

THE COMPARISON STUDY OF THE MONOPOLE TOWER FOUNDATION USING CPT AND LABORATORY DATA IN GRESIK DISTRICT, EAST JAVA-INDONESIA

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Abstract

In the millennial era, the development of information and communication technology is very fast, one of the telecommunications infrastructure is a monopole type telecommunications tower. This type of tower is one of 3 types of telecommunication towers whose main construction is made of steel. The monopole structure is supported by a tread foundation, which is one type of shallow foundation. The main factor in the design of the tread foundation is the bearing capacity factor. Calculation of foundation bearing capacity can be done directly in the field using Sondir data (CPT) and indirectly using laboratory data. In this study a study was conducted to compare the carrying capacity of monopole foundations between field data methods in the form of Sondir data or CPT with result data. Soil tests in the laboratory calculated with the Terzaghi formula. The research location was carried out in Gresik Regency, East Java Province, Indonesia at 3 sites, namely: Mojosarirejo, Kembangan Kebomas and Setromenganti. The results of the comparison of the calculation of the bearing capacity of the foundation (Q) at the Mojosarirejo site with the type of sandy soil. value of $Q_{Sondir} < 9.58\%$ of $Q_{terzaghi}$. At the Kembangan Kebomas site with brown clay and gravely clay, the Q value was $< 69.93\%$ of the $Q_{terzaghi}$ and at the Setromenganti site with brown clay soil type with the influence of water level depth – 1 m, the Q value was $< 27, 62\%$ of $Q_{terzaghi}$. From the comparison of the average calculation in the 3 study locations, the bearing capacity of Q_{Sondir} treads foundation is 26.50 % smaller than $Q_{terzaghi}$, so the use of Sondir data is more accurate for use in tread foundation planning and provides greater security assurance for the tower foundation structure. monopole type.

Keywords: Foundation bearing capacity, tower foundation, monopole, Sondir data, laboratory data.

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1. Introduction

The development of telecommunication is now increasingly advanced, and many people have used it and some even cannot be separated from their daily lives. One of the supports in the world of telecommunications is the existence of a tower or tower. Telecommunication towers are towers made of a series of iron or pipes in the form of rectangles, triangles, or just long pipes [1]. This tower functions to place the antenna, radio transmitter, and as a receiver for telecommunication and information waves. Land area and tower height are among the issues that have been faced by telecommunications operators in terms of tower construction. This is due to high land rental prices in urban areas or regulations from local governments that limit the maximum height of telecommunications towers. Monopole is one type of telecommunication tower in the form of a single pole. The monopole tower type can be used in cities or areas with high population density. The advantages of this type of tower

include the area of land that can be minimized, which is 4 m² or 25 m² with a height of 20 m or 30 m only. Theoretically, some soil mechanics have developed several methods to analyze the bearing capacity of the tower foundations. These methods have different assumptions. The bearing capacity of the soil is an important factor in the planning of the tower foundation and the structure above it. The foundation planning must consider the presence of shear failure and excessive settlement, therefore two criteria need to be fulfilled, namely the criteria for stability and settlement performance. Sondir is, in principle, an attempt to obtain the amount of ground end resistance (CONUS, qc), namely the ability of the soil to accept 10 cm² of piston pressure and the friction resistance between the ground and a tube blanket of 150 cm² [2]. Similar to laboratory testing, one of the methods used to analyze soil bearing capacity is the Terzaghi method. The data from the laboratory test results are used to calculate the bearing capacity and foundation settlement. In this study, let's discuss in detail the comparative study of the bearing capacity of the monopole tower foundation using Sondir data and laboratory test data. Because so far in planning shallow foundations using Sondir data and laboratory data together. Knowing the optimal method for planning shallow foundations, especially the bearing capacity of the foundation, will save costs and time.

Telecommunication towers are towers made of a series of steel structures, in the form of rectangles, triangles, or just one long rod which aims to place the antenna, radio transmitter, and receiver of telecommunications waves and information [3]. The use of steel as the main material for telecommunication towers is because steel has advantages compared to other building materials such as the concrete, wood, or composite. There are 3 types of communication transmitter towers in the field [4], as follows.

