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Seepage and Consolidation Characteristics of Dredger Fill

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Abstract

The consolidation process of dredger fill is the process of soil particles from disorderly and irregular arrangement to orderly and regular arrangement until flocculation and formation of more stable soil structure. In the project, it is an urgent problem to shorten the sedimentation consolidation time and make the dredger fill change from the slurry state to the foundation with a certain bearing capacity as soon as possible. In view of this situation, the indoor simulation experiment was carried out. Under the condition of simulating the soil water ratio of the actual project, the relationship between settlement and pore water pressure with time was found, and a reasonable low vacuum reinforcement scheme was determined to prevent small soil particles and water in pores from blocking the drainage channel. The curve is drawn by the observation data of the settlement amount, pore water pressure and drainage amount of the experiment, and then the time effect characteristic of the dredger fill settlement is analyzed. The change of pore water pressure and settlement amount tends to be stable at the same time with the increase of time, and the dredger fill is basically consolidated at this time. Based on the analysis of the changes in soil microstructure, particle size, particle abundance, particle orientation and macro basic physical properties, the formation of aggregates greatly improves the macro physical properties in the process of soil particles' transition from unstable to stable state, which is manifested in the reduction of water content and the increase of density.

Keywords

Dredger Fill; Subsidence; Pore Water Pressure; Aging Characteristics; Microscopic Structure; Grain; Physical Property.

1. Introduction

With the rapid development of urban construction in China's coastal areas, the contradiction of "less land and more people" is becoming increasingly prominent, and land resources are becoming increasingly tense. There are more and more projects that use tidal flats or directly reclaim land from the sea. The construction of coastal industrial belt is based on reclamation, and the potential is also reclamation. With the further development of land reclamation, it will prop up a new world for the development of coastal industrial belt. However, the blown fill has the characteristics of large plastic index, large natural water content and pore ratio, small weight, high compressibility and low permeability. The strength of the foundation composed of the blown and filled soil is very poor, which can not be directly used for engineering construction, and needs foundation treatment. Therefore, consolidation tests are carried out on the beach soil in different areas. It is devoted to obtain the change curve of permeability coefficient with consolidation pressure, pore ratio with consolidation pressure, settlement amount with time, consolidation coefficient, etc., so as to provide reference for engineering unit design.

2. Experimental Instrument

The instrument used in this experiment is modified on the basis of the conventional consolidation instrument. In addition to the conventional compression consolidation test to measure the settlement amount of soil samples under various loads, it can also measure the pore water pressure and permeability coefficient of soil samples. The pore water pressure test can be carried out as long as the switch of the pore water pressure sensor is turned on. Similarly, the permeability coefficient of soil sample can also be measured by the variable head test of the instrument. Its structure is shown in Fig 1.

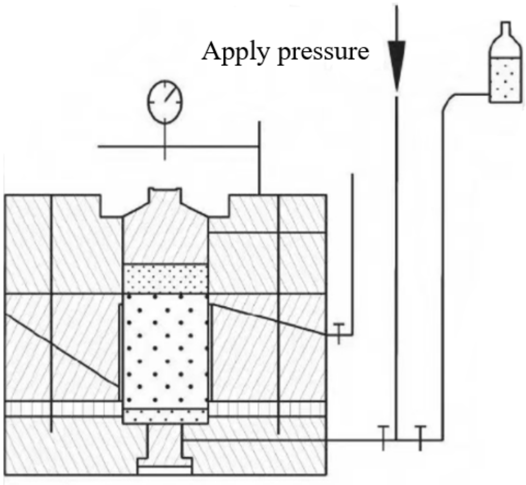

Fig 1. Test structure diagram

3. Soil Sample Preparation and Basic Physical Index

The physical indexes of surface soil samples taken from 4 different areas of Wenzhou soil blowing and filling project site are different, and the variation range of water content is 30%~45%. Density between 1.78 and 1.94; The liquid limit was 45 and the plastic limit was 22. In order to simulate the change relationship of consolidation settlement of the filled soil in different regions, four different soil samples were produced [1].

The main steps of soil sample production are :(1) Put the blown fill soil sample into the oven to dry (more than 12h); (2) Mash the dried soil sample into fine particles; (3) Take a certain amount of dry soil and configure it into 4 remodeled soil samples (cylinders with a height of 2cm and an area of 30cm2) with different moisture content. In order to minimize the air in the sample, the soil must be slowly coated along the inner wall of the ring knife one layer at a time. After filling, the soil should be vibrated on the glass plate and the surface should be scraped flat with a scraper. After that, a circular filter paper with a diameter of 61.8mm is pasted on the upper and lower surfaces; (4) Using vacuum saturation technology to saturate the soil sample; (5) Place the retainer in the consolidation container and put the ring knife with the sample into the retainer, and then put the guide ring and the pressurized upper cover. The consolidated container is placed in the middle of the pressurized frame, so that the pressurized upper cover is aligned with the center of the pressurized frame, and the dial indicator is installed; (6) Pre-add 1k Pa pressure to make the sample contact with the upper and lower parts of the instrument; (7) Remove the preload, apply the pressure of 12.5k Pa, 25k Pa, 50k Pa, 100k Pa, 200k Pa, 300k Pa, 400k Pa, 800k Pa and 1600k Pa respectively, and record the relevant data; (8) A modified consolidation instrument was used to measure the settlement-time change relationship and the change of permeability coefficient under different loads [2].

