The consolidation behavior of the slurry subjected to negative pressure

Kyushu University Student Member Jun TONG
Kyushu University Member Noriyuki Yasufuku, Kiyoshi Omine, Hazarika Hemanta

1. Introduction

Every year 10 to 15 million m^3 of dredging material is generated in Japan. The material can be a valuable resource although much of it is currently disposed because of economic, logistical or environmental constraints. Whereas, in many countries disposal is becoming more and more difficult owing to the lack of space as well as environmental concerns. Therefore, developing dewatering alternative to reduce the volume of dredged material is of significant necessity. However, most of traditional dewatering methods for the dredged material are featured by high energy-consumption or environmental harm [1]. New alternatives are urgently demanded to treat the dredged material environmentally-friendly and effectively[2,3]. As for the high-water-content dredged slurry, horizontal drainage could significantly increase the drainage area between the drainage material and the mud, avoid the operational difficulty of the machinery due to the little strength of the slurry at the initial stage of the consolidation. In this paper, compression tests were performed in the small-scale consolidometer equipped with pore-pressure transducers along the profile of the soil column. Deformation behavior was monitored with both settlement and pore-pressure measurement. The influence of the magnitude of the initial vacuum pressure was investigated.

2 The consolidation behavior on the slurry with vacuum method

2.1 Test scheme

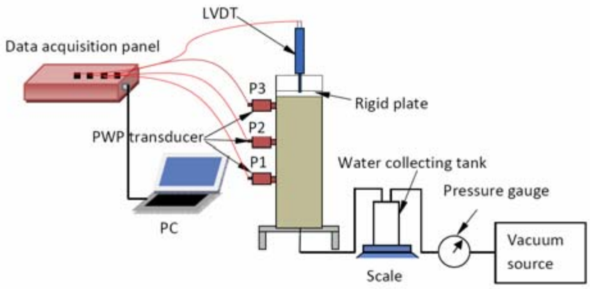
As illustrated in Table 1, a series of vacuum consolidation tests are conducted to comparatively investigate the consolidation and strength behavior of the slurry under the magnitude of 30,60,80 kPa vacuum pressure. The initial water contents of the sample for all the tests are 93.5%, which are the representative value of natural water content of the dredged slurry and about 1.2 times of the liquid limit.

Table1 Test scheme

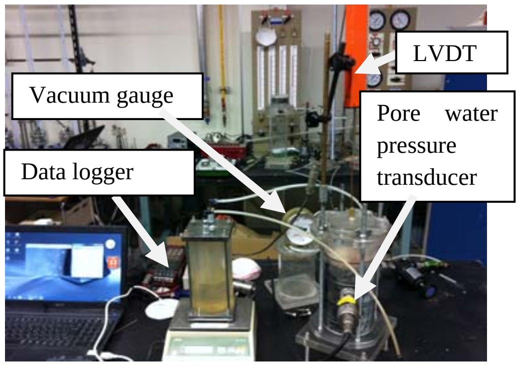
Test name	Initial water content (%)	Initial height of specimen (cm)	Diameter of specimen(cm)	Vacuum Magnitude (kPa)
S-30-1	93.5 ($1.2w_L$)	22	10	30
S-30-2				
S-60-1				60
S-60-2				
S-80-1				80
S-80-2				

2.2. Test sample and apparatus

The test sample used in the study was taken from Island city Port, Fukuoka city, Japan. According to the Unified Soil Classification System, the soil can be categorized as MH. The dredged slurry contains more than 25% clay particle (<0.005mm) and 60% silt particle (0.005~0.05mm). Detailed physical properties of the slurry are given in the preview literatures[2~5]. The illustration for the test apparatus is shown in Figure 1. The test apparatus is made of the acrylic cylinder equipped with 3 PWP transducers on the acrylic wall with the height 6cm, 11cm and 16cm away from the bottom, respectively. The diameter and height of the specimen are 10cm, 22cm, respectively. The uniform silicon oil is utilized to reduce the friction between the sample and the inner wall. The vertical displacement, drainage water volume and the pore water pressure during the consolidation process are recorded, respectively.



