

# Suitable Calculation of Shallow Foundation Bearing Capacity by Comparing The Calculation of Terzaghi's and Mayerhorf's Concepts in Jatinangor, West Java Province, Indonesia

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## ABSTRACT

Jatinangor is a major educational area in West Java, Indonesia that the infrastructure continues intensively for supporting the educational facilities. At the infrastructure construction's step needed a calculation of the bearing capacity. The objective of this research is to determine which equation of bearing capacity that suitable for this area. The Methods are using desk work, field work, and laboratory work. For field work using UDS (Undisturbed Sampling) and DCPT (Dutch Cone Penetration Test) in three locations. For laboratory work using tri-axial test and basic properties test. For desk work using shallow bearing capacity calculations by Terzaghi's and Mayerhorf's concepts. The material in this area is clay with brown color and high plasticity. The values of unit weight are 1,725 gr/cm<sup>3</sup>, 1,762 gr/cm<sup>3</sup>, and 1,715 gr/cm<sup>3</sup>, cohesions are 0,178 kg/cm<sup>2</sup>, 0,264 kg/cm<sup>2</sup>, and 0,160 kg/cm<sup>2</sup>, internal friction angles are 4,863°, 4,785°, and 3,810°, and Cones Pressure are 28 kg/cm<sup>2</sup>, 21 kg/cm<sup>2</sup>, and 27 kg/cm<sup>2</sup>. The results of Terzaghi's calculation concepts are 2,37 ton/m<sup>2</sup> in location 1, 2,64 ton/m<sup>2</sup> in location 2, and 2,18 ton/m<sup>2</sup> in location 3. Those three locations are square foundations type. Meanwhile, the results of Mayerhorf's calculation concepts are 0,7 ton/m<sup>2</sup> in location 1, 0,525 ton/m<sup>2</sup> in location 2, and 0,675 ton/m<sup>2</sup> in location 3. Based on comparing the two concepts above, the calculations of shallow foundation bearing capacity which suitable with infrastructure construction in Jatinangor is Terzaghi's calculation concept with square foundation type, because the value is higher than Mayerhorf's calculation.

**Keywords** : Soil, Bearing Capacity, Shallow Foundation, Mayerhorf's Concept, Terzaghi's Concept, Infrastructure.

## 1. Introduction

Infrastructure in Indonesia is well developed, it can be seen in one of the area in West Java Province, Jatinangor. Jatinangor is an education area that the infrastructure continues intensively for supporting the educational facilities. Therefore it needs a solid infrastructure that can survive for a long time. Before the construction begin, it needs some of investigation for the built area. Geotechnics investigation is one of method that can be done before the construction begin. By pay attention to the materials and geological condition, the value of bearing capacity in the built area could be known to determine the feasibility of an area on infrastructure development.

The value could be calculated by using Terzaghi's and Mayerhorf's concepts. The objective is to determine which equation of bearing capacity that

suitable for this area. The research is located in 3 locations at Jatinangor area, exactly at the construction area for the new building of Faculty of Geological Engineering.

## 2. Method

The methods are using field work, laboratory work, and desk work.

### 2.1 Field Work

Field work consists of UDS (Undisturbed Sample) and DCPT (Dutch Cone Penetration Test). Undisturbed samples are soil samples that show the original characteristics. Usually for UDS is using Shelby Tube for sampling, the diameter of shelly tube is about 8 cm and the length is about 50 cm, because

it helps to reduce disturbance towards soil samples for gain the original characteristic of soil.

As defined by R.W Day (2001), The cone penetration test (CPT) is an in situ testing method used to determine the geotechnical engineering properties of soils and delineating soil stratigraphy. The test method consists of pushing an instrumented cone, with the tip facing down, into the ground at a controlled rate (usually 2 centimeters/second). The resolution of the CPT in delineating stratigraphic layers is related to the size of the cone tip, with typical cone tips having a cross-sectional area of either 10 or 15 cm<sup>2</sup>, corresponding to diameters of 3.6 and 4.4 cm (see in fig. 1). This test used to determine value of cone pressure ( $Q_c$ ).



Fig. 1 Dutch Cone Penetrometer

## 2.2 Laboratory Work

Laboratory work consist of basic properties soil test and tri-axial test. Basic properties soil test are used to get a characteristic of soil from some elements. There are 6 elements of basic properties test, but for this research only one element that used in the shallow foundation bearing capacity calculation. The element is unit weight ( $\gamma$ ). Unit weight is comparison between total weight soil and soil volume.

