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

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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 collecting 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.
2.1.2 Relationship between natural water 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.

$$w_L = 0.7355w + 12.224, \quad R^2 = 0.8242$$  \hspace{1cm} (2)

$$w_P = 0.2172w + 12.809, \quad R^2 = 0.7085$$  \hspace{1cm} (3)

2.1.3 Relationship between the natural water content and the liquid indexes $I_L$, the plasticity index $I_P$.

Figure 3 shows the relationship between the natural water 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.

$$I_P = 0.5116w - 1.5025, \quad R^2 = 0.8624$$  \hspace{1cm} (4)

$$I_L = 0.6987\ln(w) - 1.6615, \quad R^2 = 0.5515$$  \hspace{1cm} (5)
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 enlarging natural void ratio. The relationships are fitting as below.

$$I_P = 18.237 e - 0.8279, \quad R^2 = 0.8536$$  \hspace{1cm} (6)
$$I_L = 0.6577 \ln(e) + 0.8515, \quad R^2 = 0.5565$$  \hspace{1cm} (7)

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.

$$w_P = 0.2998 w_L + 9.3818, \quad R^2 = 0.8166$$  \hspace{1cm} (8)
$$I_P = 0.7001 w_L - 9.3778, \quad R^2 = 0.9603$$  \hspace{1cm} (9)
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 $w_L$.

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 $I_L$.

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