Correlation of cone resistance and shear wave velocity for residual soil

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ABSTRACT: As a part of a geotechnical investigation program, mechanical cone penetration soundings and a seismic downhole test were performed at a test site with predominantly silt-clay residual soils. The results of the tests are used to develop a correlation between the two types of tests. The results and the associated correlation are then compared to another correlation of shear wave velocity and cone penetration resistance.

1 INTRODUCTION

The shear wave velocity of soils plays an important role in the design of geotechnical structures under dynamic loads. In Indonesia, it is used mostly for determining the seismic site categories and for an initial reference value for large strain problems related to seismic loading. The shear wave velocity is typically measured using the seismic downhole test. However, the equipment is not widely available and, consequently, the test is generally too expensive to perform for most construction projects. On the other hand, mechanical cone penetration tests are the most common in-situ test because it is lightweight and easy to perform.

It is of interest therefore to develop a correlation of the cone penetration resistance and the shear wave velocity. In this paper, the database of the two parameters is described, followed by a discussion on the suggested correlation.

2 TEST PROGRAM

The test program considered in this paper consisted of two locations (A and B), with two mechanical cone penetration tests (CPT) and one seismic downhole test (SDHT) conducted at each location. The distance between the two locations was about 275 m. The locations were within the University of Indonesia complex in Depok, West Java, Indonesia.

The mechanical CPTs were conducted in accordance with ASTM D3441 (2008). The cone with an apex angle of 60° is 10 cm^2 in cross-sectional area and has a 150 cm^2 friction sleeve. The cone penetration resistance q_c and the associated friction ratio R_f readings and calculations were taken and performed at 0.2 m interval. The SDHTs were conducted using OYO Borehole Pick Model 3315 and McSeis–SX 48 Model 1126C. The shear wave velocity was measured at 1.0 m interval.

3 TEST RESULTS

3.1 *Location A*

The cone penetration resistance q_c and the friction ratio R_f of the cone penetration test (CPT) for Location A are shown in Figure 1. The shear wave velocity V_s from the seismic down-hole test (SDHT) in an adjacent deep boring is shown in Figure 1 as well. Based on the results, three geomaterial layers can be identified: ① depth = 0 – 3.0 m, ② depth = 3.0 – 18.0 m, ③ depth = >18.0 m. In addition, the groundwater table in the deep boring was found at a depth of 6.2 m.

The Robertson (1990) procedure was used to further interpret the CPT results of the three layers. As shown in Figure 2, the first layer is predominantly in Zone 3 (silty clay to clay) with higher OCR, the second layer is predominantly in Zone 3 with lower OCR, and the third layer is predominantly in the Zones 4 and 5 (clayey silt to silty clay and silty sand to sandy silt) with relatively low OCR.

3.2 *Location B*

The q_c and R_f profiles of the CPT for Location B are shown in Figure 3. The V_s from the SDHT in the adjacent deep boring is shown in Figure 3 as well. Based on the results, three geomaterial layers can be identified: ① depth = 0 – 3.0 m, ② depth = 3.0 – 20.0 m, ③ depth = >20.0 m. In addition, the groundwater table was found at a depth of 9.1 m.

The Robertson (1990) procedure was again used to further interpret the CPT results of the three layers. As shown in Figure 4, the first layer is predominantly in Zone 3 (silty clay to clay) with higher OCR, the second layer is predominantly in Zone 3 with lower OCR, and the third layer is predominantly in the Zones 4 and 5 (clayey silt to silty clay and silty sand to sandy silt) with relatively low OCR.

4 CORRELATION DEVELOPMENT

A simple regression analysis was performed, taking the shear wave velocity V_s as the dependent parameter and the cone penetration resistance q_c as the independent parameter. As the q_c and V_s were determined at different intervals, five q_c values had to be averaged for the associated depth of V_s value. It is noted that the upper 3.0 m of V_s values at Location A and the upper 1.0 m of V_s values of Location B were not included in the analysis, as they appeared to be unusually high for relatively low q_c values.

