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Organic Soils Consolidation Test with Pore Water Pressure Measurements

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Abstract

The paper compares the void ratio at the end of primary consolidation obtained from log t and $\sqrt{t}$ methods with those obtained from pore water measurements. Two organic soils from the Żuławy region ware used for the study. The experimental results indicated that decrepancies between methods can be regarded as negligible for practical purposea.

Key words: organic soils, the end of primary consolidation, pore water pressure measurements

1. Introduction

The estimation of the compression index requires konwledge of the void ratio at the end of primary consolidation (EOP) (Mesri, Castro 1987). Compression index, designated C_c is defined as the change in void ratio per $\log_{10}$ cycle of effective pressure.

The void ratio at the end of primary consolidation may be obtained applying various methods available in literature (Lambe, Whitman 1978, Olson 1986). The square root of time fitting method, $\sqrt{t}$, and the logarithm of time fitting metod, $\log t$, are the most popular (Whitlow 1990). Both methods use the curve of the time-compression data obtained from one-dimensional consolidation tests.

Most analyses on the adequacy of the above methods concern mineral soils (Crawford 1964, Mesri and Choi 1985, Robinson 1999). On the other hand, data concerning organic soils are rather scarce.

The purpose of this work is to compare the values of the void ratio (estimated for some organic soils) at the end of primary consolidation obtained from the $\log t$ and the $\sqrt{t}$ methods, with those obtained from the pore water measurments.

2. Experimental Study

Some soils from the Żuławy region were used for the study. Differences in the organic matter content of these soils constitute the basis for their choice. The physical properties and organic matter content of these soils are depicted in Table 1.

Several series of one-dimensional consolidation tests were conducted using a conventional oedometer (ring size: 6.49 cm in diameter and 2.00 cm in height). The tests were carried out on fully saturated hand-remolded samples of the soils. The soil samples were made into a paste at a water content of 1.20 times the liquid water content limit, and kept in that form for uniform moisture distribution. The consolidation pressure changed from 12.5 to 200 kPa. A load increment ratio of 1.0 was adopted. The ring was smeared with silicone grease to minimise side-friction between the specimen and the ring. Special precautions were undertaken to minimise evaporation of pore water from the top of the cell.

Table 1. Physical properties and organic matter content of the soils used

Site samples	Organic matter content, I_{om}, %[1)]	Liquid limit, w_L, %	Plastic limit, w_P, %	Mineralogy
Markusy (M)	10.2	111.2	43.2	Quartz, illite, feldspar
Nowe Dolno (ND)	4.8	66.0	34.2	Quartz, illite, kaolinite montmorillonite, feldspar

[1)] determined according to PN-88/B-04481, Building Soils, Laboratory tests.

Only one-way drainage through the top of the cell was permitted during tests. The bottom of the oedometer was connected to a manometer to measure the excess pore water pressure during consolidation. Special care was taken to avoid trapping air in the measuring system.

3. Results and Discussion

One of the results obtained for the one-dimensional consolidation tests is depicted in Fig. 1. It shows time-void ratio curves for the soils in the pressure range 100–200 kPa, and corresponding time-pore water pressure data. The maximum pore water pressure and maximum pore water pressure per applied pressure versus applied consolidation pressure is shown in Figs. 2 and 3, respectively. It can be seen that the measured pore water pressure increases to a maximum value before deacreasing. The value of maximum pore water pressure is less than the pressure increment applied to the top of the sample. There is no satisfactory explanation of this observation. Some investigators assign this phenomenon to the "stiffness of the pore water pressure measuring system" which allows partial drainage of pore water from the base of the sample (Whitman et al 1961, Sonpal and Katti 1973).

