Comparison of soil classification from CPTU method and lab method in railway engineering

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Abstract. This article gives a engineering case of CPTU method and laboratory method in soil classification in railway subgrade engineering. In China, soil classification in railway subgrade engineering is often obtained through the traditional laboratory test. With in-situ tests developed in China, CPTU test is used widely in stratigraphy for soft deposit in railway subgrade survey and the National Railway Administration code based on CPTU test is also established. A study is made with a engineering case of subgrade. Two methods are applied in identifying soil strata respectively and differences of them are also discussed.

1. Introduction

As a useful in-situ test[1], CPTU test is developed quickly in China and it is widely used to determine soil stratigraphy in railway subgrade engineering survey and the National Railway Administration code[2] based on CPTU test is also established in 2018. Meanwhile, soil stratigraphy in railway subgrade engineering is determined by the traditional laboratory test in China [3]. To make a comparison, a engineering case is discussed in soil classification according to laboratory test and CPTU one in the National Railway Administration code.

2. The Engineering Case Of Subgrade[4]

The case construction site is in Shanghai, China[4], in which engineering geology belongs to alluvial plain. Results of laboratory test and CPTU test result are shown in Figures 1~2. According to Figure 1, soil profile, grain size distribution, unit weight and so on are obtained in laboratory test. According to Figure 2, CPTU test data of $q_c$, $u_2$, $f_s$ is also continuously measured, in which obvious changes are in soil layers.
Note: MC = mucky clay, MSC = mucky silty clay, SC = silty clay, $\gamma_t$ = unit weight, $w_p$ = plastic limit, $w$ = natural water content, $w_L$ = liquid limit, $e$ = void ratio, $m_v$ = coefficient of volume compressibility, clay blue silt black sand

**Figure 1.** Test result in laboratory test.

![Graph showing soil profile and test results](image1)

**Figure 2.** Test result from CPTU test.

![Graph showing soil profile and test results](image2)

3. **Soil Identification from the National Railway Administration code in China**

   With CPTU test was introduced in China, it was gradually used in railway engineering and soil classification charts have been improved by researchers. In 2018, a soil classification chart was proposed by the National Railway Administration in China for railway engineering survey, in which soil classification is divided into five zones: soft soil, clay, silty clay, silt and sand, as shown in Fig. 3.
where $B_\theta$ is defined as\cite{5}

$$B_\theta = \frac{u_z - u_0}{q_T - \sigma'_{vo}}$$ (1)

cone resistance parameter $q_T = q_c + (1 - 0.84)u_z$, $\sigma'_{vo}$ are soil stress parameters, $u_0$ is pore water parameter.

4. Discussion

To study difference between above two soil classification methods, CPTU test data of each soil layer divided by laboratory test are redrawn in National Railway Administration one respectively, as shown in Figures 5~8.

Figure 5 gives the drawing of CPTU data of gray mucky clay layer from laboratory test in the National Railway Administration code, in which all CPTU data fall in soft soil zone. It is well known that soft soil includes mucky clay, which demonstrates that soil classification determined by two
methods is consistent. Figure 6 gives the drawing of CPTU data of gray mucky silty clay layer determined by laboratory test in the National Railway Administration code, in which CPTU data fall not only in soft soil zone but also in clay zone. Figure 7 gives the drawing of CPTU data of gray silty clay layer determined by laboratory test in the National Railway Administration code, in which CPTU data fall in clay, silty clay and silt zones and these results also demonstrate that there are many clay and silt lens layers in this soil layer. Figure 8 gives the drawing of CPTU data of dark green silty clay layer determined by laboratory test in the National Railway Administration code, in which CPTU data fall in clay and silt clay zones and these results also demonstrate that there are many clay lens layers in this soil layer.

**Figure 5.** Drawing of CPTU data of gray mucky clay layer determined by laboratory test in the National Railway Administration code.

**Figure 6.** Drawing of CPTU data of gray mucky silty clay layer determined by laboratory test in the National Railway Administration code.
From Figure 2 and Figures 5~8, it can be found that both of laboratory test and the National Railway Administration one (2018) are different in the accuracies of identification of soil classification. Especially, there are many clay and sand lens layers in soil layers. For these thin layers, but laboratory test method can not identify it. This may be because the data interval was at least 500 mm for laboratory test method and the borehole data in laboratory test was obtained with the depth interval of 1m in this engineering case. So the soil classification is too large in laboratory test method. Comparing them, the National Railway Administration method (2018) is more accurate.
5. Conclusion
Comparing with two soil classification methods among laboratory test and the National Railway Administration one (2018) based on CPTU data measured in subgrade construction of Shanghai, it is found that there is the deviation between laboratory test and the National Railway Administration method. Those thin lens layers can not be determined by laboratory test method according to borehole samples because in which soil type range of this method may be too large. So the National Railway Administration one (2018) becomes more detailed and suitable for geotechnical investigation in railway subgrade construction.

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References
[1] T. Lunne, P. K. Robertson and J. M Powell. Cone Penetration Testing in Geotechnical Practice. Spon Press, Taylor & Francis Group, London and New York, 2002.
[2] National Railway Administration of the People’s Republic of China. Code for In-situ Testing of Railway Engineering Geology (TB10018-2018, J261-2018), China Railway Publishing House, Beijing, 2018.
[3] Ministry of Housing and Urban-Rural Development of the People’s Republic of China (MOHURD). Code for Investigation of Geotechnical Engineering (GB50021-2001), 2001.
[4] S.L. Shen, J.P. Wang and L. Ma. Identification of soil stratigraphy of soft deposit in Shanghai from CPTU test. In: Meier, R., Abbo, A., Wang, L.B. (Eds.), Soil Behavior and Geo-Micromechanics, Proceedings of Sessions of Geoshanghai 2010, ASCE, (2010), pp. 384-391.
[5] C.P. Wroth. The interpretation of in situ soil tests. Géotechnique, 34 (1984) 4, 449–89.