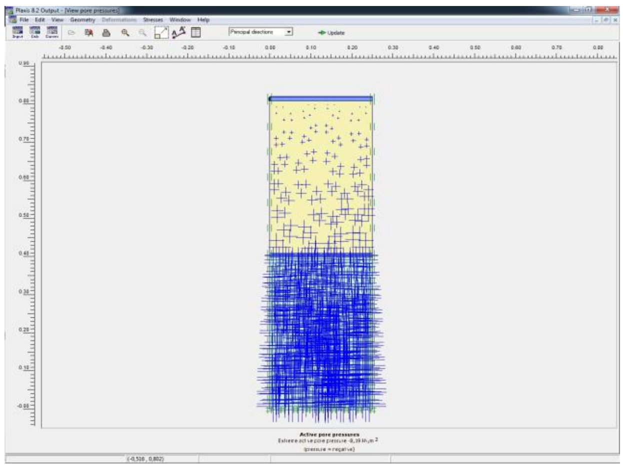

Figure 3: Plaxis: pore pressures.

RESULTS

The graph of unit deformations-pressure (Fig. 4) was built and based on the results of computing simulation and lab tests. According this model, the unit deformations were 0,247. It is 5% more than in lab tests.

In addition, the graph of the stresses in soil against the sample pressure at depths of 200 mm (Fig. 5) and graph of the excessive pore pressure against sample pressure at depths of 380 mm (Fig. 6) graph were also built.

New experimental device for investigation of mechanical properties of water saturated peat with excessive pore pressure based and built on the results of lab research and analysis of literature sources.

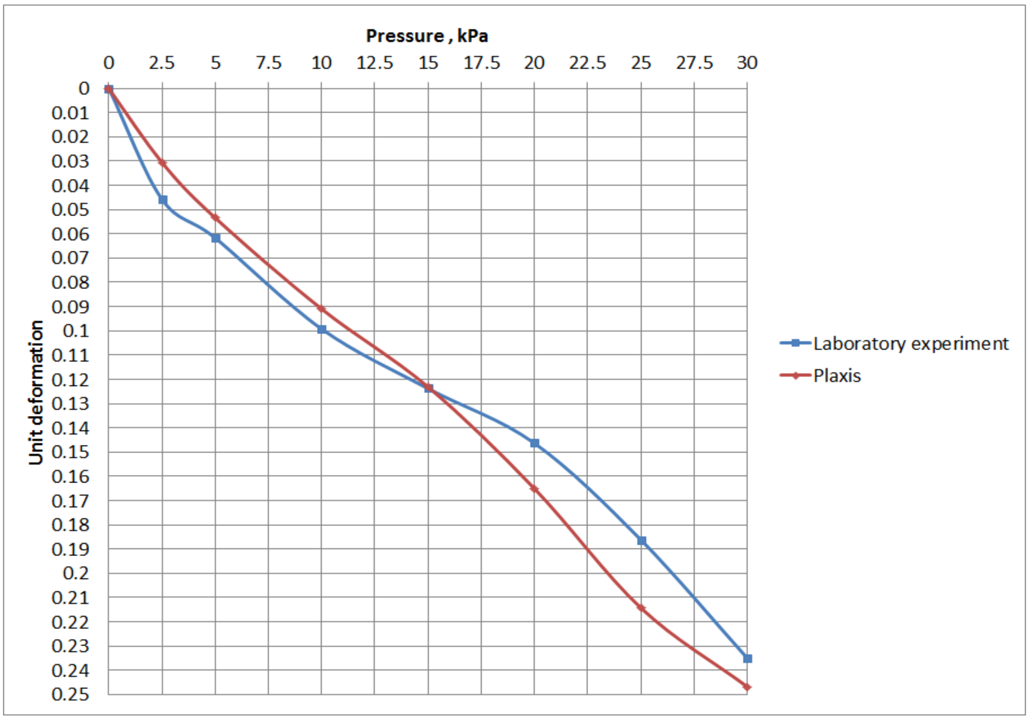

Figure 4: Unit deformation-pressure diagram.