As defined by K.H. Head (1998), The triaxial test is one of the most versatile and widely performed geotechnical laboratory tests, allowing the shear strength and stiffness of soil and rock to be determined for use in geotechnical design. Primary parameters obtained from the test may include the angle of shearing resistance ( $\phi$ ), cohesion ( $c$ ), and undrained shear strength ( $c_u$ ), although other parameters such as the shear stiffness ( $G$ ), compression index ( $C_c$ ), and permeability ( $k$ ) may also be determined. The triaxial test typically involves placing a cylindrical specimen of soil, ranging from 38mm to 100mm diameter, into a cell that can be pressurised (see in fig. 2). Most specimens have an approximate 2:1 height to diameter ratio, and are sealed within a rubber membrane.

## 2.3 Desk Work

Desk work consists of literature studies and calculating the value of shallow foundation bearing capacity. As defined by U.S Army Corps of Engineers (1992), Bearing capacity is the ability of soil to safely carry the pressure placed on the soil from any engineered structure without undergoing a shear failure with accompanying large settlements. Applying a bearing pressure which is safe with respect to failure does not ensure that settlement of the foundation will be within acceptable limits. Therefore, settlement analysis should generally be performed since most structures are sensitive to excessive settlement and generally accepted concept of bearing capacity analysis is to assume that the soil below the foundation along a critical plane of failure (slip path) is on the verge of failure and to calculate the bearing pressure applied by the foundation required to cause this failure condition (John E. Bowles, 1997). This is the ultimate bearing capacity ( $Q_u$ ).

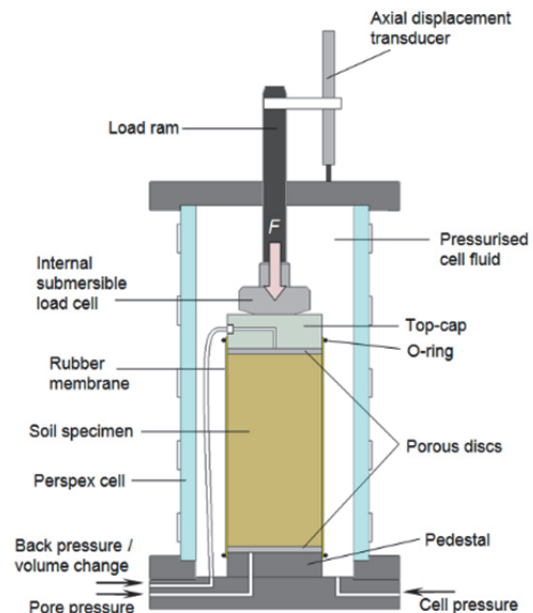


Fig. 2 General set-up of a soil specimen inside a triaxial cell

Moreover, from this work the material of the research area could be known. The material of the research area is clay with brown color and high plasticity. For calculating the values of bearing capacity in the area are using Terzaghi's and Meyerhorf's concepts in Zufaldi Zakaria (2006). There are three equations of bearing capacity ( $Q_u$ ) by Terzaghi's. The following shows an equations :

$$Q_u = (c \cdot N_c + \gamma \cdot D_f \cdot N_q + 0,5\gamma \cdot B \cdot N_\gamma) \quad (1)$$

$$Q_u = (1,3 \cdot c \cdot N_c + \gamma \cdot D_f \cdot N_q + 0,4\gamma \cdot B \cdot N_\gamma) \quad (2)$$

$$Qu = (1,3.c.Nc + \gamma.Df.Nq + 0,4\gamma.B.N\gamma) \quad (3)$$

Where :

- Qu = Ultimate Bearing Capacity Pressure
- G = Unit Weight
- Df = Depth of Foundation
- B = Width of Foundation
- c = Cohesion
- Nq, Nc, N $\gamma$  = Dimensionless bearing capacity factors

The following shows an equation of Mayerhorf's concept:

$$Qu = Qc / 40 . (B + D) \quad (4)$$

Where :

- Qu = Ultimate Bearing Capacity Pressure
- Qc = Cones Pressure
- B = Width of Foundation
- D = Depth of Foundation

For both concept to know allowable bearing capacity value (Qa) are using same formula, the following show an equation :

$$Qa = Qu / F \quad (5)$$

Where :

- Qa = Allowable Bearing Capacity
- Qu = Ultimate Bearing Capacity Pressure
- F = Safety Factor

### 3. Result & Discussion

From the results can be obtained the data that used in the calculation of bearing capacity at 3 different locations with 2 meters depth, 1 meter width foundation, and safety factor F = 3, is shown in Table 1. Calculating data using the bearing capacity of Terzhagi's concept will use three different calculation, there are circular foundation, rectangular foundation, and continuous foundation. Furthermore, after calculating these three different calculations, can be seen that the different values bearing capacity of each calculation.

