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Estimation of Bearing Capacity of Pile with Variation of Shape on Cohesive Soil Based on the Result of CPT Test (Study Case: Gunung Anyar District)

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ABSTRACT

The bearing capacity of soil provides the most important output for soil investigation. Bearing capacity becomes a reference in designing the substructure of the structure. Therefore, it is necessary to have a capable bearing capacity analyzed by varying the shape of the foundation to provide a clear description of the highest bearing capacity of all the variations presented. In this study, a soil investigation was carried out by using the Cone Penetration Test from several distribution locations in Gunung Anyar District Area, where it is well known as cohesive soil which has a lower bearing capacity compared to non-cohesive soil. Based on this analysis, it shows that the pile foundation using a square cross-section will provide a greater value for the pile bearing capacity. Increasing the dimensions of the cross-sectional shape, it will provide a greater value for the carrying capacity of the pile as well. This is evidenced at a depth of 16.4 m, for a square cross-sectional dimension of 0.4 m it gives a value of 80.49 tons, while for a cross-sectional dimension of 0.6 m it gives a value of 164.736 tons.

Keywords: Bearing capacity, CPT, cohesive soil

Introduction

The bearing capacity of the soil is very much determined by physical and mechanical properties. In civil engineering, Soil is a sedimentary material whose grains are loose (loose), and soil type is cohesive and non-cohesive. The physical properties and characteristics of the two types of soil are very much different from each other. The unified soil classification system or known as the Unified Soil Classification System (USC), is defined based on grain size and plasticity testing soil. Soil properties can be also determined from field testing, namely: Standard Penetration Test (SPT), Cone Penetration Test (or CPT), load plate test, and shear vane test (Vane Share Test). The CPT test tool (sondir) is a tool practical, easy to operate, and direct the result is obtained. Where can the results be used to analyze the bearing capacity of the soil foundation (Tomlinson, 1980). There were a lot of studies have been aimed to correlate the value of cone resistance and physical properties of soil as well as soil classification, unit weight of soil, cohesion, etc. (Begemann, 1965). Robertson and Campanella (1983) developed a chart to estimate the soil behavior type based on the value between friction ratio (FR) and cone resistance (q_c) (Figure 1).

The settlement of the foundation greatly affects the construction of it, especially for lands clay has a high drop over a long period. Foundation drop in fine-grained and water-saturated soils into 3 components, namely: immediate decrease (Si), consolidation decrease (Sc), and consolidation decrease secondary (Hardiyatmo, 2011).

The deep foundation is one of the most important elements in the construction of high-rise buildings because the burden of the large building will be fully borne by the foundation. One type of deep foundation is the pile foundation. To ensure that the pile foundation is by the carrying

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capacity of the plan, then the piles were carried out loading tests. Loading-test is a test of the foundation piles that aim to determine the actual carrying capacity of the foundation in the field.

There are two methods used to predict the bearing capacity of pile foundations stake using cone penetrometer test (CPT) reading data, namely the Direct Method and Indirect Method. This direct method assumes that the cone penetrometer is similar to a mini-pile foundation, where the measured end stress and blanket friction are similar to the component's end resistance and blanket friction of pile foundations (Mayne, 2007). From assumptions, there have been many correlative relationships that have been developed based on the results from the CPT reading. While the indirect method uses parameters and correlations to the data CPT is then processed with the analytical framework that has been found. This study aims to obtain an overview of the bearing capacity that can be analyzed by varying the shape of the foundation to provide a clear picture of the highest bearing capacity of all variations presented.

Material and Methods

Foundation

The foundation is the lowest part of the building that transmits the load of the building to the soil or rock beneath it. Foundations are divided into two types according to the method required based on the type of building, namely shallow and deep foundations. Shallow foundations are foundations that directly support loads with a depth of Df/B, while deep foundations are foundations that transmit building loads to hard soil or rock located far from the surface with a depth of Df/B≥4B. For an explanation (figure 2).