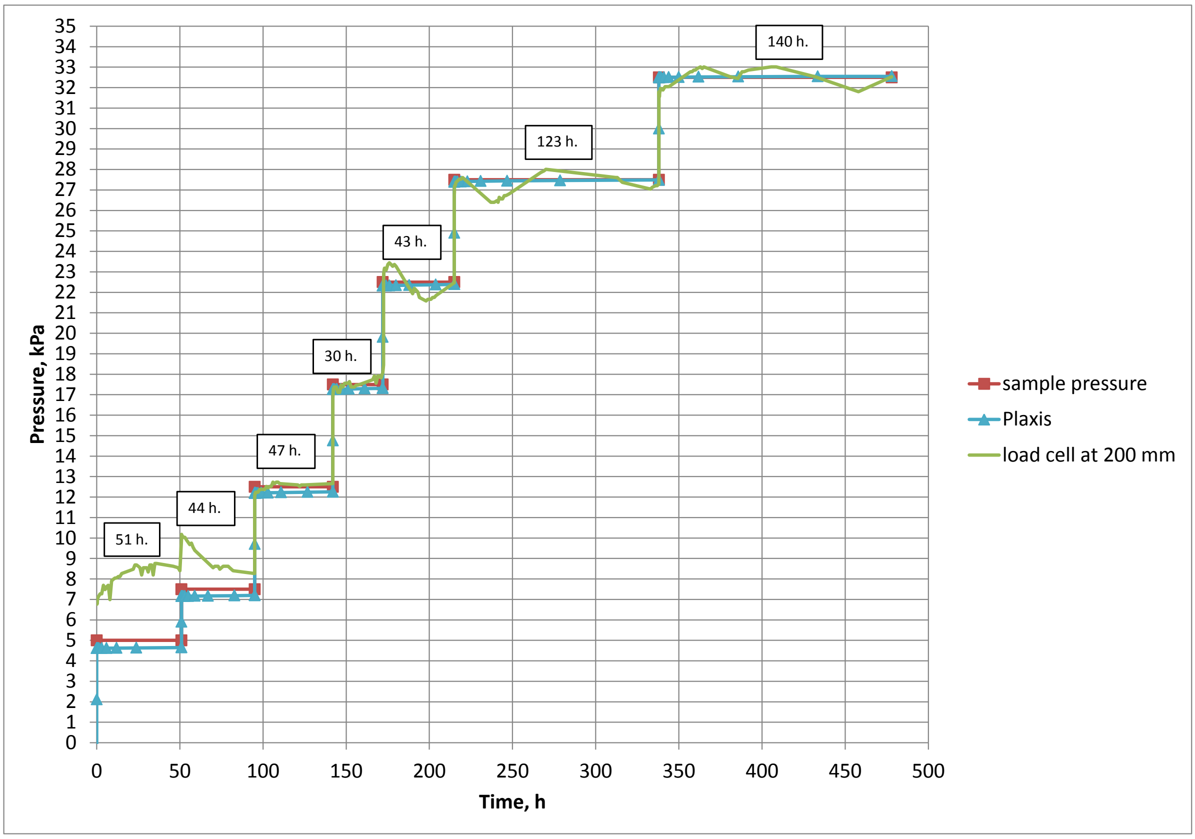

Figure 5: Graph of the stresses in soil against the sample pressure at depths of 200 mm.