4. Consolidation Compression Test

Experimental scheme: 12.5k Pa, 25k Pa, 50k Pa, 100k Pa, 200k Pa, 300k Pa, 400k Pa, 800k Pa and 1600k Pa were applied step by step to the four soil samples The load of Pa is recorded at each level of load T=6s, 15s, 1min, 2min15s, 9min...... 24h settlement. By the formula

$$e_i = e_0 - hs \ (1 + e_0)$$

Where e_i is the porosity at any time; e_0 is the initial porosity; s is the settlement amount; h is the soil sample height.

The porosity was calculated, and the curve of settlement amount changing with time, porosity changing with time, porosity changing with load was drawn [3]. Experimental law analysis: Under the action of load, water and air are gradually squeezed out, and the skeleton particles of soil are squeezed together, the effective stress increases, the pore volume decreases, and the soil compresses and deforms. With the increase of consolidation pressure, the soil settlement showed an overall increasing trend (see Figure 2). At the initial stage of the application of various loads, the settlement increased rapidly, and gradually became stable with the passage of time. As time goes on, the porosity generally presents a nonlinear decreasing trend (see Figure 3). In the initial stage of loading at all levels, the porosity decreases rapidly, and gradually tends to a stable value as time goes on. The porosity decreases nonlinearly with the increase of consolidation pressure (see Figure 4). After taking the consolidation pressure logarithmically, the porosity and consolidation pressure basically change linearly (see Figure 5). Therefore, the compression modulus and compression coefficient should gradually decrease, the soil is continuously compacted, the soil compression increases, the pore volume decreases, and the degree of consolidation becomes larger and larger [1].

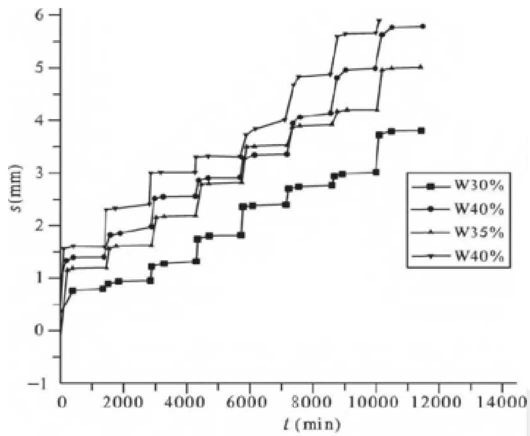

Fig 2. Settlement curve with time

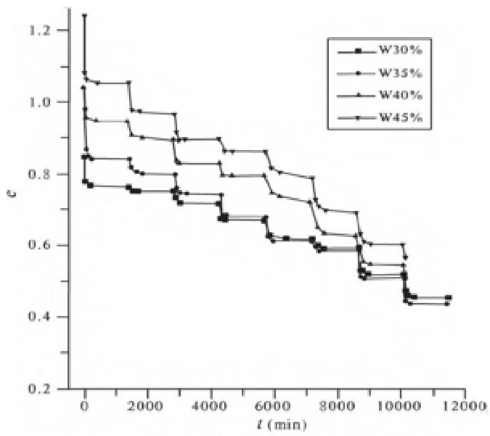

Fig 3. Porosity curve with time

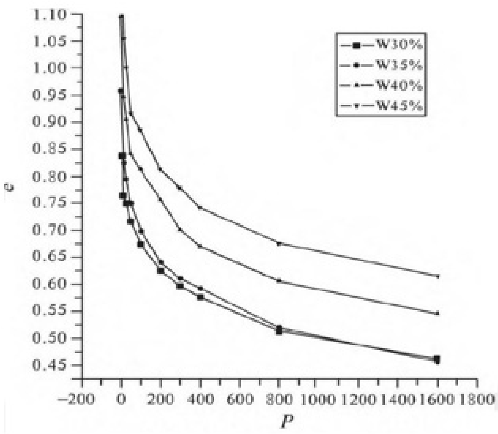

Fig 4. Porosity curve with consolidation pressure

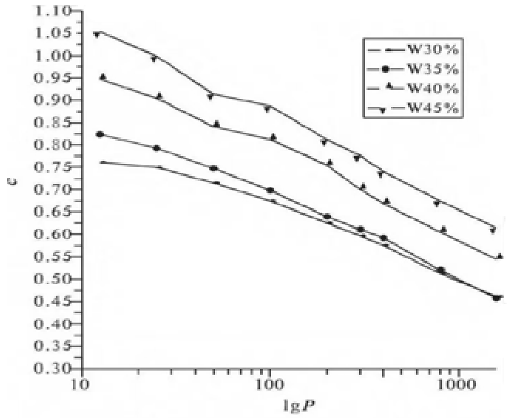

Fig 5. Porosity curve with consolidation pressure (logarithm)

5. Consolidation Penetration Test

Experimental scheme: Using variable head experiment, the four soil samples were successively applied 12.5k Pa, 25k Pa, 50k Pa, 100k Pa, 200k Pa, 300k Pa, 400k Pa, 800k Pa and 1600k respectively The load of Pa is recorded at each level of load T=6s, 15s, 1min, 2min15s, 9min...... 24 hours of sensor readings.

