SITE INVESTIGATION OF MAKASSAR MARINE CLAY USING CONE PENETROMETER (CPTU)

Graduate School of Science and Engineering, Saga University (Student Member) ○ Fakhriyah USMAN
Civil Engineering Department, Hasanuddin University Tri HARIANTO
Civil Engineering Department, Hasanuddin University Lawalenna SAMANG
Institute of Lowland and Marine Research (ILMR), Saga University (Member) Takenori HINO
Institute of Lowland and Marine Research (ILMR), Saga University (Member) Rui JIA

1. Introduction

Cone penetration testing (CPT) is the most versatile device for in situ soil testing. Without disturbing the ground, it provides information about soil type, geotechnical parameters like shear strength, permeability, density, rates of consolidation and environmental properties. Furthermore, as it can be seen as a small scale test pile, it is the best and most cost-effective device to design piled foundations and sheet piles. Cone penetration testing, with pore water pressure measurements (CPTU), gives a more reliable determination of stratification and soil type than a standard CPT. Moreover, the objective of this study are to investigate the typical geostratigraphy, soil types, water table and engineering parameters of Makassar marine clay. Furthermore, the continuing research on the soil properties such as Liquidity Index (I_L) and Sensitivity (S_t) will be conducted to obtain comprehensive soil properties of Makassar marine clay.

2. Experimental Method

This study was conducted by direct experiments in the field by taking the data correspond to the tools used. CPTU test was conducted according to standard of ASTM D-5778-95. In order to conduct accurate pore pressure measurement, filter (porous stone) located on the upper side of cone maintained in saturation state (Lunne et al. 2001). Besides filter saturation, the rate of penetration also determines the value of pore pressure measured by sensor. Moreover, the rate of penetration is required at 2 cm/sec with a tolerance of 0.5 cm/sec. Rapid cone penetration than this tolerance would result the pore water pressure become too large, while slower cone penetration than tolerance will result smaller value of pore pressure. Pore pressure value measured during penetration is called the dynamic pore pressure (u_2).

Site investigation conducted in the location of Center Point of Indonesia Project, Makassar (South Sulawesi). Table 1 shows the consistency properties of Makassar marine clay. CPTU data was collected automatically by continuous record at penetration rate of 2 cm/sec. The numbers of test points are two points namely CPTU-01 and CPTU-02 with distance 60 meters between each point.

Figure 1. Site Map (source www.googleearth.com)

Table 1. Consistency Properties of Makassar Marine Clay

No.	Properties	Value
1	Liquid Limit, w_L (%)	80 – 110
2	Plastic Limit, w_p (%)	40 – 65
3	Shrinkage Limit, w_s (%)	10 – 14
4	Plasticity Index, PI	30 - 60

3. Result and Discussion

Based on engineering properties and unified soil classification chart: relationship between swell index and Attenberg limits, Makassar marine clay tend to be classified as elastic clay. Interpretation of soil profiles based on Robertson (1986) using data of total cone resistance (q_c), sleeve friction (f_s), and dynamic excess pore pressure (u_2). These values are first calculated to obtain three derivative quantities such as total cone resistance (q_t), friction ratio (FR), and pore pressure parameter (B_q). CPTU-01 test conducted until 18.44 m depth from ground. Whereas dissipation test conducted at a depth of 13.86 m. Figure 2 shows geostratigraphy and data for CPTU-01 and Figure 3 shows result of dissipation test.

The decreased of cone resistance at 0.9 m indicate the present of silty sand. Since the compressibility of silty sands is typically higher than clean sand, silty sand may have cone resistance lower than clean sand (Robertson and Campanella, 1985). Robertson and Wride (1998) also found that the CPT penetration resistance in silty sand is smaller due to greater compressibility and decreased permeability of silty sand. Cone resistance curve tends to be stable at 6 m to 18 m indicate the present of silty clay. The pore pressure in CPTU-01 start to occur at 1,4 m below ground level as a response to water table and the pore pressure increased with occasional fluctuations up to 18 m indicate clay present in this range of depth.

Figure 3 shows result of dissipation test that the pore pressure recorded behind the cone (u_2) initially increase before decreasing to the equilibrium pore pressure, which is caused by local equalization of the high pore pressure gradient around cone (Abu-Farsakh et al. 2003). CPTU-02 test conducted until a depth 19.3 m from the ground surface. Dissipation test conducted at 13.93 m and 16.84 m depth. Result of CPTU and dissipation is shown in Figure 4 and Figure 5, respectively. Water table was found at a depth 1.5 m where pore pressure started to occur. The pore water pressure increased linearly until

11.5 m depth with occasional fluctuation indicate the presence of low permeability layer. At a depth of 6.5 m to 10 m, the increased of cone resistance value signify presence of thin sand layer. The increase of pore water pressure at 11 m and stable cone resistance curve indicate clay presence in this layer.