The first is a self-supporting tower, which is a tower that has a stem pattern that is arranged and connected to form a stand-alone frame without any other support. The second structure is Guyed Tower, which is a type of tower that is supported by cables anchored on the ground. This tower is arranged in a rod pattern similar to a self-supporting tower, but the guyed tower has a smaller trunk dimension. The third structure is Monopole, which is a type of tower that consists of only one rod or one pillar which is built directly into the ground. From the cross-section of the monopole type tower, it is divided into two types, namely Circular pole, and Tapered pole. In this study, the structure used is the Monopole type. A monopole is a tower that is a single-pole or has only one leg. Monopole tower types are widely used in urban areas or areas with high population density. There are many advantages or efficiency in using this type of tower, including the area of land that can be minimized, which is enough with an area of 4 m² or 25 m². Another advantage is that the tower height can be minimized, monopole can be built with a height of 20 m or 30 m.

The foundation is a part of building construction that is tasked with laying the building and continuing the load of the upper structure (upper structure/supper structure) to the ground which is strong enough to support it [5]. For that purpose, the building foundation must be calculated to ensure the stability of the building against its load, useful loads, and external forces such as wind pressure, earthquakes, etc., and there should be no lowering of the local foundation or evenly distributed subsidence of the foundation, certain limit [6]. The foundation used in the monopole tower structure is the tread foundation. The footplate is a type of shallow foundation with a foundation depth of less than 1/3 of the width of the foundation to a depth of fewer than 3 meters with a structure of reinforced concrete with certain reinforcement dimensions used to support individual point loads such as structural columns [7]. The foundation of this tread is circular square or square. The structure of the tread foundation is shown in **Fig. 1**.

One example of tread foundation is shown in **Fig. 1**. The foundation with a palm width of 2000 mm, a thickness of 500 mm with a number of main reinforcement units of 16 units/unit, a diameter of 16 mm. Pedestal with a height of 1500 mm, width of 500 mm × 500 mm, number of stirrups of 20 units/unit with a diameter of 12 mm, with a thickness of 50 mm of concrete cover.

The Cone Penetration Test (CPT) or what is called Sondir in principle is an attempt to obtain the amount of ground end resistance (CONUS, qc), namely the ability of the soil to accept 10 cm² piston pressure and the friction resistance between the ground with a tube blanket of 150 cm². The working principle of the CPT test is (1) The tube (bi-CONUS, A) as in the image below (position 1) is pressed into the ground through the inner handlebar (inner rod) and the end resistance of the tube (CONUS)

is read on the CONUS dial qc . At the time of pressing, the friction between the ground and the tube wall (f_s) is neglected because the wall of the cone tube (piston) is tapered (tapered) so that it is assumed that there is no friction. **Fig. 2** below shows the process that occurs at the time of CPT suppression; (2) after the end of the tube presses the ground a cm deep (position 2), the second tube (B) will be pulled by the cone tube until it is b cm deep (position 3). The force required to press the cone tube and the second tube is caused by the resistance of the cone qc and the friction between the ground and the wall of the second tube (f_s); (3) At the end of pressing as far as $(a+b)$ cm, the outer rod is pressed so that it returns to its original position (position 4) [8].

