

SHEARING RATE EFFECTS ON RESEARCH CENTRE FOR SOFT SOILS (RECESS) CLAY USING CONE PENETRATION TEST (CPT)

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Abstract: A wide range of industrial applications, on land and offshore, require the solution of time domain problems and an associated understanding of rate effects in clay soils. In recent decades many researchers have examined the correlation between shear strength of soils and variation of shear strain rate and it is generally accepted that the strength increases by 1-5% for each order of magnitude increase in shear strain rate. This paper discusses the effects of penetration rate on the penetration resistance (q_c) by using cone penetration test (CPT) test setup. The research had been conducted at RECESS and cone penetration test were used in three selected range of rate which were 0.5 cm/s, 1cm/s and 5cm/s. In addition, Mackintosh probe test had been considered as comparison with CPT test for the unconfined compressive strength. The result shows different penetration rate influenced the soil shear strength. For the slowest rate (0.5 cm/s), the shear strength was approximately 0.15% less compared to the standard rate (2 cm/s). However, for the highest rate (5 cm/s), the shear strength was 0.22% more than the reference rate (0.5 cm/s). In conclusion, it is suggested that the RECESS clay soil influenced by the rate effect and in agreement with previous research findings.

Introduction

The accuracy and detailed nature of CPT data become the principal reasons for acceptance and increased use of the CPT in recent years. The fact that the test is conducted in-situ eliminating sample disturbance and changed stress conditions, and the relative speed and economy of the method as compared to conventional drilling and sampling [1]. The measurements of cone penetration test can effectively be used in many Geotechnical engineering applications such as stratification and identification and also to evaluate different soil properties such as strength and consolidation characteristics of the soil. For this study, CPT tests were conducted by having different speed of penetrations in order to investigate the rate effect for soft soil deposit in RECESS, UTHM, Batu Pahat, Malaysia.

Literature Review

Cone penetration test

CPT test is a faster, repeatable and economical option in conducting site investigation compared to other conventional method. Based on BS 1377-9:1990, CPT method covers the determination of the resistance of soils in situ thru continuous penetration. In addition, it also capable to continuously measures or at selected depth intervals the penetration resistance of the cone. If required, the local friction resistance on a sleeve friction, (f_s) and pore pressure in the vicinity of the cone and sleeve could be investigated [2].

Previous Case Study on Rate Effect

Variable rates of penetration had been conducted in many types of soils such as in clay, sand, silty soils and also in intermediate soils. In cone penetration test, the standard rate of penetration is 2 cm/s [3, 4, 5, 6]. There were many research utilised different speed of penetration [7, 8, 9, 5, 6, 10, 11] whether in high or slow speed in cone penetration testing. Different speeds of penetration will give different influence to cone resistance (q_c), sleeve friction (f_s) and also porewater pressure (u).

The researcher has investigated the effects of drainage during penetration [4]. Penetration tests were performed with various velocities in the field and in a calibration chamber. It was found that the higher the penetration rate is, the larger the undrained shear strength (s_u) is, and the larger the q_c . The finding was inline with [11]. They found that at very high rates of penetration, where conditions are fully undrained, the resistance increases with increasing velocity due to viscous effects.

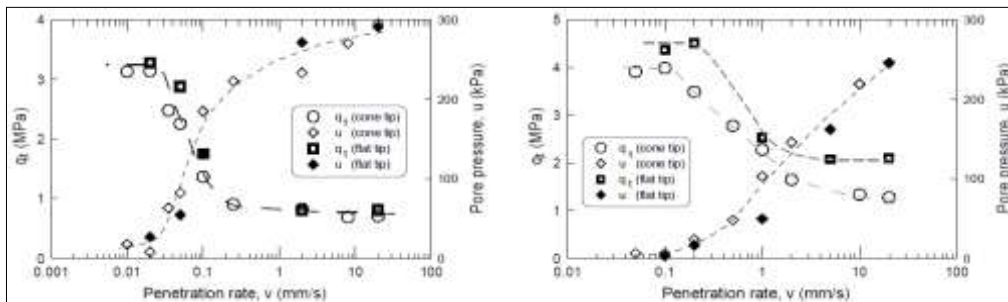


Fig.1: Effect of penetration rate on q_t and pore pressure for (a) specimen P1 and (b) specimen P2. [13]

Methodology

CPT penetrometer

For this study, a basic cone penetrometer with 35.4 mm base diameter, 10 cm² projected area and 60° cone angles was implemented. The cone had been pushed into the ground at different rates of penetration which are 0.5 cm/s, 2 cm/s, and 5 cm/s respectively. The cone, were connected to 1m long hollow drill rods as shown in Fig.2 which acting as a tubular pipe pile.