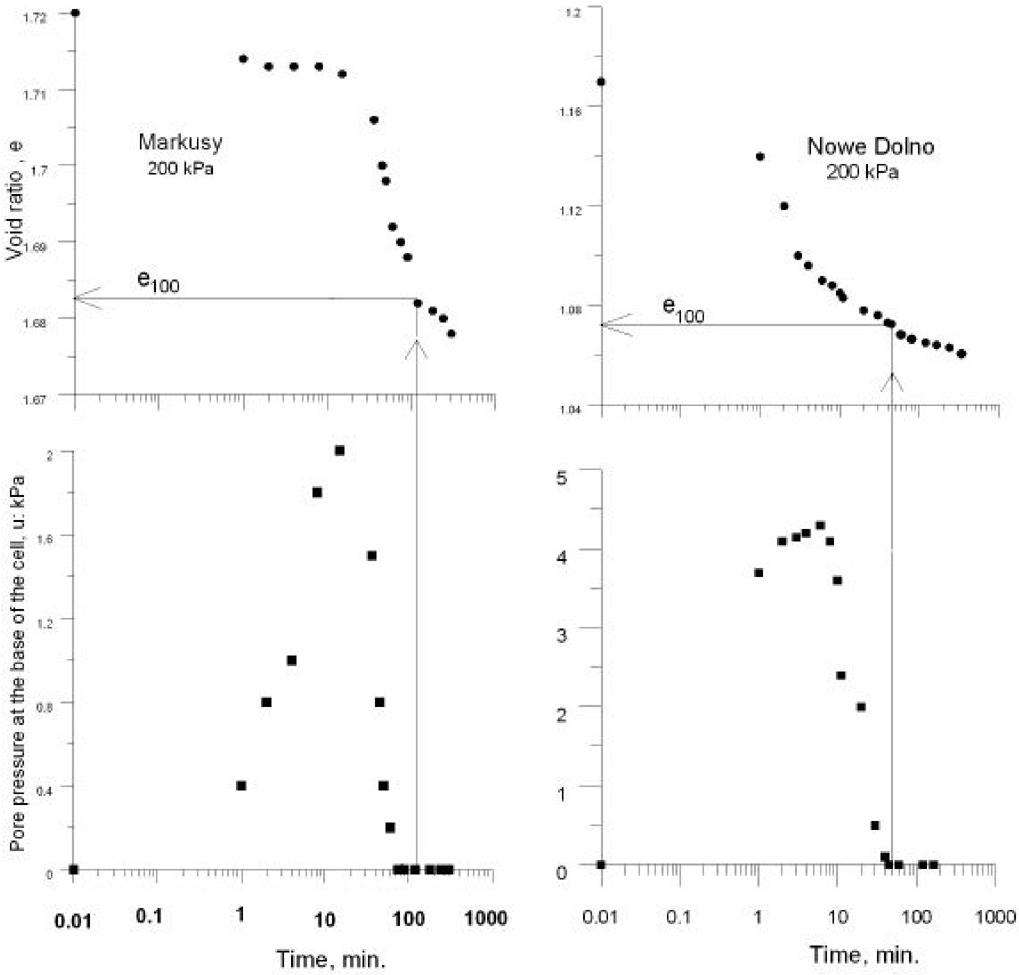

Fig. 1. Time - compression curves and the corresponding time – pore water pressure curves

It can be seen from Fig. 4, that the time taken for completion of the primary consolidation depends on the soil type. This may be attributed to the coefficient of permeability of the soils. The coefficients of organic soils at sites of Markusy and Nowe Dolno are 1.99×10^{-8} and 9.6×10^{-8} ms^{-1}, respectively (Olchawa 2003).

The values of void ratio, e_{100}, at the end of primary consolidation obtained from the $\log t$ and the $\sqrt{t}$ methods and those obtained from the pore water measurments are given in Tables 1 and 2 and shown graphically in Fig. 5.

The e_{100} values determinated from the $\sqrt{t}$ method are generally greater than those obtained from the $\log t$ method. This is in agreement with earlier findings reported by Olson (1986) and Robinson (1999). Contrary to their results, the e_{100} values of tested organic soils described in this paper determined from both methods, do not differ very much. Comparison of the e_{100} values obtained from the

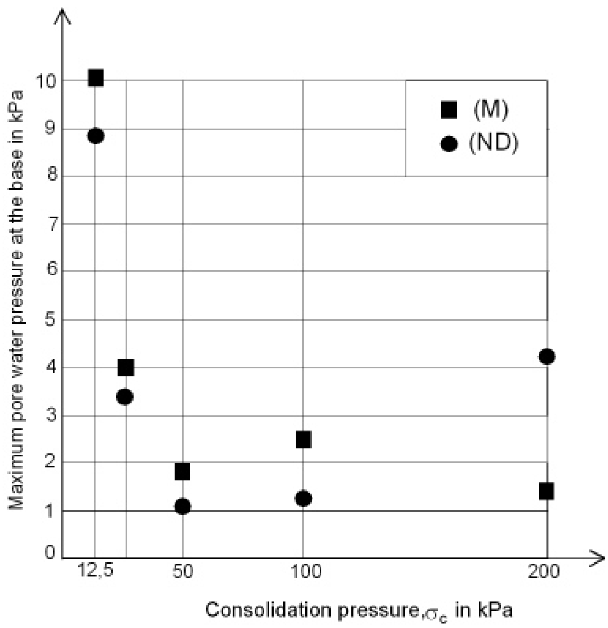

Fig. 2. Maximum pore water pressure at the base of the samples vs applied consolidation pressure

