ESTIMATION SOIL LAYERS FOR SOME AREAS IN BENGKULU CITY
BASED ON CPT APPROACH

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ABSTRACT

This paper presents the study of soil layers estimation by using CPT data approach. There are 3 CPT data in 3 areas in Bengkulu City used in this study, i.e Rawa Makmur, Pematang Gubernur, and Lempuing Sub-District. Rawa Makmur is an area in Bengkulu City that always gets flooding every raining season. Pematang Gubernur was a farming land area in the past, which is interesting to investigate, whereas Lempuing is a coastal area predicted will have serious damages due to earthquake. All collected data is then analyzed and interpreted. The method used in this study is based on Robertson Method, which is very useful in determining the soil layers, especially for predicting the soil type based on qc (cone resistance) and Rf (friction ratio). The result shows that Lempuing is dominated base sand. This result also strengthen the assumption of liquefaction potential on sand layers in Lempuing. For Rawa Makmur, clay layer is found. Based on this result, the attention should be focused on these layers. This issue could be related to the flood in this area and the possibility of soil consolidation. This area is also becoming the growing area now, therefore both coming issue must be concerned. Meanwhile, for Pematang Gubernur, the soil layer is dominated by clay layer as well. Both issues in Rawa Makmur are potential to happen in this area. However, the focus of those is still in term of preliminary, since this area is less important than Rawa Makmur, where the growing economic is started to concentrate there.

Keywords: soil layer, sand, clay, CPT

1. INTRODUCTION

Soil investigation is very important to be conducted before starting the construction project. Generally, there are two tests to investigate soil. They are Cone Penetration Test (CPT) and Standard Penetration Test (SPT). Both of them have the advantages and the disadvantages. CPT is cheap in charge and easy to be conducted, but it is not able to interpret soil layer directly, since undisturbed sampling is not performed. Meanwhile, SPT is very expensive in charge, but also taking time to perform it. However, soil layer can be interpreted, since this is followed by boring test and undisturbed sampling test. By considering the advantages and the disadvantages, soil investigation test is very limited on the available budget. To handle it, soil investigation projects normally choose the cheap one as the solution, i.e. CPT.

As explained in the previous paragraph, CPT is not able to estimate soil layers directly, therefore the soil type estimation to predict the soil layer should be conducted. Robertson et al. [1] introduced a chart to estimate the soil type based on the correlation CPT data. The data used are cone resistance
normalized \( (q_t) \) and friction ratio or \( R_f \) (in %). This method is very useful in practice, particularly, if undisturbed sample is so difficult to obtain in sites. The chart proposed by Robertson et al. [1] is shown in Figure 1. Recently, in 2010 Robertson upgraded the graph, which is shown in Figure 2. In this graph, Robertson [2] simplified cone resistance normalized to cone penetration \( (q_t) \). This graph is very useful in predicting and adjusting the value of the behavior of soil. This graph has also been the reference in studying of soil problem, which needs preliminary investigation in laboratory and field before analysis.

![Figure 1. Soil Behavior Type [1]](image1)

![Figure 2. The updated version of soil typ [2]](image2)

\( P_a = \) atmospheric pressure = 100 kPa = 1 tsf
In this study, soil investigation data in some areas in Bengkulu City are employed to apply the method to estimate soil layer. 3 investigation points data are collected, i.e. Rawa Makmur, Lempuing, and Pematang Gubernur. Rawa Makmur is an area in Bengkulu City that has potential to be center of economical activity in Bengkulu City. However, the routine hazard as flooding and drainage problem are still becoming the hot issues in this area. Therefore the sub-soil in must be investigated the relationship between the hot issues and soil layer itself.

Figure 3. Interpretation of $q_c$, $f_s$, and $R_f$ for Rawa Makmur Site

Figure 4. Interpretation of $q_c$, $f_s$, and $R_f$ for Pematang Gubernur Site
Similar to Rawa Makmur, Pematang Gubernur is one of sub-urban in Bengkulu City, that has potential to develope area for living house area. Different from two investigation spots, another investigation spot is Lempuing. Lempuing is a coastal area in Bengkulu City. Roughly, the subsoil can be predicted as sandy soil. However, the detail description of soil layer has not obtained yet. Moreover, some studies related to soil liquefaction phenomena have been studied in this area.

This study is also conducted to confirm the previous studies. This study is expected to observe the soil layers in those areas. By getting this information, the soil phenomena such as consolidation settlement potential, liquefaction potential, and etc, can be predicted.

2. METHODOLOGY

Methodology of research used in this research is elaborated step by step as follows:

1. Conduct the soil investigation test in research area. In this research, the soil investigation test using CPT were conducted in Rawa Makmur, Pematang Gubernur, and Lempuing. CPT used has resistance capacity of 200 kg/cm\(^2\). Nevertheless, the resistance capacity of 100 - 150 kg/cm\(^2\) is assigned as maximum capacity to avoid CPT machine damage. Interpret the result of CPT data i.e. cone resistance (\(q_c\)), skin friction (\(f_s\)) and friction ratio (\(R_f\)). The interpretation of CPT results is shown in Figure 3, 4, and 5.

