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Laboratory Tests for the Consolidation Property of Dredger Fill in the Shenzhen Area

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Abstract. In order to analyze the special engineering properties of the super soft dredger fill, experimental studies had been done on the physical-mechanical properties of that in Shenzhen, especially for its consolidation properties. The test results indicated that the super soft dredger fill had the properties of high water content, high void ratio and high clay content; When the confining pressure applied to the sample was less than 200kPa, the change of deformation and void ratio of it was more obvious; When the confining pressure applied to the sample was less than 80kPa, the change of permeability coefficient of that was more significant.

1. Introduction

With the rapid development of coastal ports, the demand for land has increased dramatically^[1]. Sand has always been an ideal filler for reclamation. With the increasing awareness of environmental protection, these non-renewable resources are protected or restricted. On the other hand, environmental pollution and siltation caused by waterway dredging and offshore dumping have been paid more and more attention or restricted^[2]. Tianjin, Dalian, Huanghua, Qingdao, Lianyungang and Shenzhen in China are mostly muddy coasts, with hundreds of millions cubic meters dredged soil every year.

Dredger fill is a kind of artificial accumulation formed by transporting the soil deposited in offshore or waterway through high pressure pipeline to a specific location by dredger and mud pump. Drainage fill has the characteristics of high water content, high void ratio and low strength^[3]. Its properties are closely related to the source of dredger fill and hydraulic conditions of dredger fill. In this paper, laboratory tests on consolidation characteristics of dredger fill super soft soil in Shenzhen are carried out.

2. Physical properties of dredger fill

The raw mud of the dredger fill comes from the Quaternary marine sediment, which is black-gray and contains 5%-10% organic matter. Test results of physical properties of dredger fill for test are shown in Table 1.

Table 1. Physical properties of dredger fill

parameter	Max	Min	Ave
ω (%)	93.4	98.6	95.7
ρ (g/cm ³)	1.45	1.50	1.48
e	-	-	2.67



ω_L (%)	48.0	56.8	51.2
ω_P (%)	22.5	34.0	27.6
I_P	19.0	28.9	23.6
I_L	1.78	2.66	2.15

The water content was much larger than the liquid limit, and it was in a Flow-Plastic state. Intergranular pore is the most developed pore in dredger fill, the maximum is $1-2\mu^{[4]}$, and the average natural pore ratio was as high as 2.67.

3. Consolidation property of dredger fill

3.1 Consolidation test

64 groups of high-pressure consolidation tests were carried out with automatic pneumatic consolidation instrument. Because of the low strength of soil sample, the first and second order of load sequence were respectively 5kPa and 12.5kPa. The height of the sample was 2cm, the stability standard of each grade of load was 0.005mm/h, and consolidation continued for 3 days after the last grade of load was stabilized.

3.2 Analysis of test results

3.2.1 Deformation. The consolidation deformation and porosity ratios of samples under different loads are shown in Figure 1 and 2 respectively. Under a load of 5kPa, the consolidation deformation of the sample was 15.6% of its height, and the porosity ratio was reduced by 21.4%. At 3200kPa, the deformation could reach 49.3% of the sample height and the porosity ratio was reduced by 67.7%. When the consolidation pressure was less than 200kPa, the curvature of the curve was larger, and an obvious inflection point appears at 200kPa. Later, with the increase of consolidation load, the deformation and porosity ratio of the sample tended to change slowly, which indicates that the consolidation rate of the sample is higher when the load is less than 200kPa.

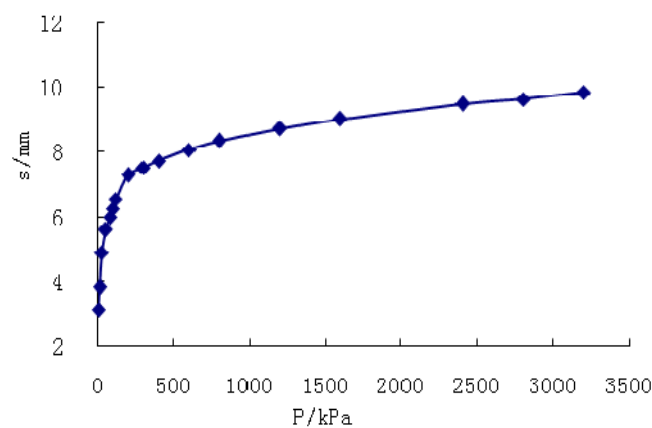


Figure 1. Relationship between deformation and consolidation pressure

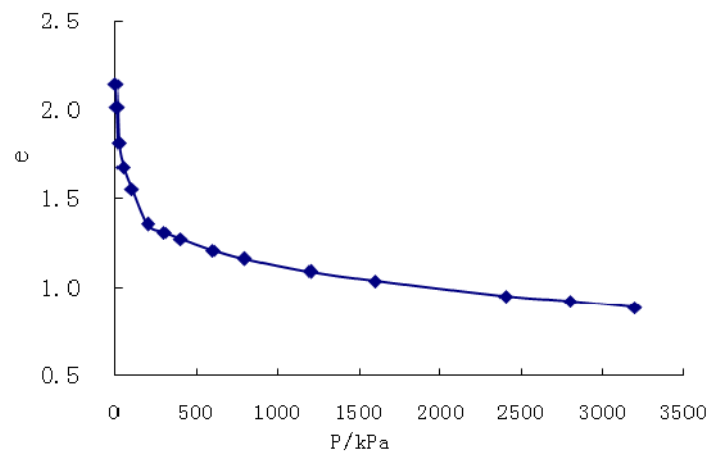


Figure 2. Relationship between void ratio and consolidation pressure

3.2.2 Permeability and moisture content. Curves of moisture content and permeability coefficient are shown in Figure 3 and 4 respectively. When the consolidation load increased from 5kPa to 80kPa, the sample moisture content and permeability coefficient decreased sharply. Under consolidation load of 80kPa, the moisture content decreased from 95.7% to 51.1%, and the permeability coefficient decreased obviously too. When the load was greater than 80kPa, the curve of the relationship between the permeability coefficient and consolidation load was basically a horizontal straight line, and the permeability coefficient changed slowly with the increase of load.