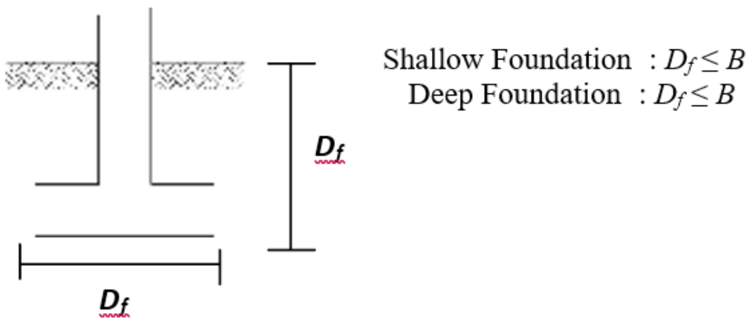


Figure 2. Determination of deep foundation (Hardiyatmo, 2011)

In this study, researchers used deep foundations with variations in cross-sectional shapes and dimensions for analysis.

Meyerhoff Methods

An empirical method based on the correlation between Standard Penetration Test (SPT) and Cone Penetration Test (CPT), the analysis was carried out from the results of the loading test and CPT test as proposed. (Meyerhoff, 1956). Meyerhoff found a method for estimating the bearing capacity components for the piles of and. Meyerhoff observed the effect of foundation erection in different soil layers type (figure 3).

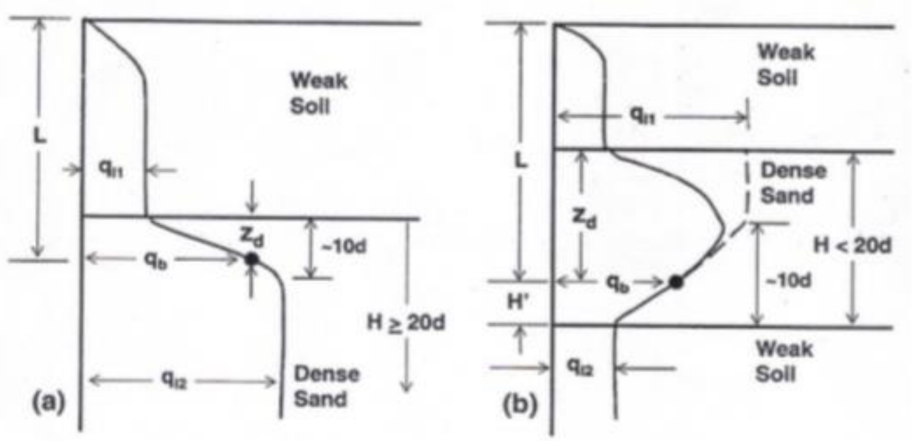


Figure 3. End of pile resistance and depth in sandy soil between soft soils: a) A thick layer of sand; b) Thin sand layer (Meyerhof 1976)

Meyerhoff developed the results of the CPT test and loading test on the pile piles and drill piles to provide accurate design equations and graphics, where the effect of the diameter of the pile tip is also taken into account (figure 4). (Meyerhoff, 1983).

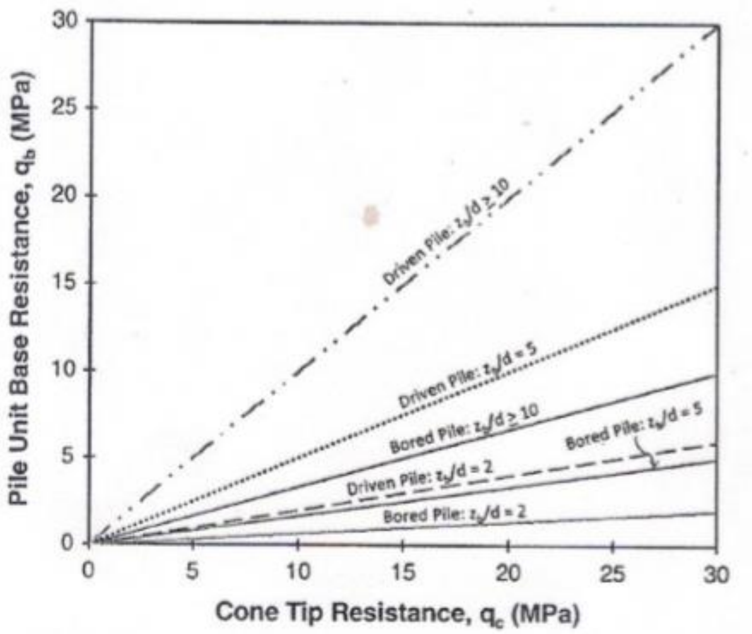


Figure 4. Relationship of End Resistance with q_P CPT (Meyerhoff, 1983)

