

The correlational research on the physical mechanical indexes of typical soil collecting from the Xu Wei Lianyungang port

Wenbin LIU^{1,2} Yuanzhan WANG¹ Aimin LIU²

¹, Tianjin University, civil engineering institute, 92 Weijin Rd, Nankai District, Tianjin, China, 300072

², CCCC Tianjin Port Engineering Institute Co., Ltd., 1002 South Dagu Rd, Hexi District, Tianjin, China, 300222

liuwenbin3943@163.com

Abstract. The tests on the physical mechanical indexes of the reclaimed soft clay are necessary to be done before the foundation strengthening treatment. This paper focus on the study of correlational relationship between the physical mechanical indexes, such as the natural water content, the void ratio, the liquid limit etc., by fitting the data of model test on samples collecting from the Xu Wei Lianyungang port. The linear relationship fitting curve of the physical mechanical indexes is proposed, and these results support the high efficient operation in engineering practice.

1. Introduction

The reclaimed soft clay consists of lots of high natural water content, high compressibility and low bearing capacity mud deposit and little humus soil. The genetic type of the reclaimed soft clay is complex, and most part of this clay belongs to the sediment of the late stage of Middle Holocene. The physical mechanical indexes of the reclaimed soft clay are weak and cannot fit the need of engineering practice. The foundation strengthening treatment should be carried out. Before processing the strengthening treatment, the engineering properties should be tested first. The engineering properties of reclaimed soft clay mainly refers to the natural water content, the wet density, the void ratio, the particle proportion, the saturation, the liquid limit, the plastic limit, the plasticity index and so on. The traditional method for obtaining the physical mechanical indexes is carried out large amounts of model tests. Studying the correlational relationship of these indexes based on large number of existing test data can reduce the workload and improve the work efficiency.

This paper analyzed the test data obtaining from clay samples correcting from the Xu Wei Lianyungang port, focusing on the correlational relationship of physical mechanical indexes, and proposed the linear fitting formulas of correlational relationship between the physical mechanical indexes.

2. The correlational relationship between physical mechanical indexes

2.1. The relationship between the natural water content and other indexes

2.1.1 Relationship between the natural water w content and the void ratio e . Based on the test data, the correlational relationship between w and e are gathered and displayed in Figure 1.



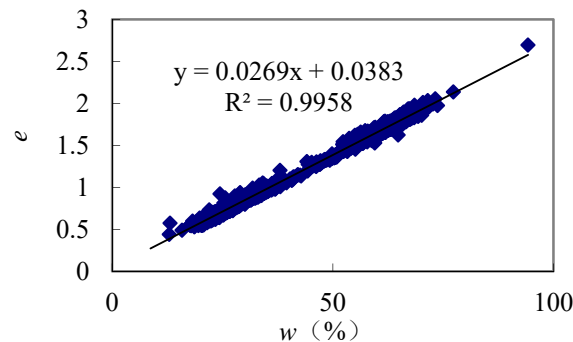


Figure 1 The relationship between the natural water content and the void ratio

From Figure 1 we can see that the natural water content almost rises linearly with the increasing void ratio. The fitting function to express this relationship between w and e is concluded using the least square method and shown as followed.

$$e = 0.0269w + 0.0383, \quad R^2 = 0.9958 \quad (1)$$

Formula (1) shows that the void ratio e for the reclaimed soft clay used in the Xu Wei Lianyungang port has a strong linear positive correlation with the natural water content w .

2.1.2 Relationship between natural water w content and the liquid limit w_L , the plastic limit w_P . The critical water content is the water content when soil turns from one condition to another condition. The liquid limit w_L and the plastic limit w_P are two kinds of commonly used critical water content. The liquid limit w_L is the upper limit of water content for the plastic clay. Once water content is larger than this limit, the soil turns to flow condition. The plastic limit w_P is the lower limit of water content for the plastic clay. Once water content is smaller than this limit, the soil turns to semi-solid state. Figure 2 shows the relationship between natural water content and the liquid limit, the plastic limit.

From this figure, we can see that the liquid limit w_L and the plastic limit w_P increases linearly with the rising natural water content w . The relationships are also fitting using the least square method and displayed as followed.