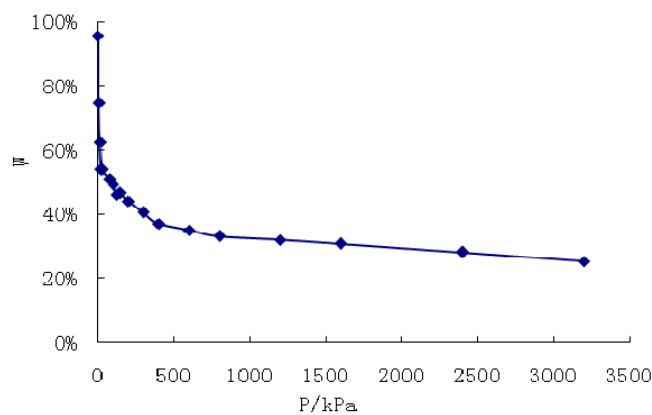


Figure 3. Relationship between water content and consolidation pressure

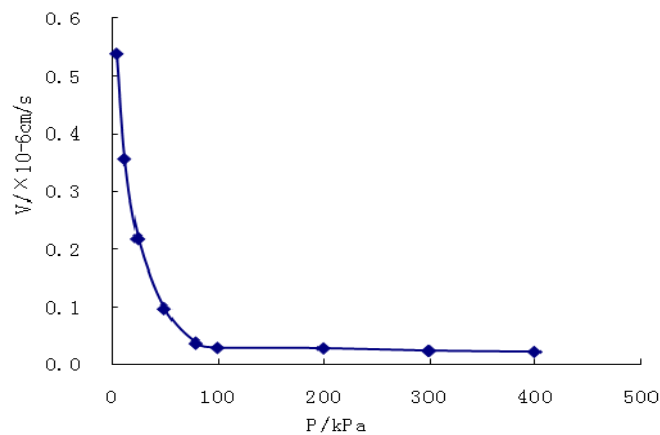


Figure 4. Relationship between coefficient of permeability and consolidation pressure

3.2.3 Consolidation coefficient. Consolidation coefficient is an index to estimate the settlement rate, and is the main factor affecting the consolidation time and degree of drainage consolidation. The larger the consolidation coefficient, the faster the consolidation speed of soil. The methods of solving consolidation coefficient in laboratory consolidation test mainly include time logarithm method, time square root method and three-point method. Due to the fact that the soil under test was an unconsolidated soil formed by artificial blowing and filling, the falling and silting process of the soil sample under the action of self-weight had not been completed, the consolidation coefficient was small, and the consolidation rate was slow.

The consolidation coefficients of samples under different consolidation loads are shown in Figure 5. The test results show that the consolidation coefficient of soil samples under different load increases with the overall trend of load increase, and its value is between 10^{-4} cm²/s and 10^{-3} cm²/s. However, no matter at which consolidation pressure, the variation of consolidation coefficient is very large, and the relation curve between consolidation load and consolidation coefficient is not smooth, which is consistent with the non-uniformity of the blown silt.

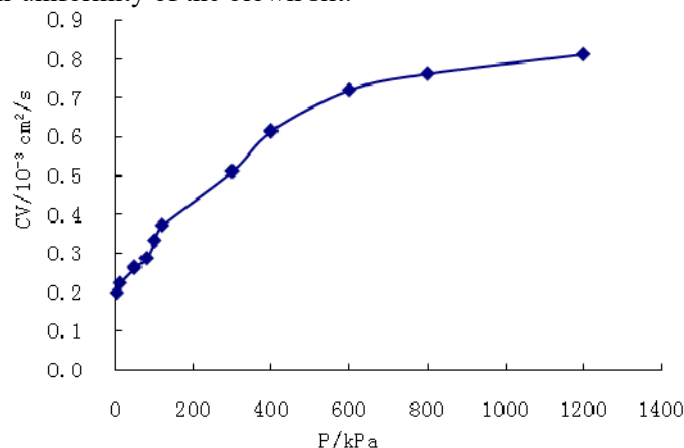


Figure 5. Relationship between coefficient of consolidation and consolidation pressure

4. Conclusion

(1) Dredger fill has the basic characteristics of "three high and three low", that is, high water content, high porosity, high compressibility, low dry density, low strength, low permeability, which belongs to the typical soft soil. The consolidation test shows that part of the water in the soil sample can be

discharged freely under a certain load, and the strength of the soil increases, indicating that the drainage consolidation method is completely feasible in theory to deal with this type of soil.

(2) The dredger fill has high compressibility and large deformation during consolidation. Under 3200kPa load, the deformation is nearly half of the height of the sample. Therefore, in the process of foundation reinforcement, settlement stability standard should be strictly controlled to reduce residual settlement.

(3) When the consolidation pressure is 5kPa, the physical and mechanical properties of the samples have changed. When the consolidation pressure is less than 80kPa, the changes in the sample's deformation, permeability coefficient and consolidation coefficient are very obvious. When the consolidation pressure is greater than 80kPa, the change speed of soil sample slows down. Therefore, the final consolidation pressure should be no less than 80kPa to achieve a satisfactory effect after foundation reinforcement.

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