Creep Characteristics of Organic Soft Clay Soil Using Large–Scale Model

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Abstract-- The long-term settlements in organic clay can create a kind of an engineering challenge that appear in most facilities design and construction in areas with deep deposits of soft clay. Peat ground is widely distributed throughout the southern part of Iraq. Peat contains a large amount of organic matter and has a very high natural water content. Three soil samples were collected from depths of 1.5 m, 2.5 m, and 3.5 m, below the soil surface in Halfaya oilfield, which lies east of Missan governorate southern Iraq.

A series of tests were conducted in a large-scale model using a plate footing and considering three different percent of organic content. The percent of secondary settlement found is dependent on the stress level applied. A large fraction of the total settlement may be due to secondary compression. The assumption of a constant coefficient of secondary compression, Cα, may not be valid for a long-term settlement of peats. Laboratory data indicate that Cα generally increases with time. Thus, settlement predictions using constant Cα may underestimate field settlement.

Key words: Organic soil, settlement, secondary settlement, coefficient of secondary compression, Cα

1. Introduction

The mechanisms of the process of consolidation and shear failure in clay soils are interconnected subjects, and knowledge of them is necessary for a basic understanding of soil behavior. As a starting point for such a study, a one-dimensional fusion case was taken, as this includes the basic physics of the process but requires the simplest mathematical and experimental treatments.

During a long-term settlement, the structure of the clay will creep into a stable formation as ties develop from edge to face as the molecules approach through highly viscous water. The "contact" between the particles may be mineral, but it is likely through a few molecules of water that is highly absorbent and virtually solid. The resistance of the movement that has evolved at each contact is usually called "bond strength", and this will increase over time due to the variable. After the crawl process some of these links will be strong and others hardly stable, which generally gives a wide range of strengths.

The existence of organic materials in soil has been noticed long time ago and in highly organic soil that is more than 20%, (Arman, 1969), there is clear evidence that the engineering behavior of soil may be considerably influenced by the organic constituents. Casagrande (1948) illustrated the great effect that an organic content has on Atterberg limits; in addition to that, Martin and Lambe (1957) emphasized the effect of concentrations (even if they are small) on the

DOI: http://doi.org/10.24086/aces2020/paper.254

properties of soil. However relatively little is identified about the mechanics whereby organic matter can change the behavior of soil.

When the soil foundation is composed of organic soils, the efficacy of the preloading methodology and consequently the behavior of the structures (embankments, buildings, etc.) is largely dependent on the organic matter (OM) content, because: (a) the creep strains are very significant in organic soils (Mesri et al., 1997) and also depend on the type of OM (Tremblay et al., 2002); (b) the OM influences the properties of natural soils, such as the plastic characteristics (Correia, 2011).

The compressibility and the shear strength and, as shown by Booth and Dahl (1986), a quantity of 3–4% of OM is sufficient to change the properties of the soil (Oliveira et al., 2010). In general, soft soil areas exhibit a high variability in terms of OM content (Coelho, 2000, Oliveira et al., 2010). Even for chemically stabilized soils, the behavior is dependent on the OM content (Oliveira et al. 2014).

Hameedi et al. (2019) discussed the results of the settlement of the water storage tank in the southern Iraq oil field. The first part of the study covered experimental work in the field, which included drilling boring holes and evaluating the mechanical properties of soils. The second part was performed using the finite element method through the Plaxis 3-D program, using the soft-soil creep model and the soft-soil model. The results showed that the secondary settlement has a significant influence on the behavior and final settlement of the tank, and the soft soil creep model is the best representative of the field settlement than the soft soil model. The results of the soft soil creep model are greater than the results of the soft soil model for vertical displacement, horizontal displacement, and pore water pressure due to the effect of secondary pressure.

The objective of the present paper is to determine the creep characteristics of organic soft clay soil using large–scale model with varying organic matter contents.