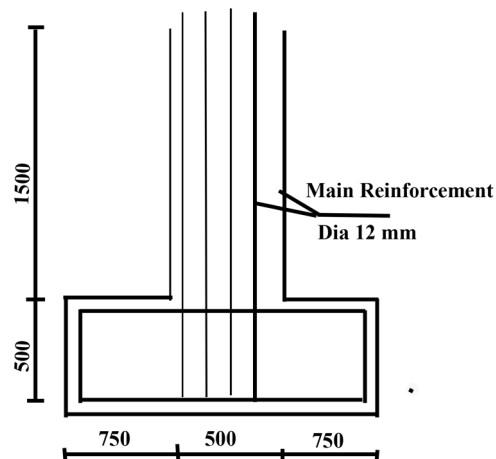


Fig. 1. Foot plate type concrete foundation

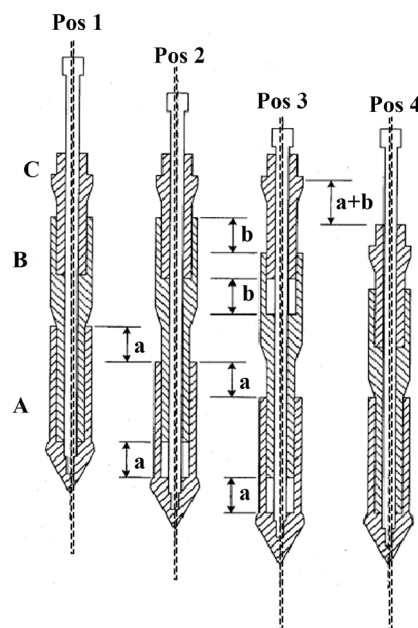


Fig. 2. Emphasis Process

The CPT test results consist of 3 parameters in the form of a Sondir graph as shown in **Fig. 3**. The first parameter is the friction resistance (f_s) per depth (**Fig. 3, a**). The second parameter is the cone resistance (qc) at each depth of spraying (**Fig. 3, b**) and the third parameter is the friction ratio (Fr) which is the ratio between the friction resistance (f_s) and the cone resistance (qc), as in **Fig. 3, c** can be used to predict soil types [9].

The depth of the ground in **Fig. 3** is carried out to a depth of 11 meters, so that the three graphs of the results of the filtering (friction resistance, cone resistance and friction ratio) stop

at a depth of 11 meters. This shows that the watering was stopped because the biconus had reached hard ground.

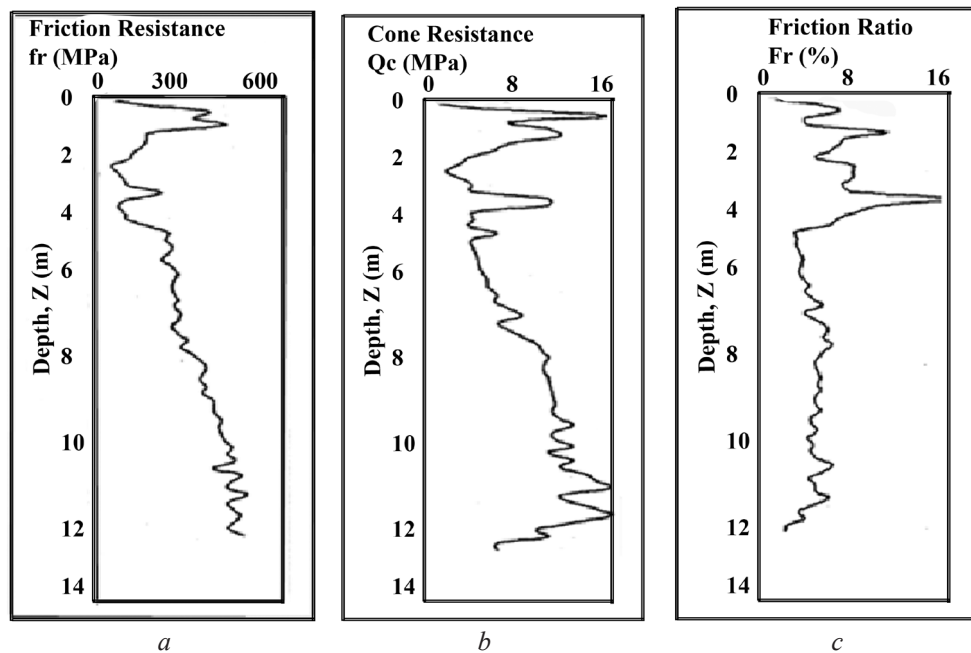


Fig. 3. Graph of CPT Test Results (Sondir):

a – Results of the reading of friction resistance (f_s), *b* – Result of reading cone resistance (q_c),
c – the ratio of the reading of friction resistance to cone resistance (Fr)