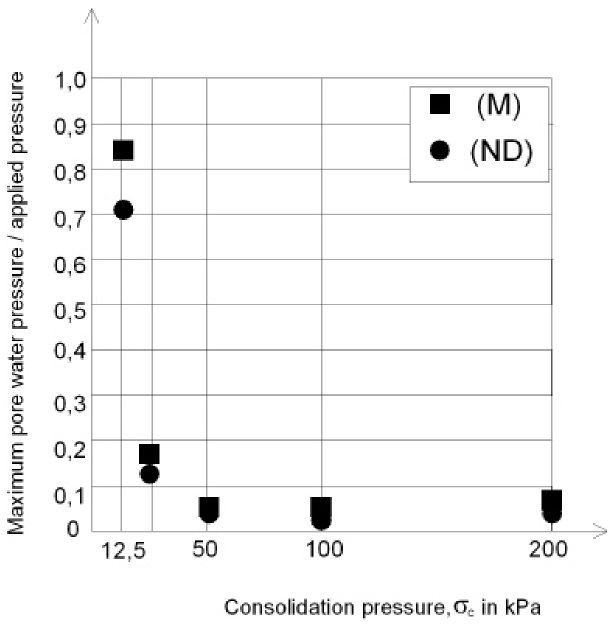

Fig. 3. Maximum pore water pressure per applied consolidation pressure ratio vs applied consolidation pressure

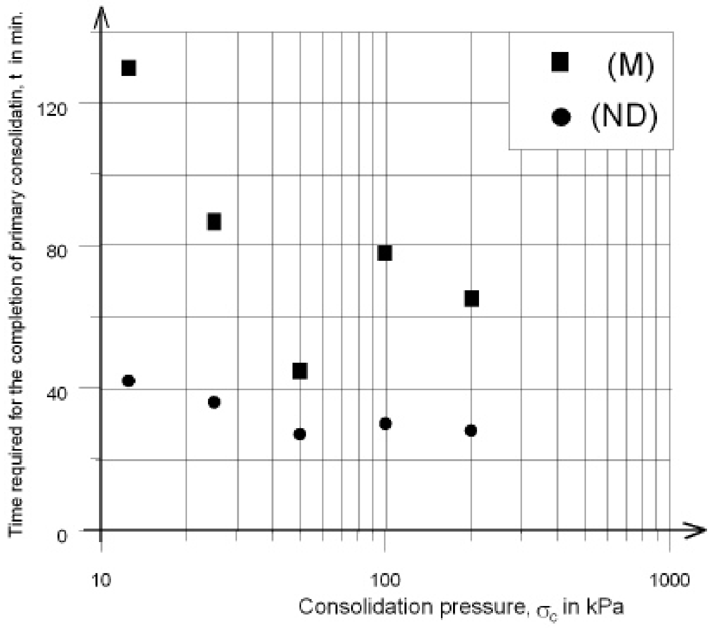

Fig. 4. The time required for completion of the primary consolidation obtained from pore water pressure dissipation measurements vs consolidation pressure in log scale

Table 2. The values of the void ratio at the end of primary consolidation, e_{100}, obtained from the porewater pressure indication and from the $\log t$ and $\sqrt{t}$ methods. Markusy site sampling

Consolidation pressure, σ_{ci} in kPa	e_{100}		
	$u^{2)}$	$\log t$	$\sqrt{t}$
12.5	2.400	2.398	2.440
25	2.167	2.169	2.170
50	1.972	1.972	1.974
100	1.742	1.739	1.742
200	1.683	1.691	1.689

[2)] obtained from water pressure indication

Table 3. The values of the void ratio at the end of primary consolidation, e_{100}, obtained from the porewater pressure indication and from the $\log t$ and $\sqrt{t}$ methods. Nowe Dolno site sampling

Consolidation pressure, σ_{ci} in kPa	e_{100}		
	$u^{2)}$	$\log t$	$\sqrt{t}$
12.5	1.498	1.499	1.501
25	1.371	1.370	1.372
50	1.282	1.280	1.279
100	1.187	1.187	1.189
200	1.072	1.075	1.072

[2)] obtained from water pressure indication.