Fig.2: The tubular pipe pile model

Field testing at RECESS

The test has been conducted at RECESS UTHM as shown in Fig. 3 and Fig. 4. A model pile was used to represent the actual pile on site. For cone penetration test (CPT) the pile was penetrated into the soil approximately about 4.6m depth. On the other hand, Mackintosh probe was conducted at the same test site up to 9m depth. The cone resistance (q_c) for CPT and probe blows from the operation had been monitored and recorded as shown in Fig.3 and Fig.4.



Fig.3: Cone penetration testing operation



Fig.4: Mackintosh probe operation

Result and Discussion

This chapter is focused on the analysis and discussion from the field monitoring test conducted at RECESS, UTHM. The shear strength and bearing capacity for cone penetration test and Mackintosh probe test had been compared.

Field monitoring data

From the field monitoring, the results are as shown in Fig. 5 and Fig. 6. From the data obtained in Fig. 5, there are 3 different rate of penetrations were applied. Each rate was penetrated into soils constantly at the designated speed to ensure the accuracy of data analysis.

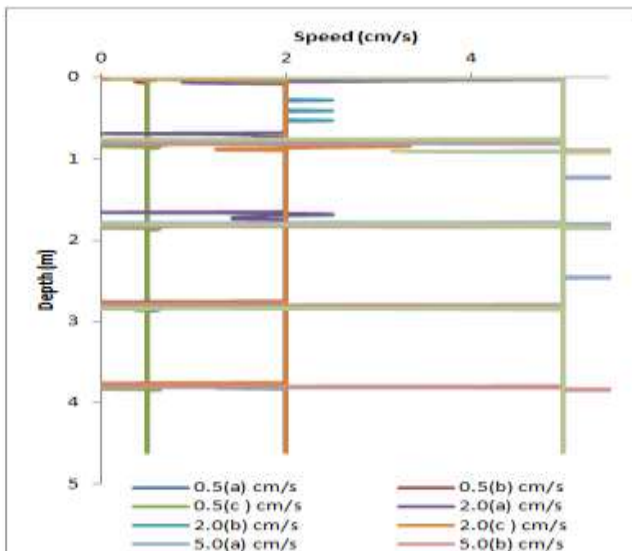


Fig.5: Different penetration speed

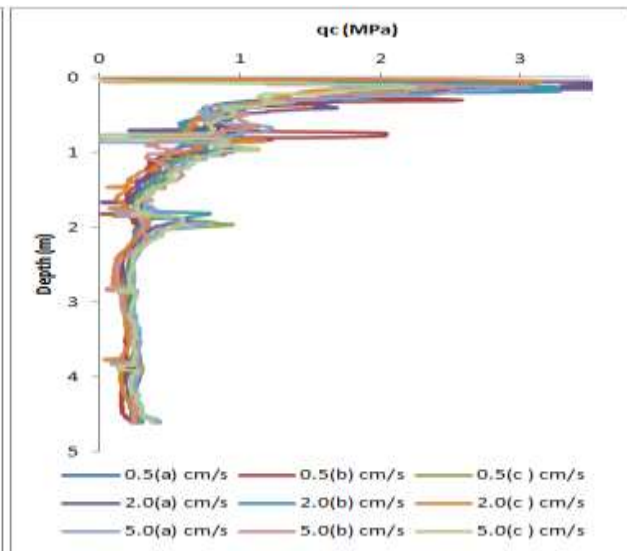


Fig.6: Cone resistance varies with depth

Rate effect analysis

Fig.7, 8 and 9 show some analysis of rate effect of soil at RECESS UTHM. It was found that the cone resistance was increases when higher speed of soundings performed for the CPT.