2. Experimental work

2.1 Soil

The un-disturbed samples of soil were gathered from depths of 1.5, 2.5, and 3.5 m below the natural soil level in Halfaya oil-field, which is positioned to the east of Al-Emara city southern Iraq. The soil of this region is described to be soft clay with large amounts of organic matter (Fattah et al., 2006). They were then labeled as soil A, soil B, and soil C, respectively. The samples of these soils were tested in the laboratory by routine tests to illustrate their properties, including the coefficients of secondary compression, C_α, as seen in Table 1.

2.2 Testing model

The large-scale model is a new model suggested in this study to consider distribution of pore water pressure, and distribution of the horizontal stress in a large soil sample, and measuring the settlement of a soil layer under small footing. The large-scale model provides a better simulation of a layer in the site so it can give more accurate results. Figure 1 shows that the large-scale model consists of steel container with dimensions of 0.6 m × 0.6 m and 0.5 m depth, loading frame, loading device, Plate footing with dimensions 0.1m ×0.1m, two dial gauges, two-pore water pressure sensor with a data logger, and lateral load sensor with a data logger and accessories.

Table 1: Properties of the used soils.

DOI: http://doi.org/10.24086/aces2020/paper.254

Property	Soil A	Soil B	Soil C
Liquid limit (LL), %	48	46	47
Plastic limit (PL), %	22	24	23
Plasticity index (PI) , %	26	22	24
Specific gravity (GS)	2.69	2.67	2.66
Sand content %	0	2	0
% Passing sieve No. 200	100	98	100
Silt content %	25	19	25
Clay content %< 0.005 mm,	75	79	75
Natural unit weight kN/m3	17.6	18.1	17.91
Natural water content, %	20	32	39
Undrained shear strength, Cu	22-25	20-22	16-18
Organic matter %	12-15	8-10	4-6
Compression index, C_c	0.432	0.31	0.26
Recompression index, C_r	0.045	0.049	0.058
Coefficient of secondary compression, Cα	0.042	0.028	0.022
Sulphate content SO_3, %	1.7	0.35	0.36
Gypsum content, %	3.6	0.75	0.77