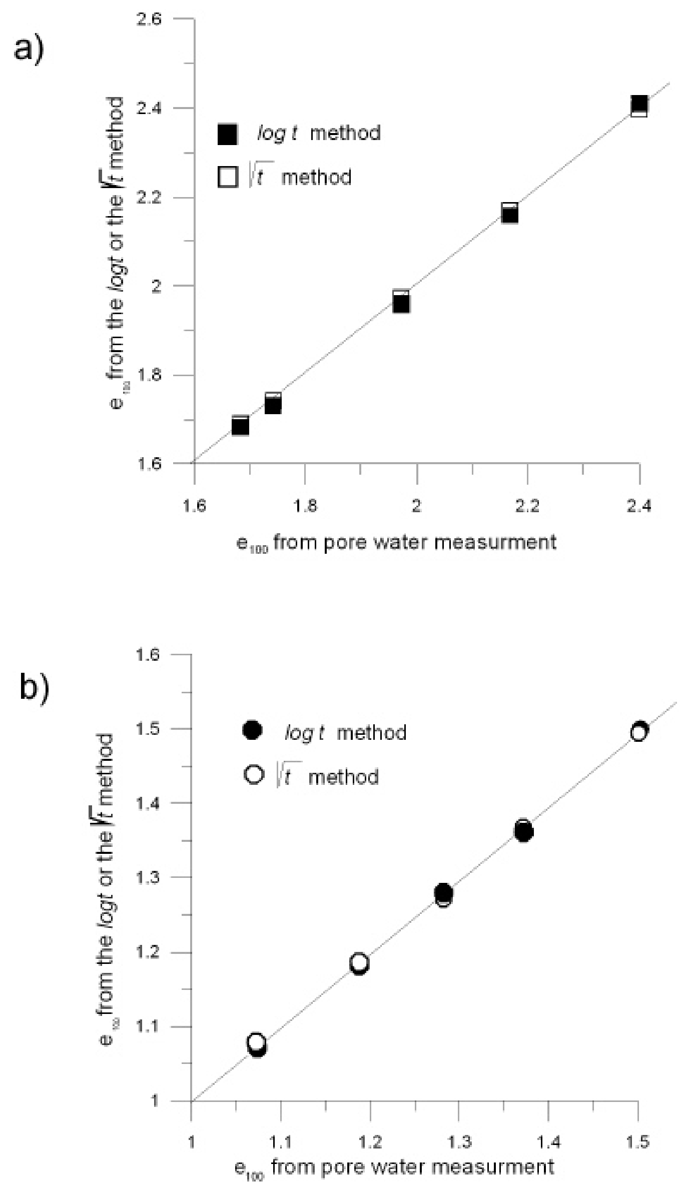

Fig. 5. Comparison of the e_{100} values determinated from the $\log t$ and the $\sqrt{t}$ methods with those obtained from pore water measurements. Site sampling a) Markusy, b) Nowe Dolno

$\log t$ and $\sqrt{t}$ with those obtained from pore water pressure measurements indicate that both methods are good predictors of the end of primary consolidation (EOP).

Identification of the EOP using the $\log t$ method requires a longer consolidation period than when using the $\sqrt{t}$ method. The $\log t$ method requires sustained pressure over a period of 24 hours, whereas the $\sqrt{t}$ method only for a period no longer than 90 min. The time needed for dissipation of excess pore water pressure is less than 130 min.

4. Conclusions

The main conclusions concerning the laboratory organic soils consolidation test data, taking into account both settlement and pore water measurement can be summarized as follows:

- The maximum pore water pressure in the consolidated cell of organic soil is considerably less than the value of the applied consolidation pressure.
- The discrepancies between void ratio at the end of primary consolidation obtained from $\log t$ method and $\sqrt{t}$ method can be regarded as negligible.
- The $\log t$ method, as well as the $\sqrt{t}$ method, yield comparable values of e_{100} to those obtained from pore water pressure dissipation measurement.
- For practical purposes the values of e_{100} of consolidated organic soils obtained from the $\sqrt{t}$ method, may be considered adequate. The main advantage of the $\sqrt{t}$ method compared with the $\log t$ method lies in its shorter duration of sustained applied consolidation pressure.

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