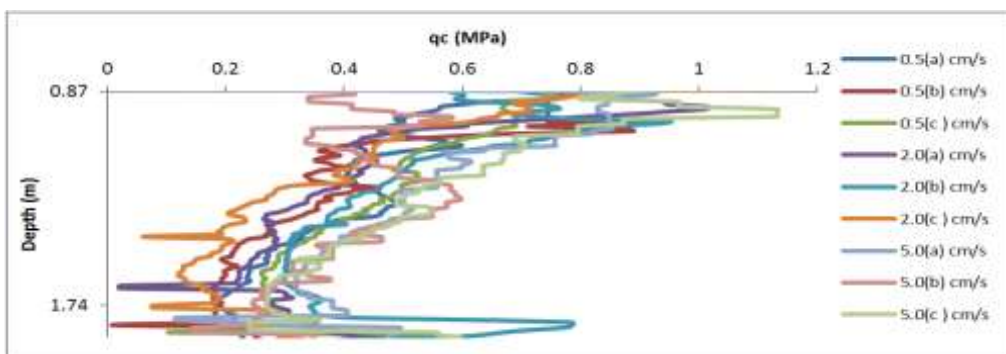


Fig.7: Rate effect at 0.87 m to 1.87 m depth

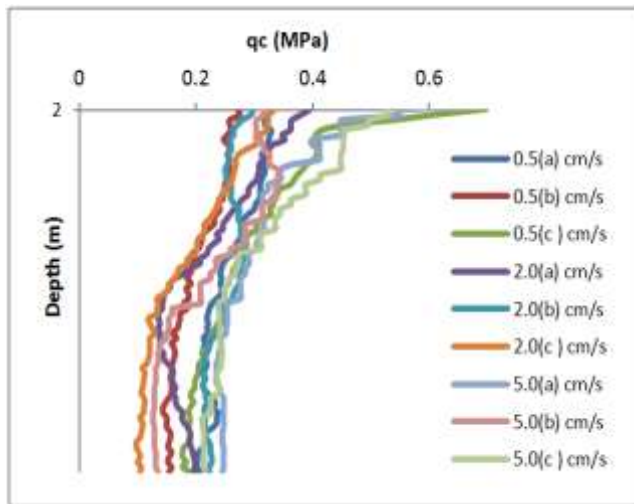


Fig.8: Rate effect at 2.01 m to 2.73 m depth

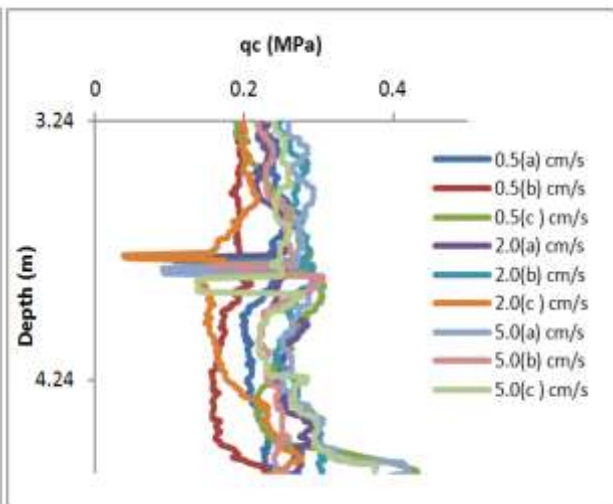


Fig.9: Rate effect at 3.24 m to 4.61 m depth

CPT analysis

Based on this study, the percentage different of cone resistance, (q_c) for 0.5 cm/s which are the lowest speed and the highest speed which 5.0 cm/s is about 0.22%. The percentage different for 0.5 cm/s with 2.0 cm/s is about 0.15% while the percentage different for 2 cm/s with 5 cm/s is about 0.06%. Based on previous research [11], the scenario may be due to soil viscous effect. In conclusion, faster speed of penetration influence greater cone resistance.

Mackintosh probe analysis

In order to clarify the condition in the previous section, a simple approach by utilizing Mackintosh probe test had been conducted. The results are as shown in Fig. 10(a) at B2, 10(b) at B5 and 10(c) at D5. It can be observed that the soil layer is harder for the first 1m depth.

In comparison, the soil strength from Mackintosh probe was lower than the CPT data. Anyway, for this particular study, it is appropriate enough to act as comparison. Further elaboration may be required to fully understand the scenario.

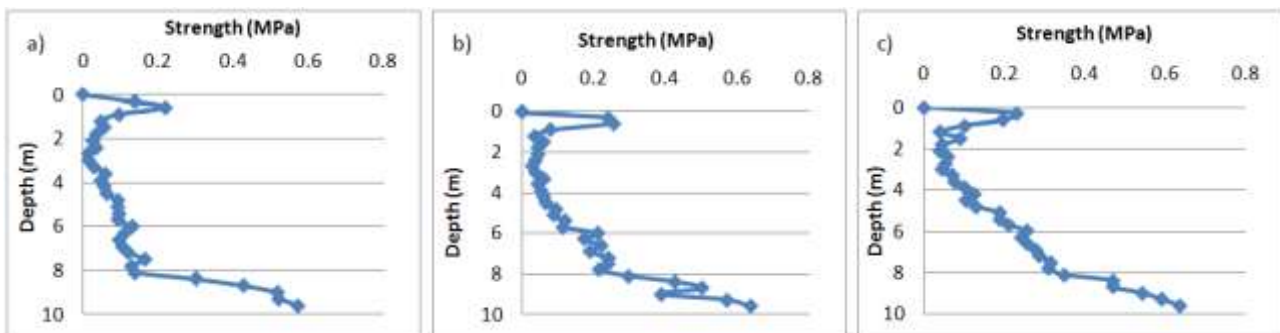


Fig.10: Soil strength based on Mackintosh probe test

Conclusion

The results obtained from this study may be a platform for comparison between the standard speed of penetration of CPT with slower and higher speed of penetration. Each imposed speed will give a different reading on the cone resistance in which showing a rate effect problems. When the speed of 0.5 cm/s was imposed, cone resistance recorded a lower reading than the higher speed of which are 5 cm/s. The percentage different is about 0.22%. The percentage different for 0.5 cm/s with 2.0 cm/s are 0.15% while percentage different for 2.0 cm/s with 5.0 cm/s is about 0.06%. In addition, the cone resistance increases with the increasing penetration velocity possibly due to viscous effects [11].

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