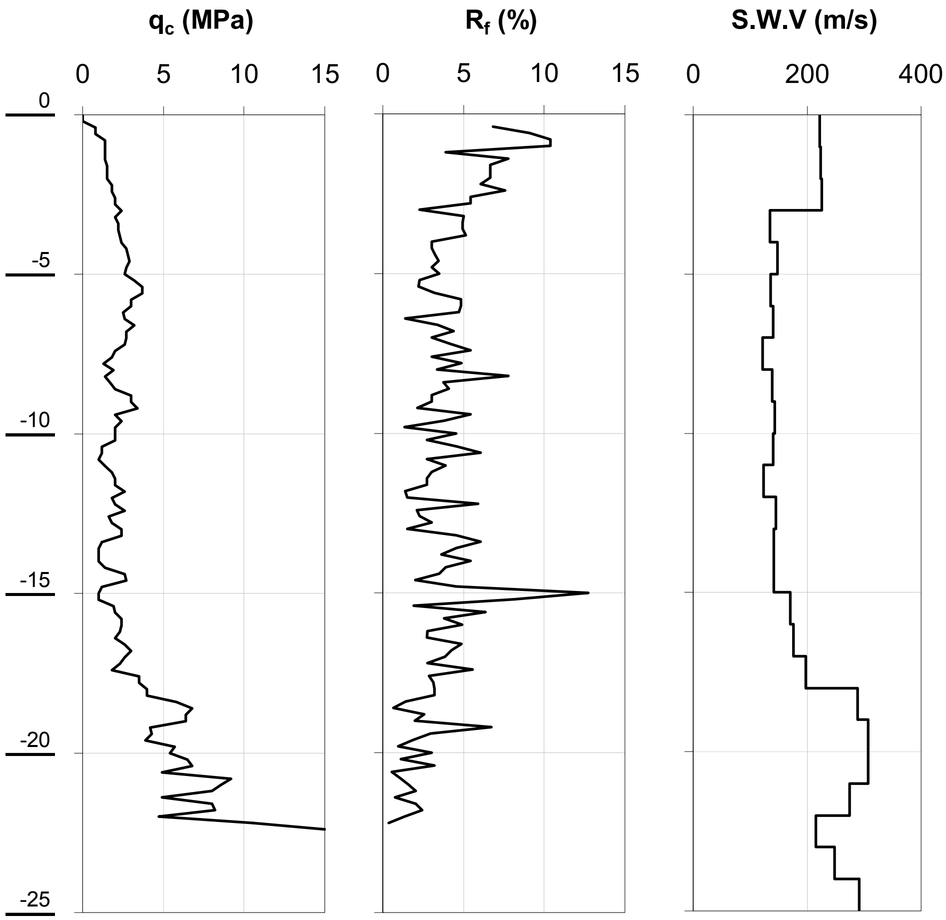

Figure 1. Mechanical CPT and SDHT results for Location A in Indonesia.

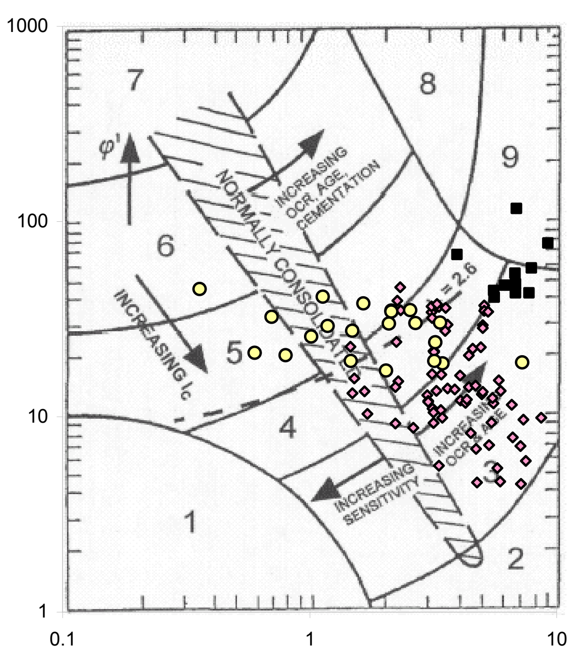

Figure 2. Q-F analysis for Location A (■: 0-3 m, ◇: 3-18m, ○: >18m)