2. Determine the soil behavior based on Robertson (2010) as presented in the previous explanation.
3. Classify the soil stratum based on the soil behavior type on each soil investigation point of CPT test.

4. Discussion the soil phenomena related to the soil layer interpretation.

3. **SOIL TEST RESULT**

The interpretation of CPT result is presented in Figure 3. For Rawa Makmur, cone resistance \(q_c\) are varied into 0 to 49 kg/cm\(^2\), with the \(f_s\) are varied into 0 to 120 kg/cm and \(R_f\) is varied into 0 to 30%. For Pematang Gubernur (Figure 4), \(q_c\) is varied into 0 to 80 kg/cm\(^2\), with the value of \(f_s\) and \(R_f\) are in range of 0 to 120 kg/cm and 0 to 45%, respectively. In general, the soil type of both areas will be quite similar. For Lempuing (Figure 5), \(q_c\), \(f_s\), and \(R_f\) are in range of 0 to 150 kg/cm\(^2\). In particular, Lempuing soil can be conclude having different soil type from those previous locations.

4. **SOIL LAYER ANALYSIS RESULT**

Interpretation of soil layer for each CPT data can be seen in Figure 6. Figure 6 is the interpretation of soil layer for Rawa Makmur. Rawa Makmur soil layers are dominated by Clay. However, sand layer is also found on quite shallow depth, i.e. 3.6 to 7.4 m. Whereas clay layer is found on ground surface up to 3.6 m deep, 7.4 to 10.6 m deep, 10.6 m deep to 12.4 m deep, 16.8 to 22.4 m deep. The interesting point is the peat layer, which is found on 12.4 to 16.8 m deep.

Interpretation of soil layers in Pematang Gubernur is shown Figure 7. As shown in Figure 5b, it can be seen that clay layers dominate this site. Clay layers are found on 0 to 5.4 m, 7.4 to 9.6 m, and 10.6 to 19.4 m. Thin layers of sand are also found on 5.6 to 7.2 m deep, 9.8 m to 10.4 m deep.

Interpretation of Lempuing soil layers is presented in Figure 8. In general, soil layers in this sites are different from the previous sites. In this site, sandy soil layers are dominating.

5. **ISSUE RELATED TO SOIL LAYER**

Rawa Makmur is an area experiencing flooding disaster periodically, especially during raining season. The drainage problem always becomes the main concern. If we look into the result of soil interpretation for Rawa Makmur. Some thick clay layers are giving the indication that is very difficult for clay to drain the water, which in this case is flooding. Therefore the problem of drainage system of soil type is possibly being the issue. Rawa Makmur is also the growth area for economic aspect. Several shops have been build in this study and it will increase the load for building foundation. As we know that clay in rawa makmur has potential to undergo consolidation settlement. Therefore, the combination of
drainage problem and consolidation settlement are accumulating the significant flooding. The drainage problem will result in the problem of water drain, whereas the consolidation will result in the soil settlement and automatically the flooding volume will increase due to the enlarge stagnant water zonation.

The same problem will also occur in Pematang Site, especially drainage problem due to quite thick clay layer. If the growth of building increases significantly, the consolidation settlement will occur as well.

For lempuing site, the problem of drainage and consolidation settlement are not being big issue, since the sand layer can easily drain the surface run-off if flooding occurs.

However, the problem of liquefaction due to earthquake will be the serious issue in this site. Even though several liquefaction study are done already in this site, it seems to increase the significant study of liquefaction, especially related to experimental study. By conducting the experimental study of liquefaction, at least the preliminary mitigation effort can be arranged to cover this problem, particularly in the future.

Figure 5. Interpretation of $q_c$, $f_s$, and $R_f$ for Rawa Makmur Site

Figure 6. Interpretation of $q_c$, $f_s$, and $R_f$ for Pematang Gubernur Site

6. CONCLUDING REMARKS

This study aims to observe the soil layers of some areas in Bengkulu City. Some points that can be drawn as concluding remarks are listed below:

1. Rawa Makmur and Pematang Gubernur have the similar characteristic of soil layer each other.
Lempuing is a coastal area in Bengkulu city, which is dominated by sandy soil.

2. The main issue in Rawa Makmur and Pematang Gubernur related to soil type is consolidation settlement that has the effect to the flooding and surface runoff due to very low permeability of clay layer. In Lempuing, the main issue is Liquefaction. The preliminary study of liquefaction in this location is conducted by some researchers. Therefore, the intensive study is able to be conducted to accomplish the previous study. Lempuing site is also sub-urban area that has potential to be economic center for the coastal area in Bengkulu City. Pantai Panjang tourism place crossing this area is very potential for the economical aspect, and perhaps, in the future the capital growth will be significantly created in this area.

3. The similar study should be conducted in each site in some important areas in Bengkulu City, to interprete the soil layer and soil type in Bengkulu City, in general. This is very important in the future, since the consideration of sub soil is very useful prior to construct the building.

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References