Testing in the laboratory is carried out to design the foundation, which is as follows. (1) Testing from Direct Observation, this test is carried out to record the color, smell, consistency of disturbed and undisturbed soil samples obtained from the field; (2) Inspection of moisture content, for soft soil with high moisture content, checking the moisture content is useful to ensure the condition of the extinct soil. Checking the moisture content is part of the soil shear strength test; (3) Granular Analysis, the test is carried out through sieve and sedimentation analysis or hydrometer analysis, to obtain the gradient curve; (4) Plastic Limits and Liquid Limits are tested on selected soil samples from each representative soil type. This soil sample is obtained from a borehole; (5) Triaxial test, limited to clay soils, silt, and soft rock; (6) Free-pressure test, which is useful for determining the undrained shear content of saturated clay soils that do not contain coarse grains, which will be used at bearing capacity; (7) Fan Shear Test, is useful for soil which is very sensitive, soft and makes it difficult to install soil samples at the time of the Press-free Test; (8) Consolidation Test, which is carried out for fine-grained types such as clay and silt and is used to measure the amount of consolidation and velocity of settlement. The test is carried out on an oedometer or consolidometer. From the resulting consolidation coefficient (C_v), the rate of subsidence can be determined; (9) Permeability test, carried out on undisturbed soil samples. This is done to determine the amount of water that must be pumped in the excavation of the foundation soil; (10) Chemical analysis is carried out to determine the possibility of chemical content from groundwater which can damage concrete foundations, steel sheet piles, or steel piles. In summary, the stages of laboratory tests carried out in the design of the foundation are as shown in **Fig. 4**. The research flow chart in the laboratory testing section.

Bearing capacity studies the ability of the soil to support the foundation load of the structure above it. The carrying capacity states the shear resistance of the soil to **Fig. 4** the decline due to loading, which is the shear resistance that the soil can exert along its shear planes [10]. The requirements that must be met in the design of the foundation, namely the safety factor against collapse due to exceeding soil bearing capacity must be met.