Pile bearing capacity can be obtained from CPT data. The end resistance mobilized in the pile shall be equal to the end resistance during the penetration test. In determining the ultimate bearing capacity of the pile, it can be determined in the following equation (1):

$$Qu = Qb + Qs \qquad (1)$$

with:

Qu = ultimate bearing capacity of the pile (kg)

Qb = ultimate bearing capacity of pile tip (kg)

Qs = ultimate bearing capacity of pile blanket (kg)

The pile end bearing capacity is determined in the following equation (2):

$Qb = Ab \times qc$ (2)

with:

Qb = End bearing capacity (kg)

Ab = Cross-sectional area (cm^2)

qc = Average pressure (kg/cm^2)

The value of QC is taken from the average of 4d above the pole tip and 1d below it. The formula for calculating the bearing capacity of the blanket:

$Qs = As \times fs$ (3)

with:

Qs = Carrying capacity of the skin (kg)

As = Area of blanket (cm^2)

fs = wall resistance (kg/cm^2)

According to de Ruiter and Beringen fs is determined by equation (2.4) as follows:

$fs = 0.05 \times \times qc$ (4)

with:

fs = Unit frictional resistance, with a maximum value of 1.2 kg/cm^2 (120 kPa)

= adhesion factor, taken 1 for normally consolidated clay and 0.5 for excessively consolidated clay

qc = Cone resistance at the end of the pile (kg/cm^2)

$Qall = Qu / SF$ (5)

with:

Qu = Boundary bearing capacity (kg)

SF = Safety factor 3-5 for a fixed load

Results and Discussion

This research, is to determine the bearing capacity of the foundation using the Meyerhoff method. The calculation of the carrying capacity for this method is influenced by pile dimensions and pile foundation depth. Using the depth according to the CPT data, we tried to use the same diameter for both pile cross-sections. To simplify the presentation of the estimation results for each dimension of the cross-sectional shape, the data is plotted on a scatter diagram as figure 5.

The first uses dimensions of 0.4 m for both circular and square shapes. Figure 5 below shows that a dimension of 0.4 m for a square cross-section, provides a value for the bearing capacity of the pile that is greater than that of a circular cross-section. For pile foundations with the same dimensions of 0.4 m, for a square cross-section, it gives a greater value. At a depth of 2.8 m, the value of the bearing capacity of the rectangular cross-sectional pile gives a carrying capacity of 4.14 tons, while the circular cross-sectional pile is 3.25 tons. And then. at a depth of 16.4 m, the value of the bearing capacity of the rectangular cross-sectional pile gives a carrying capacity of 80.49 tons, while the circular cross-sectional pile is 66,41 tons.

The second uses dimensions of 0.6 m for both circular and square shapes. Figure 6 below shows that a dimension of 0.6 m for a square cross-section, it provides a value for the bearing capacity of the pile that is greater than that of a circular cross-section. For pile foundations with the same dimensions of 0.6 m, for a square cross-section, it gives a greater value. At a depth of 2.8 m, the value of the bearing capacity of the rectangular cross-sectional pile gives a carrying capacity of 8.21 tons, while the circular cross-sectional pile is 6.45 tons. And then at a depth of 16.4 m, the value of the bearing capacity of the rectangular cross-sectional pile gives a carrying capacity of 164,736 tons, while the circular cross-sectional pile is 131,616 tons.

