Theoretical Analysis on Soft Soil Foundation Long-term Settlement for Storage Yard Engineering

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Keywords: Soft soil foundation, storage yard engineering, long-term settlement, in-site monitoring, theoretical calculation.

Abstract: This paper analysed the long-term settlement of storage yard engineering located at Tianjin Nanjiang Port. The long-term settlement was calculated based on "Code for Foundation of Port Engineering", and the predicted result is compared with the in-site monitoring data. The comparison results show that the long-term settlement calculation results based on code should be modified before using for settlement prediction. The modify factor is 1.1 to 1.3 for Tianjin area.

1 INTRODUCTION

The research on soft soil foundation settlement is a hot topic and many scholars had done lots of work. The two dimensional formulas of viscous elastic BIOT's consolidation was established based on MERCHANT's model(Tang, 2001). The settlement development regular was analysed with specification and one-dimensional consolidation theory(Zhou, 2009). The modulus of compression and consolidation coefficient was also being determined(Zhou, 2009). A back analysis on consolidation coefficient with layer-wise summation method and Terzaghi's one-dimensional consolidation theory was proposed(Qin, 2012). The variation regular of consolidation coefficient was also analyzed and the prediction model for calculating consolidation coefficient in different situations was proposed(Qin, 2012). Hierarchical structure model was replaced with shark fin figure in research and analyzed 6 factors affecting long-term settlement with Delphi and analytic hierarchy process (AHP) method(Li, 2013).

This paper analyzed the long-term settlement based storage yard engineering in Tianjin Nanjiang Port. The long-term settlement was calculated based on "Code for Foundation of Port Engineering". The in-site monitoring results were also used for verifying the calculation results. The comparison between calculation results and in-site test data offers a simple way to optimize the code calculation results for engineering practice.

2 ENGINEERING CASE

The case used in this paper is storage yard engineering located at Tianjin Nanjiang port. The specific parameters of foundation soil are listed in Table 1. Table 2 shows the parameters of *e-p* curve for each soil layers.

The vacuum load is 85 kPa, lasting for 120 days. The construction load is 20 kPa, lasting for 10 days.

Table 2 Parameters of *e-p* curve for each soil layers.

void ratio *e* / Layer	*e*=0	*e*=0.5	*e*=1	*e*=2	*e*=4
Mud	1.144	0.966	0.903	0.826	0.748
mucky silty clay	1.543	1.299	1.199	1.084	0.971
Mud	1.399	1.266	1.140	1.042	0.944
Mud clay	1.256	1.116	1.045	0.949	0.853
Silty clay	1.393	1.187	1.098	0.981	0.858

Table 1 Parameters of foundation soil.

Layer	Thickness (m)	γ_{sat} kN/m³	γ_{wsat} kN/m³	Shear strength	
				c/kPa	Φ (°)
Mud	6.1	17.5	7.5	11.91	9.38
mucky silty clay	2.2	17.8	7.8	12.81	9.67
Mud	2.7	16.8	6.8	12.75	9.57
Mud clay	7.8	17.7	7.7	12.98	11.18
Silty clay	6.2	19.4	9.4	19	4.11
silty-fine sand	35	19.9	9.9	19	4.11

3 THEORETICAL ANALYSES

The Port engineering foundation calculation system (2008) is used for calculating the long-term settlement of this road engineering case. Figure 1 shows the calculation settlement and the final settlement is 1.902 m.

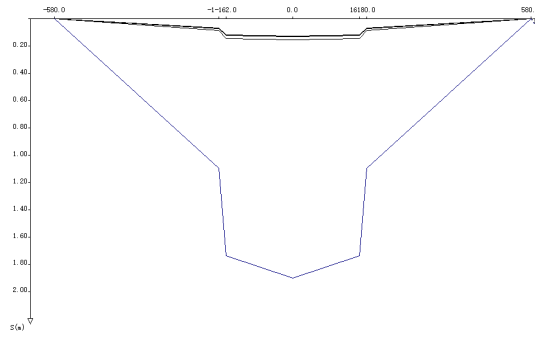

Figure 1 Final settlement for the storage yard engineering.

The final settlement value according to theoretical calculation method is 1.902 m, while the in-site monitoring data shows that the final settlement is 2.323m, 1.22 times as large as calculation result. The major reason responding for that is the calculation model according to theory method is a one-dimensional consolidation model and ignores the influence of others dimensions on settlement. The influence of this assumption on settlement calculation depends heavily on the soil properties.

4 THEORY OPTIMIZATION

In order to modify the gap between code calculation result and in-site test value, a modification factor is used in predicting long-term settlement. The formula for calculating final settlement is as follow.

$$S_{d\infty} = m_s \sum \frac{e_{1i} - e_{2i}}{1 + e_{1i}} h_i \qquad (1)$$

Where, symbol $S_{d\infty}$ refers to final settlement of soft soil foundation; $m_s$is modification factor, determining by the experiment or the empirical equation; e_{1i} and e_{2i} respectively represents the void ratio of its layer under average design value of self-weight stress and average design value of final stress. h_i is the thickness of its soil layer.

The modification factor for Tianjin area usually varies from 1.1 to 1.3.

5 CONCLUSIONS

The long-term settlement according to theoretical calculation should be modified. The value of modification factor is affected by the preloading situation and foundation stiffness. The modification factor for Tianjin area usually varies from 1.1 to 1.3. The foundation with higher stiffness and exhibiting lower preloading value needs a larger value of modification factor.

ACKNOWLEDGEMENTS

The authors are grateful for the support provided by Natural Science Foundation of Tianjin (16JCQNJC07200)

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