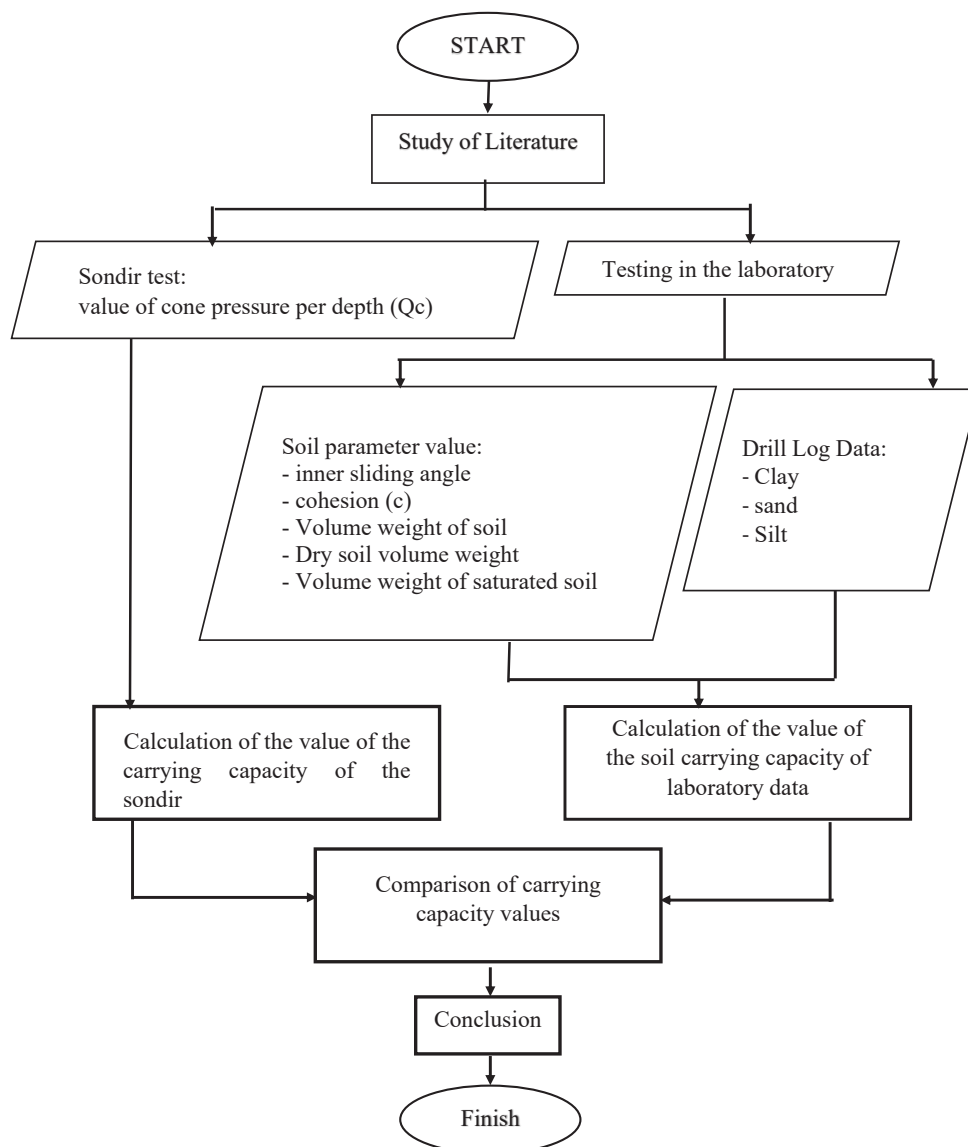


Fig. 4. The research flow chart

In calculating the carrying capacity, generally, a safety factor is used 3. The settlement of the foundation must be within the tolerable value limits. In particular, a differential settlement should not result in damage to the structure. [11] Supporting capacity analysis), based on assumptions including; (a) The foundation is infinitely elongated; (b) The soil under the foundation is homogeneous; (c) The weight of the soil above the base of the foundation is replaced by an evenly distributed load of $P_o = Df\gamma$, where Df is the depth of the foundation and γ is the weight of the volume of the soil above the base of the foundation. Ultimate bearing capacity (q_u) is defined as the maximum load per unit area over which the soil can support the load without collapsing. On a square foundation, Terzaghi provides a form factor influence on the ultimate bearing capacity based on the analysis of the foundation as follows [12]:

$$q_u = 1.3N_c + p_o N_q + 0.4\gamma B N_\gamma, \quad (1)$$

where q_u – ultimate carrying capacity (kN/m²); c – soil cohesion (kN/m²); $p_o = Df\gamma$ – overburden pressure at the base of the foundation kN/m²); γ – weight of soil volume that is considered to the groundwater level (kN/m²).

2. Material and Method

In this study, the data needed is secondary data from field investigations (Sondir) including the value of pressure and cone of each depth (qc). The data soil is consisting of internal shear angle, cohesion, soil volume weight, dry soil volume weight, saturated soil volume weight, and drill log data of soil (clay, sandy soil or silt soil). The data was obtained from three different locations, namely Setromenganti Site, Menganti-Gresik, East Java; Mojosarijejo Site, Driyorejo-Gresik, East Java, and the Kembangan Kebomas Site, Manyar-Gresik, East Java. The selection of the type of foundation based on existing secondary data is more likely to use shallow foundation types. In the next stage, after the required data is complete, the value of the carrying capacity of the sender and the value of the soil carrying capacity of the laboratory data is calculated using the Terzaghi equation for the square type of foundation. The results of the two carrying capacity values will be compared so that the efficiency of the two calculations can be seen.

3. Result

3.1. Result of Calculation of Force on Foundation

The forces that occur in the foundation structure include axial forces, shear forces, and moment bending. This force has been obtained in this study from the results of structural analysis (secondary data) based on the basic reaction from PT. Telkom, Tbk. Indonesia. The load that occurs in the tower building includes dead loads, namely the tower's weight, and live loads, namely all loads that occur due to the load on the tower, including mounts, sectoral antennas, microwave antennas, and their accessories. The forces that occur on the monopole foundation are as shown in Fig. 5.