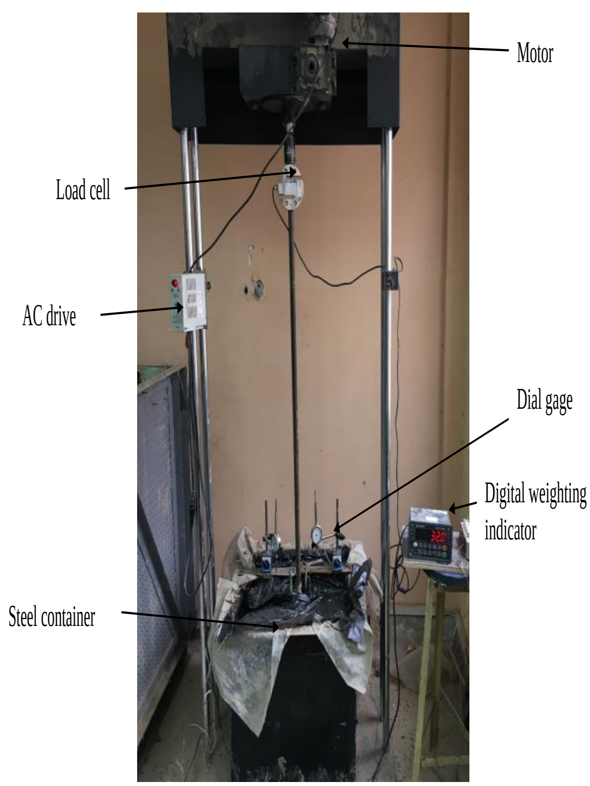


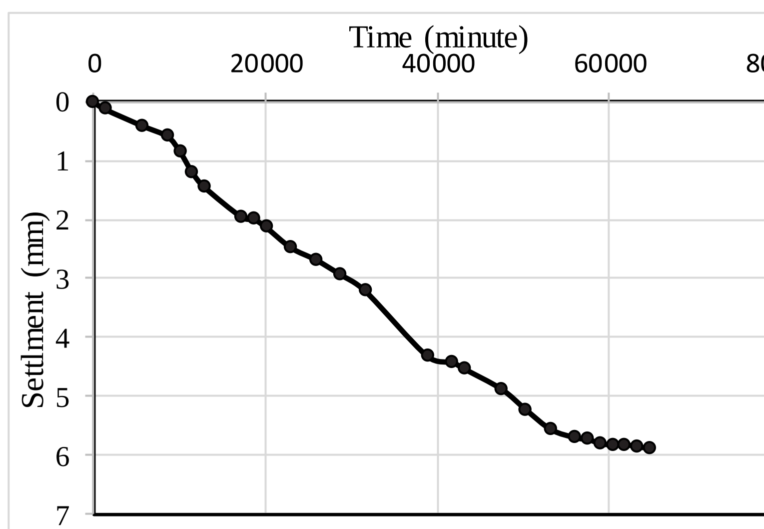
Figure 1: Large scale model.

3. Results and Discussion

A series of tests has been performed using large scale model. Figure 2 shows the variation of the settlement with time until (45 days) for soil A. The test was conducted with applied constant stress 45 kPa. The settlement increased after application of loading, but the increase rate was decreasing after 35 days from the beginning of the test. This suggests that creep has stared at this time.

Figure 3 presents the pore water pressure with time for soil A. The pore water pressure increases after starting the test. The maximum value of excess pore water pressure is 33 kPa after 14 days, then the pore water pressure drops down until returning to the initial level before starting the test.

Figure 4 shows the variation of lateral stress with time for soil A at depth B (footing width). The lateral stress increases after 1 day from start of the test. This is attributed to particles sliding towards each other resulting in increasing the lateral stress.



DOI: http://doi.org/10.24086/aces2020/paper.254

Figure 2: Settlement verses time for large scale model using soil A.

Figure 5 shows the variation of the settlement with time for (70 days) using soil B. The test was carried out with applied constant stress of 40 kPa. It is observed that the settlement increased after applying the load, but the increase rate was decreased after 55 days from the beginning of the test. This indicates that creep has started.

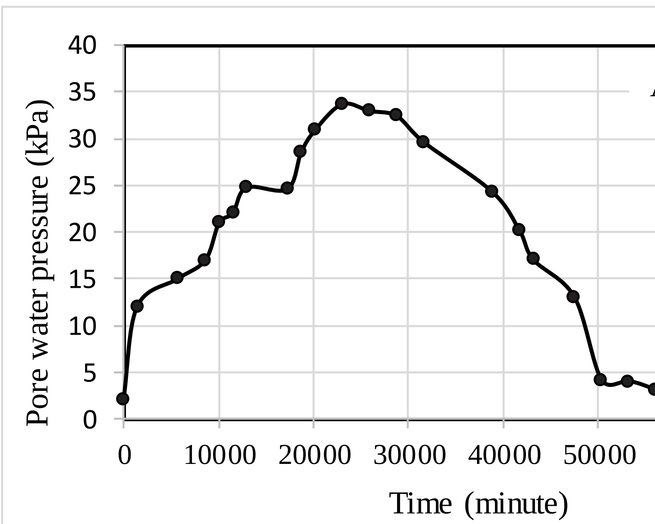


Figure 3: Pore water pressure verses time for large scale model using soil A.