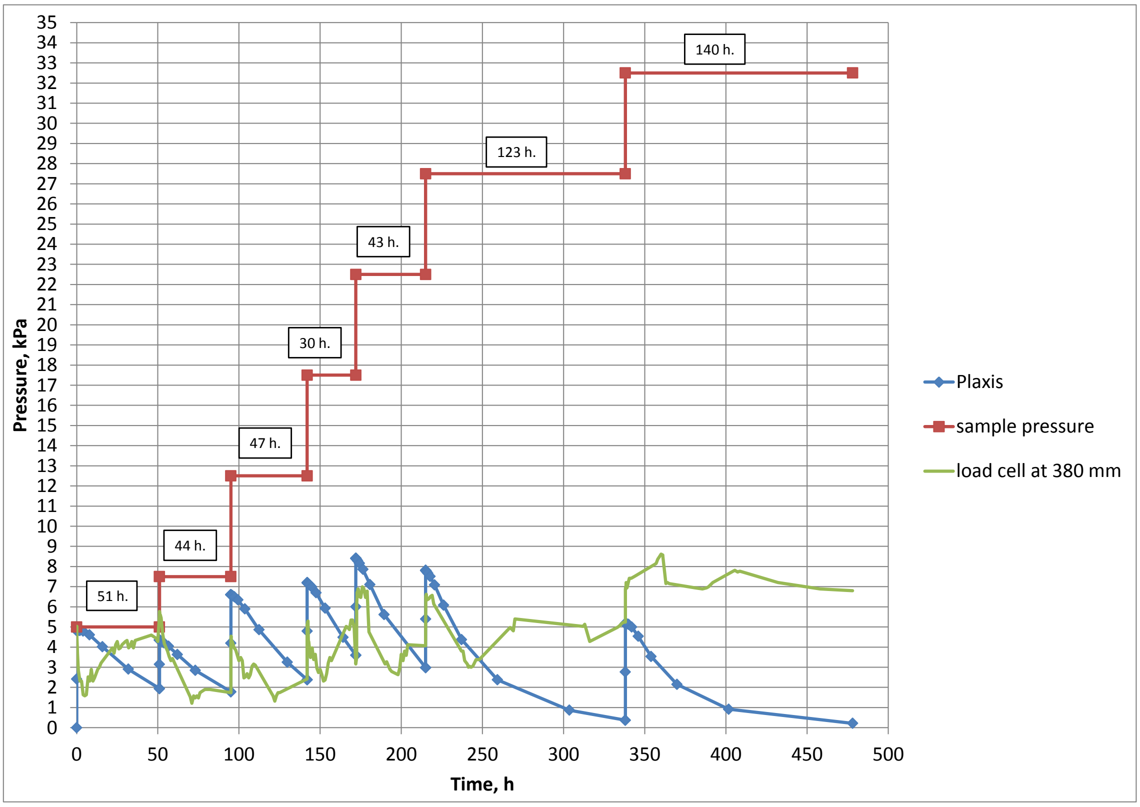

Figure 6: Graph of the excessive pore pressure against sample pressure at depths of 380 mm.

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.

REFERENCES

[1] L.I.Inisheva and S.G.Maslov “Rol torfyanyh resursov v strategii ustojchivogo razvitiya” [The role of peat resources in sustainable development strategies]. Trudy Instorfa, vol. 8 (61), pp.3-10, 2013.

[2] L. S. Amaryan “Svojstva slabyh gruntov i metody ih izuche” [Properties of weak soils and methods for studying them]. Moscow: Nedra, 1990.

[3] L. S. Amaryan "Prochnost i deformiruemost torfyanyh gruntov" [Strength and deformability of peat soils]. Moscow: Nedra, 1969.

[4] I. E. Evgenev "Stroitelstvo avtomobilnyh dorog cherez bolota" [Construction of motor roads through bogs]. Moscow: Transport, 1968.

[5] I. E. Evgenev and V. D. Kazarnovskij "Zemlyanoe polotno avtomobilnyh dorog na slabyh gruntah" [Roadbed of highways on weak grounds]. Moscow: Transport, 1976.

[6] N. N. Morareskul "Osnovaniya i fundamenty v torfyanyh gruntah" [Grounds and foundations in peat soils]. Leningrad: Strojizdat, 1979.

[7] P. A. Konovalov and S. Ya. Kushnir "Namyvnye grunty kak osnovaniya sooruzhenij" [Embedding soils as base structures]. Moscow: Nedra, 1991.

[8] M. Yu. Abelev "Stroitelstvo promyshlennyh i grazhdanskih sooruzhenij na slabyh vodonasyshchennyh gruntah" [Construction of industrial and civil structures on weak water-saturated grounds]. Moscow: Strojizdat, 1983.

[9] V. V. Voroncov, V. P. Ovchinnikov and A. V. Kulikov "Rezultaty laboratornyh ispytanij makroobrazca vodonasyshchennogo torfa s imitaciej udaleniya ot dnevnoj poverhnosti" [The results of laboratory tests of a macro sample of water-saturated peat with an imitation of removal from the day surface]. Nauchno-tekhnicheskij vestnik Povolzhya, vol. 5, pp. 150-154, 2014.

[10] A. V. Kulikov and A. N. Kraev The findings of laboratory tests of macro sample of water saturated peat with simulation remote from day surface. International Journal of Applied Engineering Research, Volume 12, Issue 11, 2017, pp. 2728-2730.