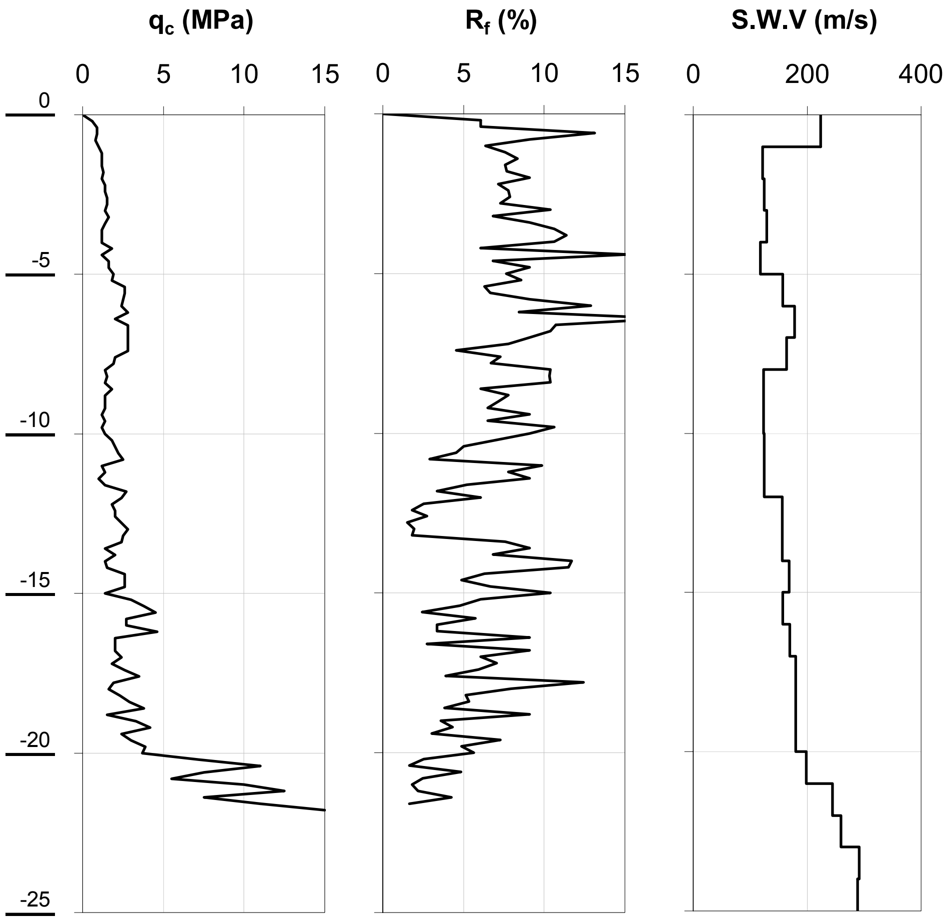

Figure 3. Mechanical CPT and SDHT results for Location B in Indonesia.

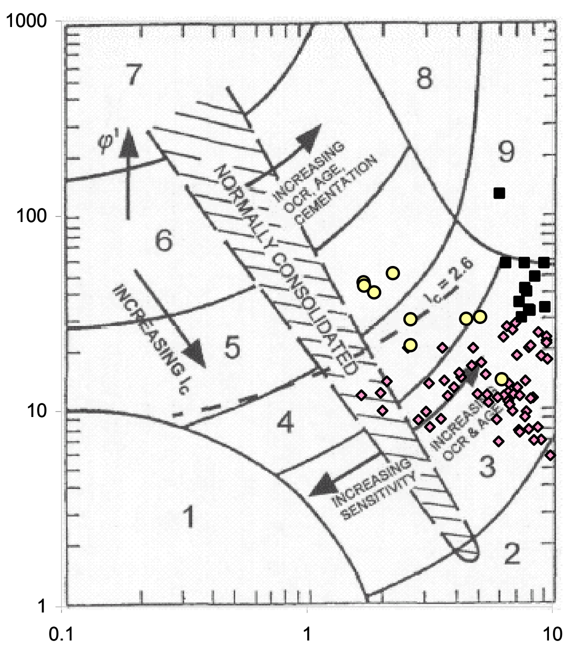

Figure 4. Q-F analysis for Location B (■: 0-3 m, ◇: 3-18m, ○: >18m)

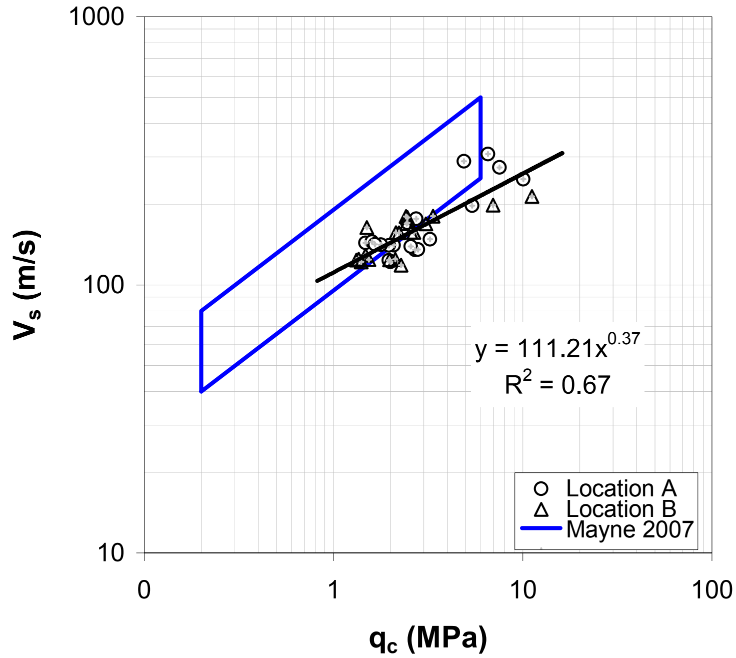

Figure 5. Correlation between V_s and q_c for Indonesian sites.

The following correlation has been derived for the silt-clay residual soil of the research site:

$$V_s = 111.21\ (q_c)^{0.37} \qquad (1)$$

in which V_s in m/s and q_c in MPa. Note that the number of data is 39 and the r^2 value is 0.67. The data and the regression line and equation are shown in Figure 5.

Figure 5 also shows the clayey soil database for the V_s – q_t correlation developed by Mayne (2007). Note that the Mayne's database is a q_t database, not a q_c database. Nevertheless, it can observed that the present above-groundwater-table V_s – q_c data appear to be in the lower bound of the Mayne's database.

5 CONCLUSIONS

A site-specific trend that correlates the measured cone penetration resistance q_c obtained from mechanical CPTs to the shear wave velocity V_s obtained from seismic downhole tests in Indonesia is presented. These tests have been carried out at two locations. The suggested correlation between V_s and q_c can be used for rough estimates of V_s from q_c, particularly for preliminary studies and/or noncritical projects are under consideration.

REFERENCES

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