$$w_L = 0.7355w + 12.224, \quad R^2 = 0.8242 \quad (2)$$

$$w_P = 0.2172w + 12.809, \quad R^2 = 0.7085 \quad (3)$$

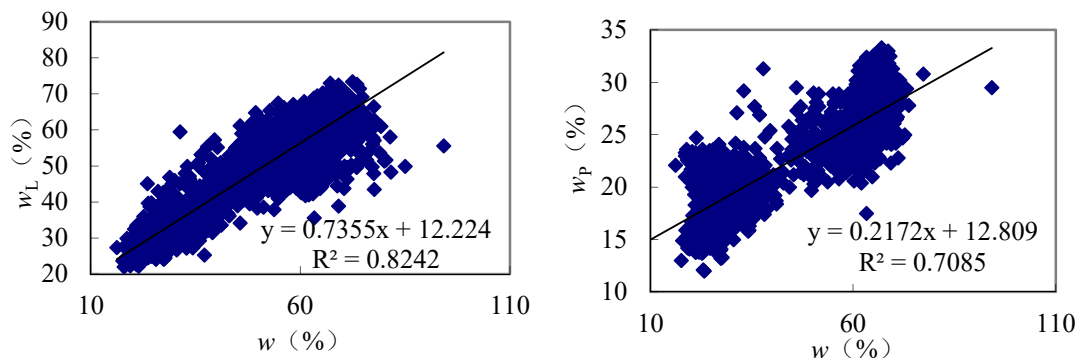


Figure 2 The relationship between natural water content and the liquid limit, the plastic limit

2.1.3 Relationship between the natural water w content and the liquid indexes I_L , the plasticity index I_P Figure 3 shows the relationship between the natural water w content and the liquid indexes I_L , the plasticity index I_P . The natural water content increases with the increasing liquid indexes and the plasticity index, and the correlation between the natural water content and the plasticity index is more strongly. Formula (4) and (5) show the fitting function of the correlation.

$$I_P = 0.5116w - 1.5025, \quad R^2 = 0.8624 \quad (4)$$

$$I_L = 0.6987 \ln(w) - 1.6615, \quad R^2 = 0.5515 \quad (5)$$

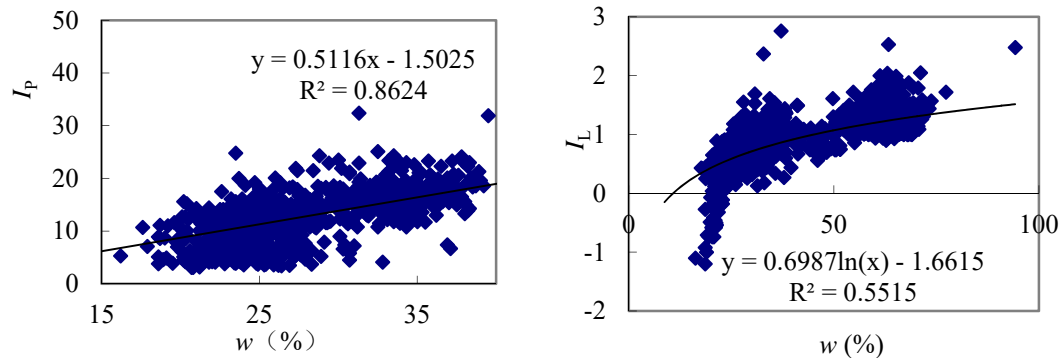


Figure 3 The relationship between the natural water w content and the liquid indexes I_L , the plasticity index I_P

2.2. The relationship between the natural void ratio e and the liquid indexes I_L , the plasticity index I_P

The relationship between the natural void ratio e and the liquid indexes I_L , the plasticity index I_P is shown in Figure 4. It is easily to find that the liquid indexes I_L , the plasticity index I_P increases with the enlargin natural void ratio. The relationships are fitting as below.

$$I_P = 18.237e - 0.8279, \quad R^2 = 0.8536 \quad (6)$$

$$I_L = 0.6577\ln(e) + 0.8515, \quad R^2 = 0.5565 \quad (7)$$

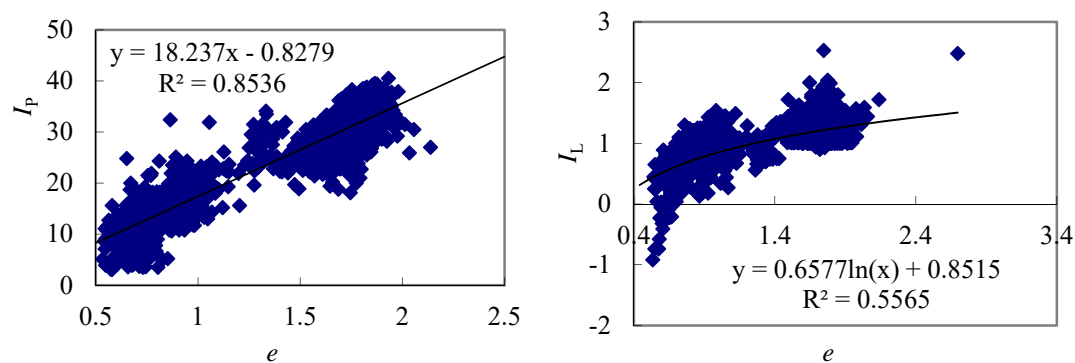


Figure 4 The relationship between e and I_L , I_P

2.3 The relationship between the liquid limit w_L and other indexes

2.3.1 The relationship between liquid limit w_L and the plastic limit w_P , the plasticity index I_P . The relationship between the liquid limit w_L and the plastic limit w_P , the plasticity index I_P obtained from the liquid limit and plastic limit test on remolded clay samples is shown in Figure 5. It shows that the plastic limit w_P and plasticity index I_P increases almost linearly with the increase on the liquid limit w_L . The fitting function is proposed as below.