(a) Schematic diagram



(b) Photo for the apparatus

Fig.1. Vacuum consolidation system

2.3 Test results and analysis

Figure 2 shows settlement versus time with vacuum pressures of 30, 60, 80kPa. The variations of the settlement with the time in the vacuum show no significant distinct response to the magnitude of the vacuum pressure in the initial 200 minutes. However, thereafter the settlements subjected to greater negative pressure become gradually greater than that subjected to less vacuum pressure. The final strains of the soil column are proportional to the magnitude of pressures, which are 23%, 26%, 27%, correspondingly. The elapsed time at 90% consolidation, as commonly expressed as t_{90} for 30, 60, 80 kPa negative pressure are 9500min, 6600, 3130min, respectively, suggesting the settlements increase with the magnitudes of the negative pressures.

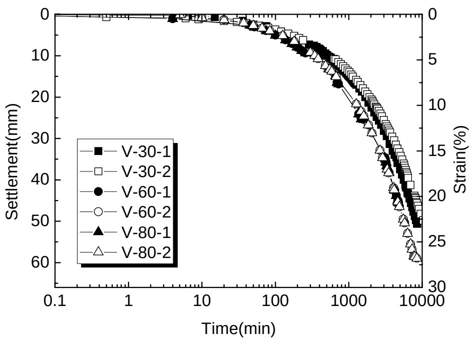


Fig.2. Comparison of settlement versus time with different magnitudes of vacuum pressures

Pore pressures are measured at three different height of the soil column, which have been indicated as P1, P2, and P3 from bottom to top, as shown in Fig.1 (a). Figure 3 shows isochronous curves of the PWP under 30 kPa vacuum pressure. Every curve contains 3 data points, indicating the pore water pressures at the point P1, P2, and P3 at the time of 22h, 43h and 153h, respectively. The variation magnitudes of the pore pressure during the intervals (from 22h, 44h to 153h) at P1, P2 and P3 decrease successively. Notably, the pore pressure at P3 shows little variation. It seems that there is a moving consolidation boundary during the slurry consolidation process.

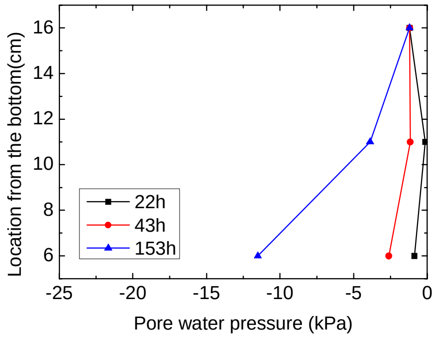


Fig.3 Isochronous curves of the PWP under 30 kPa vacuum pressure

5 Conclusions

Through a series of consolidation tests with different negative pressures, the conclusions can be drawn as follows.

1. The greater the magnitude of the negative pressure, the greater the settlement and the settlement rate are.

2. There is a moving consolidation boundary during the slurry consolidation process.

References

1) UMEZAKI ET AL.: A Dewatering method for dredged soil with high water content using gravity and atmospheric pressure. *Proceeding of 39th Japan National Conf. on Geotechnical Engineering*, pp. 973-974, 2004. (In Japanese)

2) Jun Tong, Noriyuki Yasufuku, Kiyoshi Omine, Taizo Kobayashi: Experimental study on an alternative method to dewater the dredged mud by siphon method. *The 45th Japanese Geotechnical Symposium*, pp. 771-772, 2010. (CD-ROM)

3) Jun Tong, Noriyuki Yasufuku, Kiyoshi Omine, Taizo Kobayashi: Experimentally comparative study on the dewatering of the dredged mud by siphon and vacuum methods. *Proceedings of the 7th International Symposium on Lowland Technology*, pp. 79-83, 2010.

4) Jun Tong, Noriyuki Yasufuku, Kiyoshi Omine, Taizo Kobayashi: Experimental study on the dewatering behavior of the dredged mud with horizontal drainage by siphon method. *Geosynthetics Engineering Journal*, Vol.25, pp. 267-270, 2010.

5) Chai,J-C., Miura,N. and Bergado, D.T.: Preloading clayey deposit by vacuum pressure with cap-drain: Analyses versus performance. *Geotextiles and Geomembrances*, pp. 220-230, 2008.