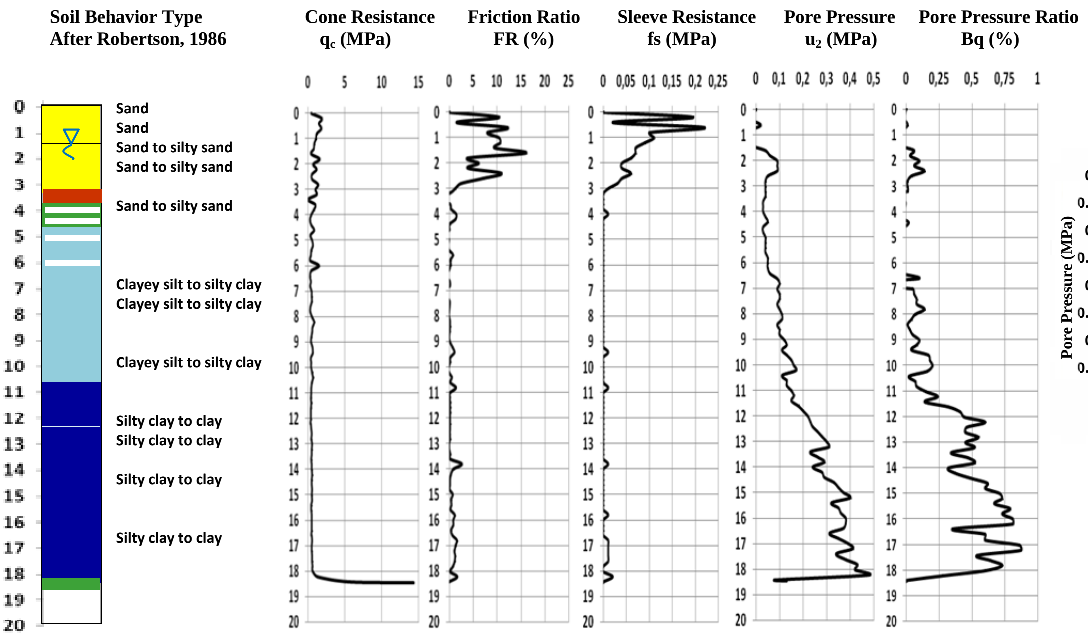

Figure 2. Test Result and geostratigraphy for CPTU-01

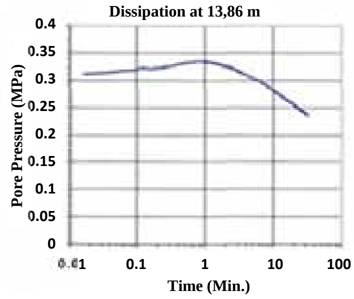

Figure 3. Dissipation result for CPTU-01

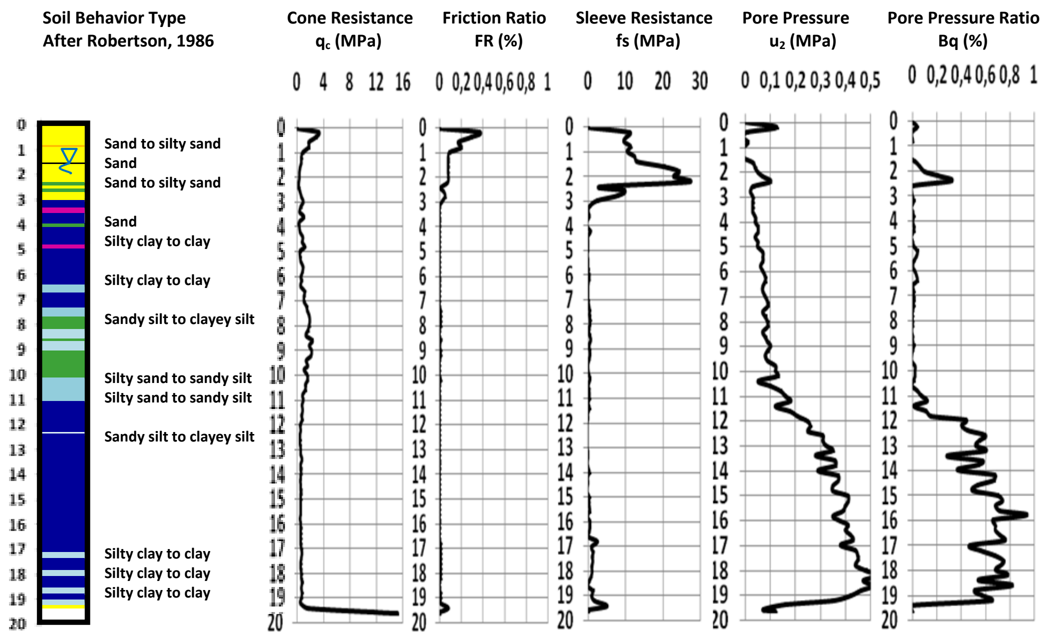

Figure 4. Test Result and geostratigraphy for CPTU-02

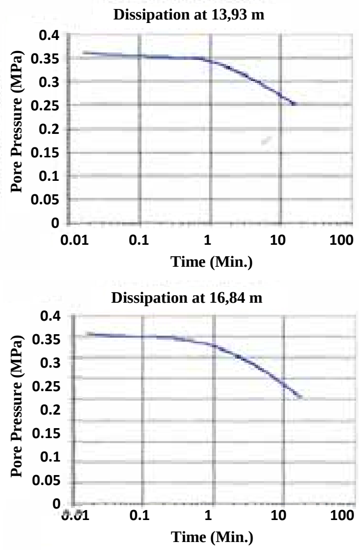

Figure 5. Dissipation result for CPTU-02

4. Summary

Based on this investigation, the clay was found between 6 m to 18 m below the surface. The thick deposit of Makassar marine clay indicated the possibility of high compressible soil layer in Makassar coastal area in which must be taken into consideration before constructing building in this region.

5. Acknowledgement

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