$$w_P = 0.2998w_L + 9.3818, \quad R^2 = 0.8166 \quad (8)$$

$$I_P = 0.7001w_L - 9.3778, \quad R^2 = 0.9603 \quad (9)$$

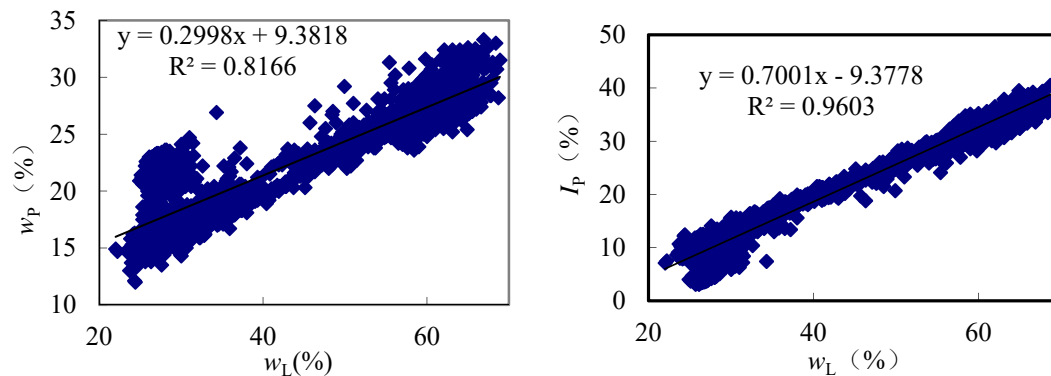


Figure 5 The relationship between w_L and w_P , I_P

2.3.2 The relationship between liquid limit w_L and the liquid index I_L . Figure 6 shown the relationship between liquid limit w_L and the liquid index I_L . The variation of the liquid index I_L does not very clearly relate with the increasing the liquid limit w_L .

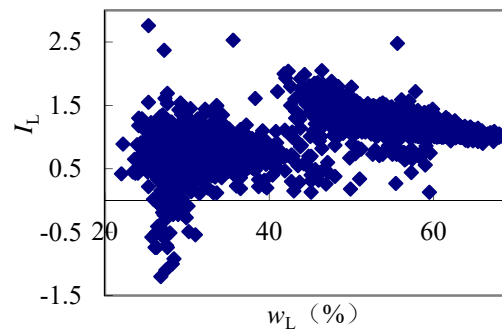


Figure 6 The relationship between liquid limit w_L and the liquid index I_L .

3 Conclusions

Based on large amount of test data on samples correcting from the Xu Wei Lianyungang port, the correlational relationship between physical mechanical indexes is plotted. The corresponding fitting functions are proposed using the least square method. The analysis shows that:

- (1) The natural water content w varies almost linearly with the variation of the void ratio e , the liquid limit w_L , the plastic limit w_P , the plasticity index I_P and the liquid index I_L .
- (2) The natural void ratio e increases linearly with the increase on the plasticity index I_P and the liquid index I_L .
- (3) The liquid limit w_L has a good linear relation with the plastic limit w_P and the plasticity index I_P , and does not has clearly relation with the liquid index I_L .

Acknowledgement

The authors are grateful for the support provided by Key Laboratory of Port Geotechnical Engineering of Tianjin and Key Laboratory of Port Geotechnical Engineering, Ministry of Communications, PRC.

References

- [1] Goovaerts, P., Geostatistical modeling of uncertainty in soil science [J], Geoderma, 2001, 103(1): 3-26
- [2] Azm, S. A. H., Najat, T., Modeling uncertainty in stability analysis for design of embankment dams on difficult foundations [J], Engineering Geology, 2004, 71(3-4): 323-342
- [3] Nguyen, V. U., Chowdhury, R. N., Simulation for risk analysis with correlated variables [J], Géotechnique, 1985, 35 (1): 47-58.

- [4] Heuvelink, G. B. M., Webster, R., Modelling soil variation: past, present, and future [J], *Geoderma*, 2001, 100(3): 269-301.
- [5] Lacasse, S., Nadim, F., Probabilistic geotechnical analyses for offshore facilities [J], *Georisk*, 2007, 1: 21 - 42
- [6] Hong, H. P., Roh, G., Reliability Evaluation of Earth Slopes [J], *Journal of Geotechnical and Geoenvironmental Engineering*, 2008, 134 (12): 1700 – 1705.