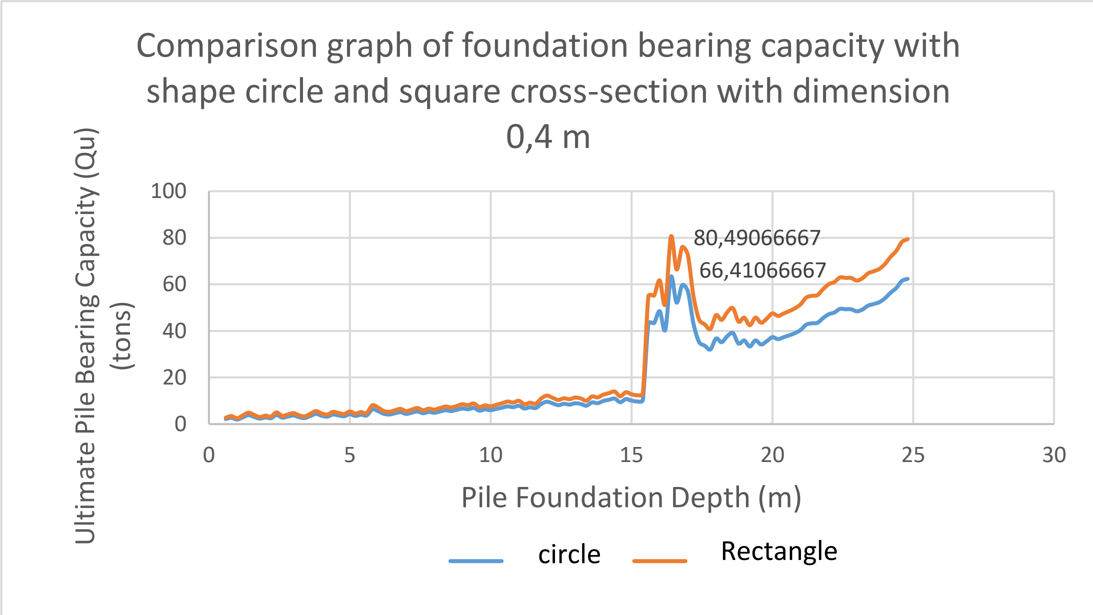
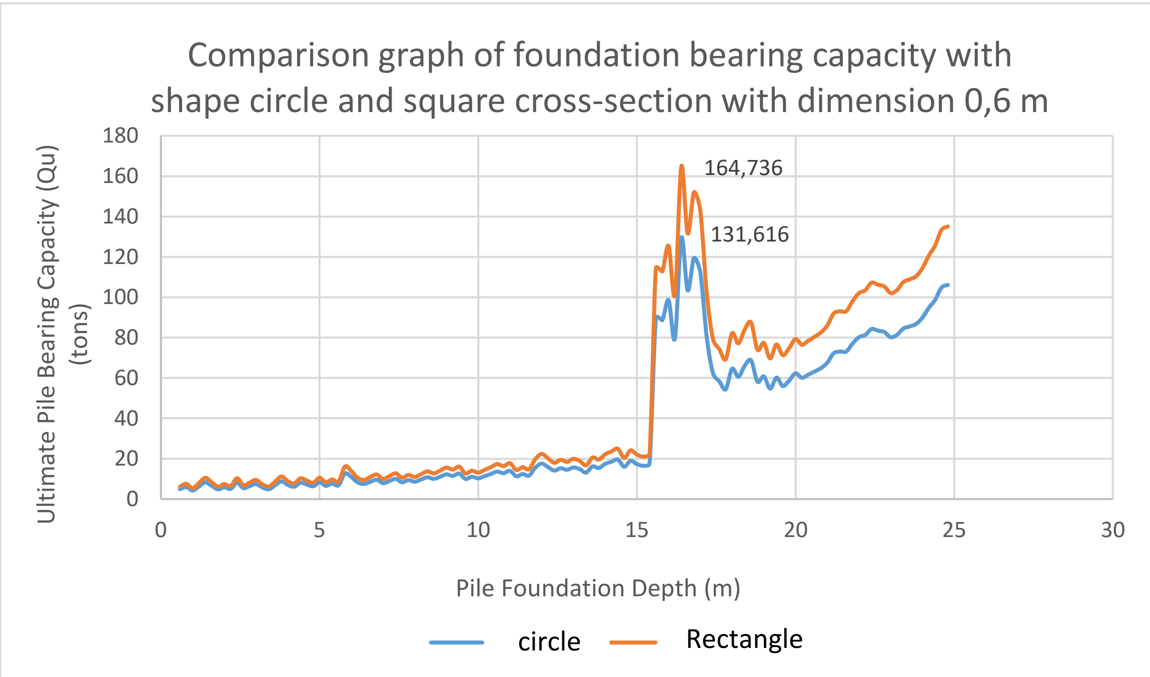


Figure 5. Comparison graph of foundation bearing capacity with shape circle and square cross-section with dimensions 0,4 m



Conclusion

Based on this analysis, it shows that the pile foundation using a square cross-section will provide a greater value for the pile bearing capacity. Increasing the dimensions of the cross-sectional shape, it will provide a greater value for the carrying capacity of the pile as well. This is evidenced at a depth of 16.4 m, for a square cross-sectional dimension of 0.4 m it gives a value of 80.49 tons, while for a cross-sectional dimension of 0.6 m it gives a value of 164.736 tons.

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