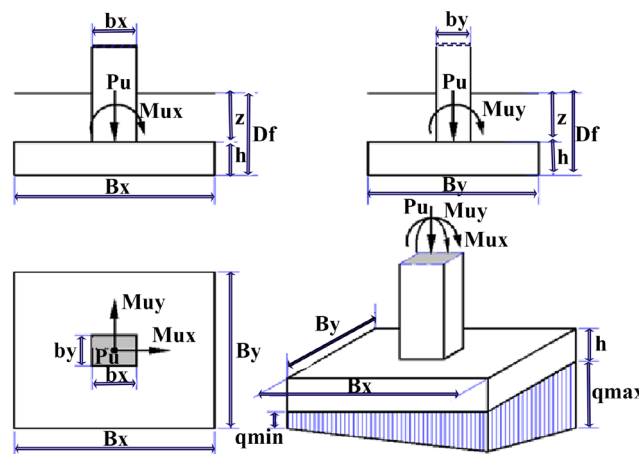


Fig. 5. The forces acting on the monopole foundation structure

Based on this loading, the results of the basic reaction recapitulation from PT. Telkom, Tbk Indonesia as in Table 1.

Table 1

Recapitulation of Loading Results Working on the Monopole Tower Foundation Structure

NODE	Fx kN	Fy kN	Fz kN	Mux kN-m	Muy kN-m	Muz kN-m
902	0.000	8.676	50.84	-182.883	-189.181	-0.978

The typical foundations at the three planned tower building site locations are as follows: (1) Site Mojosarijejo (Fig. 6, a), using a square foundation with a depth of 1.6 m and a foundation area of 2×2 m; (2) Site Kebomas (Fig. 6, b), with a square foundation type with a depth of 3 m and a foundation area of 3×3 m; (3) Site Setromenganti (Fig. 6, c), the type of foundation uses a square foundation with a depth of 3 m and a foundation area of 3×3 m.

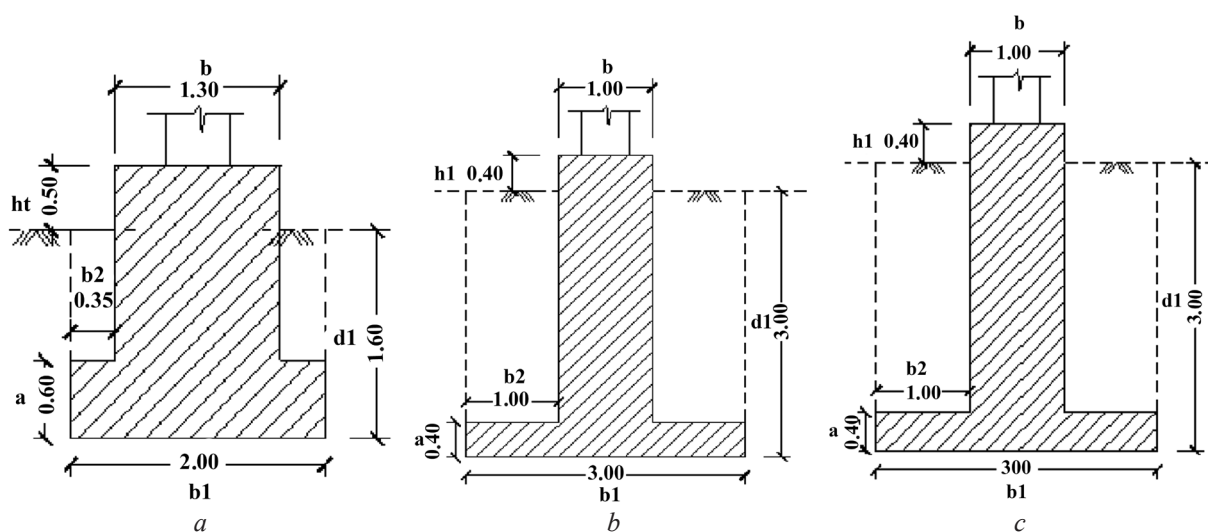


Fig. 6. Dimensions of Monopole Tower Foundation:
a – Site Mojosarirejo; b – Site Kebomas; c – Setromenganti

3. 2. Soil Bearing Capacity Calculation Results

The land must be able to support loads of any construction that is placed on the land. When the soil is subjected to loads such as foundation loads, the soil must not experience distortion and settlement (deformation). To calculate the bearing capacity of the soil based on the soil test, Sondir data can be used. The results of the watering carried out at the Mojosarirejo location are as shown in **Fig. 8**, the Kembangan Kebomas location is as shown in **Fig. 10** and the Setromenganti location is as in **Fig. 12**.