**Table 1** Variables of bearing capacity

Location	c	$\phi$	$\gamma$	Nc	Nq	N $\gamma$	Qc
1	0.18	4.86	1.73	6.45	1.55	0.43	28
2	0.26	4.79	1.76	6.42	1.54	0.42	21
3	0.16	3.81	1.76	6.13	1.43	0.34	27

Calculations that generate the most large value of bearing capacity shows that the calculation is the most suitable calculation of bearing capacity for the study

area. From the data in Table 1, show some values of Terzhagi's bearing capacity concept by using the formula (1) for the continuous foundation, the formula (2) for the rectangular foundation, and the formula (3) for the circular foundation as shown in Table 2.

**Table 2** Values of Qu by Terzhagi's

Location	Qu (Circular)	Qu (Continues)	Qu (Square)
1	7.06	6.87	7.14
2	7.85	7.49	7.93
3	6.49	6.32	6.56

After the values of Qu determined, then with formula (5) the value of Qa can be calculated that shown in Table 3.

**Table 3** Values of Qa by Terzhagi's

Location	Qa (Circular)	Qa (Continues)	Qa (Square)
1	2.35	2.29	2.38
2	2.62	2.5	2.64
3	2.16	2.11	2.18

After the value of Qa determined, could be seen that square foundation is the largest value of bearing capacity. So the recommended foundation form for this area is square foundation.

Furthermore, the calculation of bearing capacity Mayerhorf's using formula (4) and the data from Table 1. The result of the calculation is shown in table 4.

**Table 4** Values of Qu by Mayerhorf's

Location	Qu
1	2.1
2	1.58
3	2.02

After the values of Qu determined, then with formula (5) the values of Qa can be calculated that shown in Table 5.

**Table 5** Values of Qa by Mayerhorf's

Location	Qa
1	0.7
2	0.52
3	0.68

After calculating values bearing capacity with different concepts, which using Terzhagi's and Mayerhorf's concept, then bearing capacity of different values have been obtained (see table 3 and 5). It can be seen that the bearing capacity values by

using the calculation of Terzhagi's concept generate larger  $Q_a$  value than the calculation by using the Mayerhorf's concept. Different values of bearing capacity between Terzhagi's and Mayerhorf's concept happen because a lot of factors. Several factors are the different variables for each concept (can be seen at formula (1), (2), (3), and (4)). Terzhagi's concept have some different variables that used in the formula with Mayerhorf's concept, there are unit weight ( $\gamma$ ), cohesion ( $c$ ) and dimensionless bearing capacity factors ( $N_q$ ,  $N_c$ , and  $N_g$ ) for Terzhagi's concept and for Mayerhorf's concept there is one different variable, conus pressure ( $Q_c$ ). Can be seen at table 1 that the values of conus pressure at research area is low. So that the values of bearing capacity by using Mayerhorf's concept have less values than the other one (Terzhagi's concept). Low values of conus pressure shown that material of research area have a low stiffness, that matter supported by material composition of research area is clay. Generally, clay is material with low stiffness, that affect to the calculation of bearing capacity. So that the calculation of bearing capacity by using Mayerhorf's concept is not suitable for research area.

Moreover, it also seen from the result of variable by Terzhagi's concept that the cohesion values thereby affecting the bearing capacity values of Terzhagi's concept have larger value. The content of the material in the research area affect the values of cohesion, which known as clay material with a fine grain size, so it has a larger value of cohesion than the coarse grain size material.

#### 4. Conclusions

After calculating values of bearing capacity in the research area obtained different values by using Mayerhorf's and Terzhagi's concepts. Then, after compared the values of bearing capacity by using the different concepts, Terzhagi's concept has greater values than the Mayerhorf's concept. So can be concluded that the calculation of bearing capacity by Terzhagi's concept is more suitable for the research area, because:

- The material of research area is dominated by clay, so the characteristic of soil is low stiffness that show a low values of cone pressure.
- The values of cohesion in the research area is high, because the dominated material is clay. That affect the values of bearing capacity by using the calculation of Terzhagi's concept is greater than the other one (Mayerhorf's concept).

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