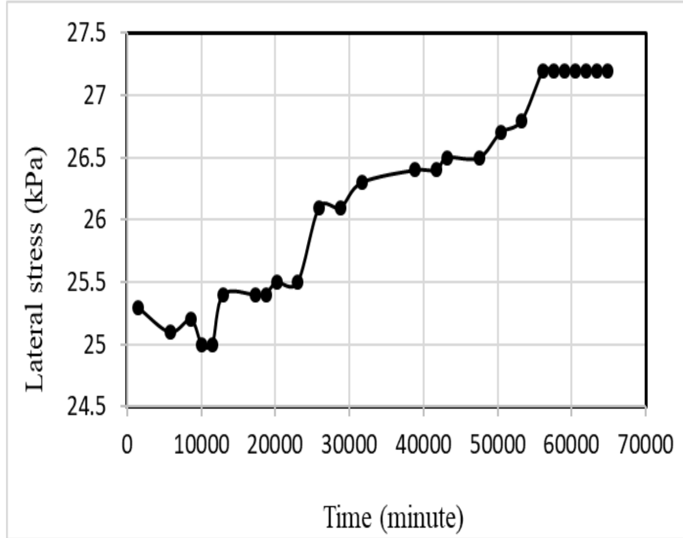


Figure 4: Change of the lateral stress with ... odel using soil A.

Applied stress = 45 kPa

Figure 6 presents variation of the pore water pressure with time for soil B. The pore water pressure has been increased after starting the test. The maximum value of pore water pressure is 40 kPa after 5 days, then it slows down until returning to initial before starting the test.

Figure 7 shows changes in the lateral stress with time for soil B at depth B. The lateral stress has been increased after 5 days from the start of test. This is attributed to particles sliding towards each other resulting in increasing the lateral stress.

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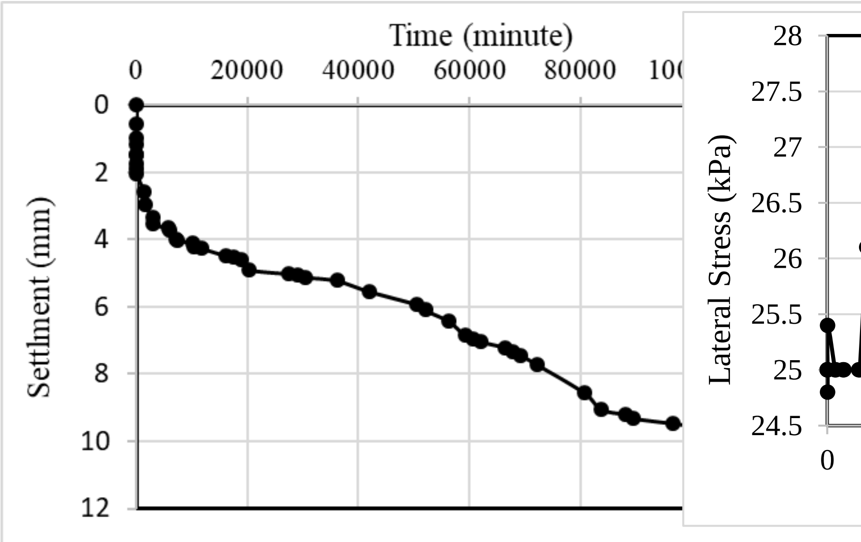

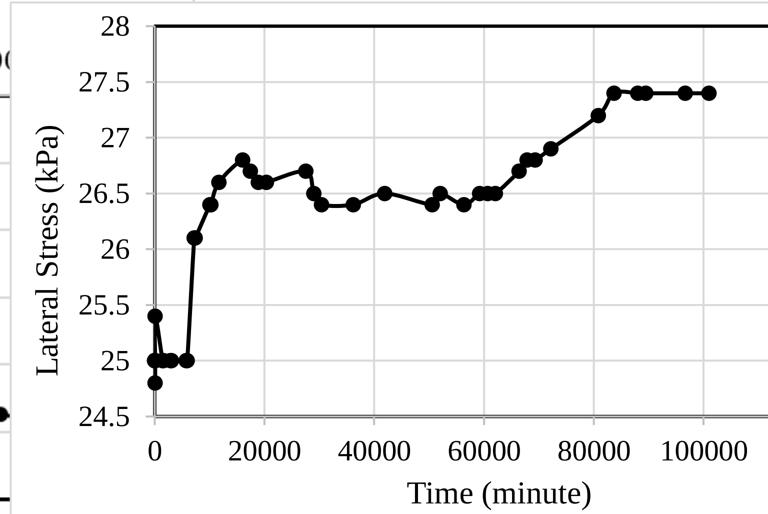

Figure 5: Settlement versus time for large scale model using soil B.