Experimental law analysis: With the increase of porosity, the permeability coefficient presents a nonlinear decreasing trend (see Figure 6). When the porosity is less than 0.9, the permeability coefficient decreases faster; when the porosity is greater than 0.9, the permeability decreasing speed gradually slows down and finally tends to a stable value. Under the action of load, excess pore water pressure is generated in the soil, and under the action of water head difference, seepage occurs in the soil, resulting in the discharge of water in the soil, the excess pore water pressure is dissipated, the pore ratio of the soil decreases, the volume of the soil decreases, the seepage path is slowly blocked, and the seepage becomes more and more difficult. Therefore, the permeability coefficient keeps decreasing and eventually tends to a stable value [1].

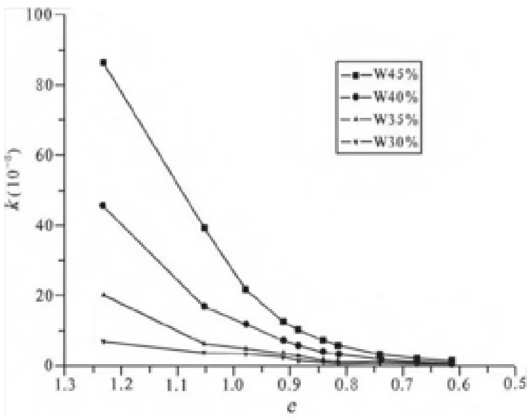

Fig 6. Permeability coefficient with porosity curve

6. Determine the Consolidation Coefficient

Consolidation coefficient is an important index of soil consolidation rate and a key parameter of settlement calculation. The main methods for determining consolidation coefficient through indoor consolidation test include time square root method, time logarithm method and time logarithm slope method, etc. In this experiment, time square root method is used to find vertical consolidation coefficient. According to the formula [4]

$$\frac{\partial u}{\partial t} = C_v \frac{\partial^2 u}{\partial z^2}, \quad C_v = \frac{T_v H^2}{t} = \frac{0.848}{t_{90}} H^2$$

Where t_{90} is the time required for soil sample consolidation to reach 90%. H is the vertical thickness of the soil sample, cm.

Experimental law analysis: It can be found that the consolidation coefficient presents a nonlinear change law in the process of compression consolidation. When the load is small, the soil consolidation speed is slow, so the consolidation coefficient does not increase. With the continuous increase of the load, the consolidation coefficient keeps increasing, but it should eventually become stable (see Figure 7). The disadvantage is that the consolidation coefficient measured in the laboratory test is too small, and it must be corrected to reflect the actual consolidation of soil layer on site. Therefore, when designing soft soil foundation, the consolidation coefficient measured in the laboratory should be used in the future according to local practical experience.

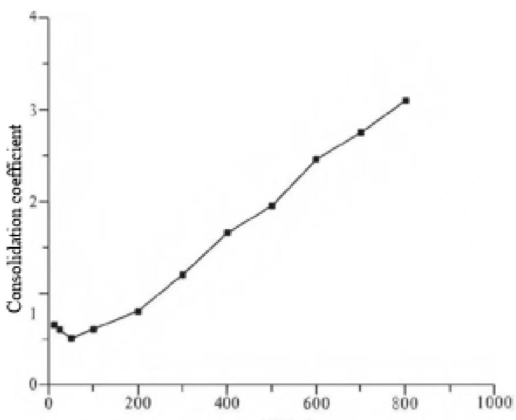

Fig 7. Consolidation coefficient change curve with load

7. Conclusion

Based on the laboratory consolidation test data, the permeability coefficient changes with porosity, porosity changes with consolidation pressure, settlement amount changes with time, consolidation coefficient changes with load, etc.

1 When the porosity is less than 0.9, the permeability coefficient decreases faster. When the porosity is greater than 0.9, the permeability coefficient decreases slowly and finally tends to a stable value.

2 Under the action of load, excess pore water pressure is generated in the soil, and under the action of water head difference, seepage occurs in the soil, resulting in the discharge of water in the soil, the excess pore water pressure is dissipated, the pore ratio of the soil decreases, the volume of the soil decreases, the seepage path is slowly blocked, and the seepage becomes more and more difficult, so the permeability coefficient keeps decreasing and eventually tends to a stable value.

3 At the beginning of the application of various levels of load, the settlement increases rapidly, and gradually becomes stable with the passage of time.

4 In the process of compression, the consolidation coefficient shows a nonlinear change law. When the load is small, the soil consolidation speed is slow, so the consolidation coefficient does not increase. With the continuous increase of the load, the consolidation coefficient keeps increasing, but eventually tends to a stable value.

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