Comparison of soil classification methods among domestic and oversea based on CPTU test

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Abstract. This article presents the comparison of two soil classification methods among domestic and oversea based on CPTU test in geotechnical practice of soft deposit subgrade. Although CPTU test exists earlier in the world, however, CPTU test has been not applied in geotechnical practice of road subgrade until in recent years in China. Two soil classification methods among domestic and oversea are applied to soil classification and differences of them are analyzed.

1. Introduction

CPTU test is widely employed in many countries, especially in geotechnical practice of road subgrade. One of the important applications of CPTU test is in-situ soil classification¹². Many scholars have been devoting themselves to the study of soil classification based on CPTU test and proposed different methods¹²³. Robertson method (1990) of soil classification is among them. With the rapid development of traffic transportation industry in China, CPTU test has been widely applied in geotechnical practice of road subgrade in recent years. Especially, an in-situ soil classification method was proposed based on CPTU test by the National Railway Administration of China in 2018³. According to above two methods, a case is studied to identify soil classification of subgrade in China.

2. The Case History

The engineering case of subgrade is in Shanghai, China⁴, which belongs to marine soft soil. CPTU test result is shown in Figure 1. According to Figure 1, four soil layers are divided based on borehole samples in laboratory test. Meanwhile, CPTU test data of $q_c$, $u_2$, $f_s$ is also continuously measured, in which there are obvious changes in different soil layers.
3. Soil Classifications From Between Robertson method And The National Railway Administration one In China (2018)

Robertson and Campanella proposed a soil classification method based on CPTU test. In later engineering practice, this method have been improved. A new method modified was presented by Robertson in 1990\(^\text{[1]}\), as shown in Figures 2(a)–(b).

\[
Q_i = \frac{q_i - \sigma_\text{vo}}{\sigma_\text{vo}} \quad F_r = \frac{f_\text{s}}{q_i - \sigma_\text{vo}} \quad B_q = \frac{u_2 - u_0}{q_i - \sigma_\text{vo}}
\]

where cone resistance parameter \(q_i = q_c + (1 - 0.84)u_2\), \(\sigma_\text{vo}\) and \(\sigma_\text{vo}'\) are soil stress parameters, \(u_0\) is pore water parameter.

**Figure 1.** Geotechnical profile based on laboratory test and CPTU one.

**Figure 2.** Robertson soil classification method (1990)\(^\text{[1]}\)

- Soil behavior type zone
  1. Sensitive, fine grained; 2. Organic soil-peats; 3. Clays-clay to silty clay;
  4. Silt mixtures clayey silt to silty clay; 5. Sand mixtures; silty sand to sand silty;
  6. Sands; clean sands to silty sands; 7. Gravelly sand to sand;
  8. Very stiff sand to clayey sand; 9. Very stiff fine grained
In China, with widely application of CPTU test in geotechnical practice of road subgrade, a soil classification chart was proposed by the National Railway Administration of China in 2018, in which soil classification is divided into soft soil, clay, silty clay and silt and sand zones, as shown in Fig. 3.

To study soil classification difference between above two methods, CPTU test result of each soil layer divided by laboratory test are redrawn in Robertson method and the National Railway Administration one respectively, as shown in Fig. 4 to Fig. 11.

According to Figure 4, CPTU result measured fall to not only zone 3 but also other zones, which demonstrate that there are many thin lens layer in the clays-clay to silty clay layer. However, Figure 5 shows that all CPTU result measured fall in soft soil zone. It is well known that soft soil includes mucky clay, so the identification from between Robertson method and the National Railway Administration method are different.
Administration one is consistent, but the result of Robertson method is more detailed because the National Railway Administration chart can not identify those thin lens layers.

![Figure 6](image1)

Figure 6. Drawing of CPTU result measured of mucky silty clay layer determined by laboratory test in Robertson method

![Figure 7](image2)

Figure 7. Drawing of CPTU result measured of mucky silty clay layer determined by laboratory test in the National Railway Administration method

According to Figure 6, CPTU result measured falls to zone 3, which demonstrates that there are silty particles in mucky clay layer. However, Figure 7 shows CPTU result measured falls to soft soil and clay zones. It can be seen that the deviation exists between Robertson chart and the National Railway Administration one, because the result of the National Railway Administration chart is rough.

According to Figure 8, CPTU result measured fall to not only zone 3 but also zone 4, which demonstrates silt mixtures exist in this clay layer. Meanwhile, two sand lens layers were found based on CPTU result measured. However, Figure 9 also shows CPTU result measured of silty clay layer fall to clay, silty clay zones except for a few data falling in other zone. It is obvious that the soil type identified is consistent from between Robertson chart and the National Railway Administration one, but the result of Robertson chart is more detailed.

![Figure 8](image3)

Figure 8. Drawing of CPTU result measured of silty clay layer determined by laboratory test in Robertson method
According to Figure 10, CPTU result measured fall to zone 3. However, Figure 11 shows CPTU result measured fall to not only clay zone but also silty clay zone. There is evident deviation between Robertson chart and the National Railway Administration one and it is can be seen that the result of the National Railway Administration chart is rough.

4. Discussion

From Figure 1 and Figures 4~11, it can be found that both of Robertson method (1990) and the National Railway Administration one (2018) are different in the accuracies of identification of soil classification. Especially, From CPTU data shown in Figure 1, there are many clay and sand lens layers in four layers. For these thin layers, the National Railway Administration method can not identify it, however, Robertson method can do. For the National Railway Administration method,
although it is the basis on CPTU test, the soil type range is too large by means of above comparisons of Figs. 7~14. Comparing them, the accuracy of the National Railway Administration method (2018) is a little low and Robertson one (1990) becomes more detailed and accurate.

5. Conclusion
Comparing with two soil classification methods among domestic and oversea based on CPTU data measured in soft subgrade of Shanghai, it is found that there is the deviation between the National Railway Administration method and Robertson one (1990). Those thin lens layers can be determined by Robertson method according to CPTU data. However, this trait is very difficult to be found by the National Railway Administration method, because soil type range of this method is too large. So Robertson chart becomes more detailed and accurate.

6. Acknowledgments
This work was financially supported by the Science Foundation for Doctor Research from University of Jinan (XBS160100112) fund and for Science and Technology Project from University of Jinan (XKY1910) fund.

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