Figure 7: Variation of lateral stress with time for large scale model using soil B.

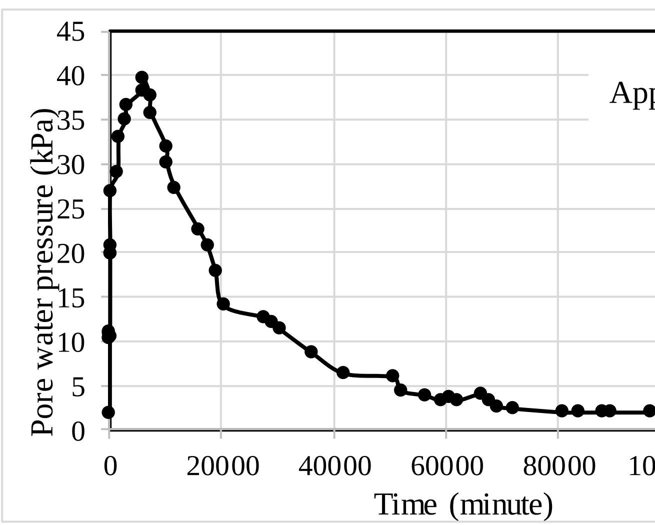

Figure 6: Pore water pressure change with time for large scale model using soil B.

Applied stress= 40 kPa

Figure 8 shows the variation of the settlement with time until 44 days for soil C. The test was conducted with applied constant stress 32 kPa. It ment increased immediately after load application, but the increase rate was decreasing after 35 days from the test beginning. This indicates that creep has stared.

Figure 9 presents the pore water pressure with time for soil C. The pore water pressure has been increased after starting the test. The maximum value of pore water pressure is 25 kPa after 7 days. Then it drops down to negative value because the sample was not covered, and cracks on the soil surface have happened.

Figure 10 shows the variation of lateral stress with time for soil C. The lateral stress increased after 4 days from the start of the test. Comparing between Figures 9 and 10, it is noted that the excess pore water pressure and lateral stress have been raised within 4 days, then the pore water

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pressure drops down and lateral stress continues to increase for some more days.

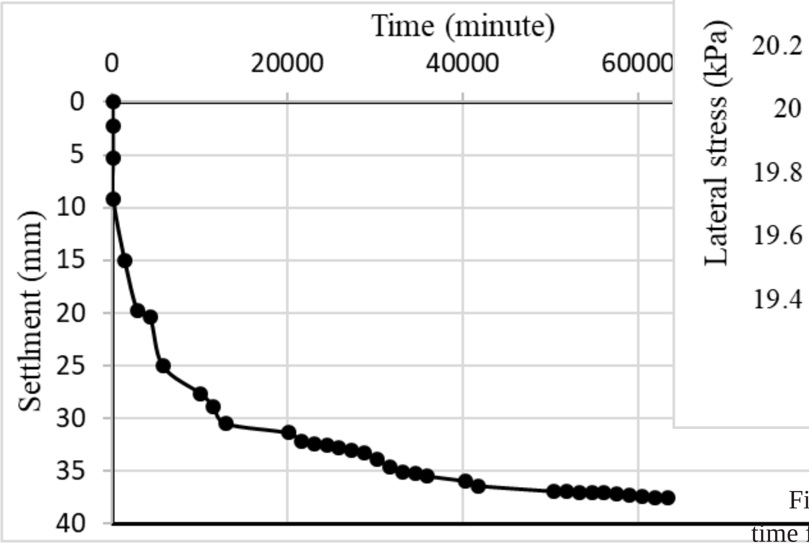

Figure 8: Settlement versus time for large scale model using soil C.

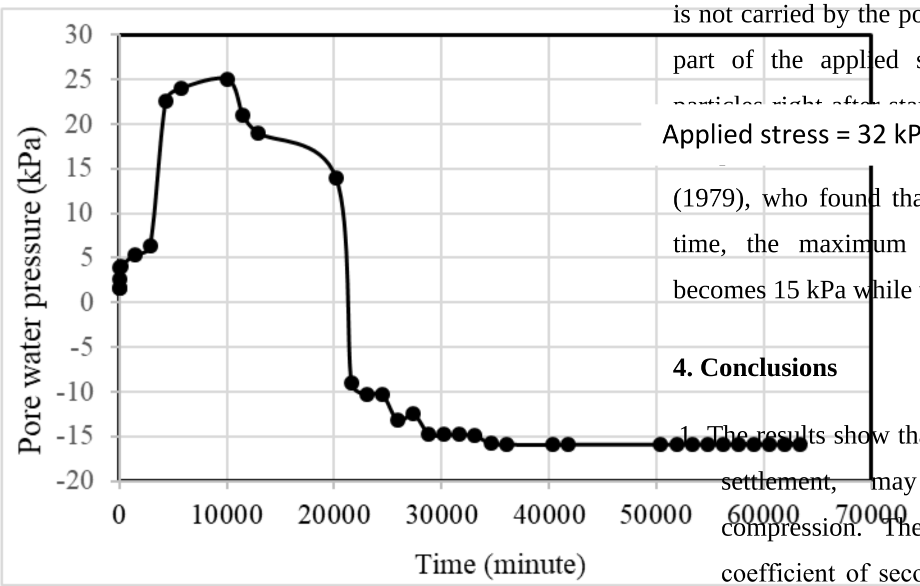

Figure 9: Pore water pressure change with time for large scale model using soil C.

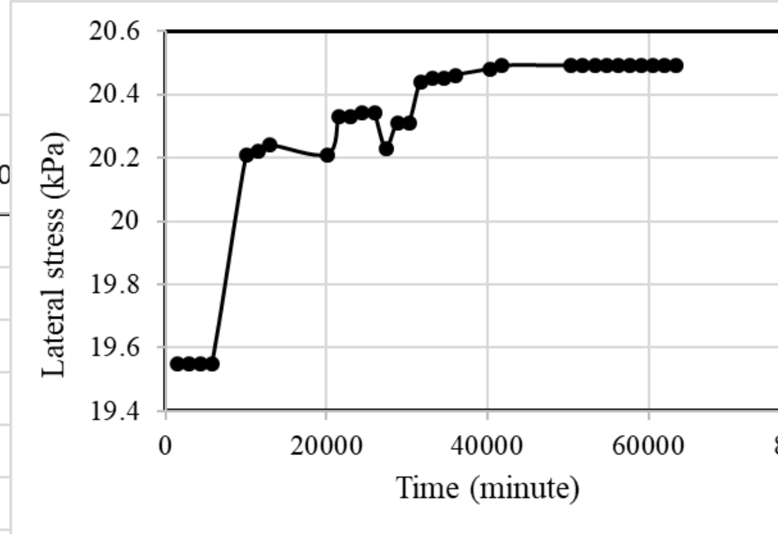

Figure 10: Variation of lateral stress with time for large scale model using soil C.

Generally the creep starts after few seconds from loading because about 20 % from loading stress is not carried by the pore water, so this confirms that part of the applied stress is transferred to solid particles right after start of the test. These results are [illegible] f Eoil and Dhowian (1979), who found that after a very short period of time, the maximum excess pore water pressure becomes 15 kPa while the applied load 25 kPa.

4. Conclusions

1. The results show that a large fraction, of the total settlement, may be due to secondary compression. The assumption of a constant coefficient of secondary compression, Cα, may not be valid for a long-term settlement of peats. The laboratory data indicate that Cα generally increases with time. Thus, settlement predictions using constant Cα may underestimate field settlement.

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DOI: http://doi.org/10.24086/aces2020/paper.254