Meanwhile, for the calculation of the bearing capacity of the soil based on laboratory data, the Terzaghi method analysis can be performed. For the calculation of the bearing capacity of the tread foundation at the Mojosarurejo location with the dimensions and types of soil layers as in **Fig. 7**.

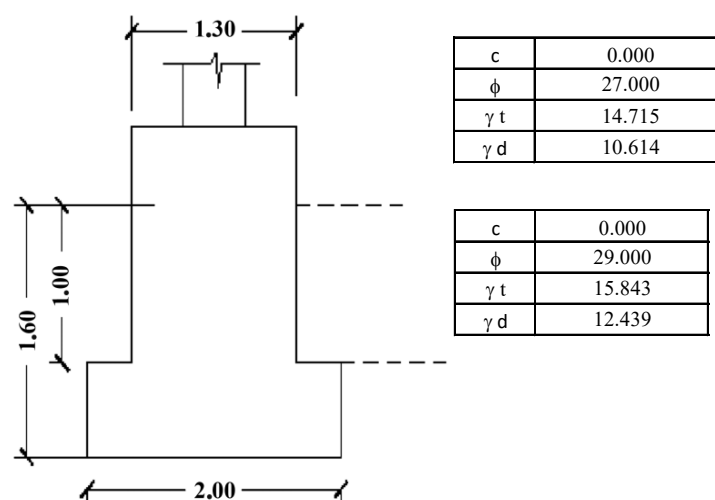


Fig. 7. Dimensions and types of soil layers at the Mojosarirejo Site

The dimensions of the plate foundation at the Mojosarirejo location are on 2 layers of sand soil (**Fig. 7**). The first layer is a type of clay-gravel sand with a depth of 0.0 m to 1.0 m and the second layer is a type of sandy soil with a depth of 1.0 m to 1.6 m. Because the foundation is located in sandy soil, formula 1 is bearing capacity of the Terzaghi method foundation on sandy soil. Formula (2) is as follows.

$$q_u = P_o \cdot N_q + 0.4 \cdot \gamma \cdot B \cdot N_\gamma \quad (2)$$

where q_u – ultimate carrying capacity (kN/m²); P_o (overburden pressure) = $D_f \gamma$; D_f – foundation depth (m); B – foundation width (m); γ – weight of soil volume (kN/m³); N_c , N_q , N_γ – Terzaghi carrying capacity factors.

Laboratory data are used to produce the bearing capacity of the tread foundation on sandy soil (1), for the physical properties of the soil the weight of the soil volume is used (γ) both beside the foundation and under the foundation, while the mechanical properties of the soil require the value of the friction angle of the soil (ϕ), which is used to determine the values of N_c , N_q , and N_γ . The results of the calculation of the bearing capacity of the tread foundation using formula (2) are presented in graphical form as in **Fig. 8** together with the graph of the bearing capacity of the Sondir.

The second study location is in Kembangan Kebomas, with dimensions and types of plywood as in **Fig. 9**. The depth of the foundation plate is 3 m which consists of 3 layers of soil. The first layer is 0.0 to 1.0 m deep with brown clay soil, the second layer is 1.0 to 2.5 m deep, brown clay soil type and the third layer is 2.5 to 3.0 m deep with the type of soil in the clay gravel. In general, the location of Kebomas soil type is soft soil which has a cohesion value (c), so to calculate the bearing capacity of the plate foundation, formula (2) is used. So that the laboratory data for mechanical properties other than the inner friction angle (ϕ), the soil cohesion value (c) is also used. So that the three factors of the carrying capacity of Terzaghi are used N_c , N_q and N_γ .

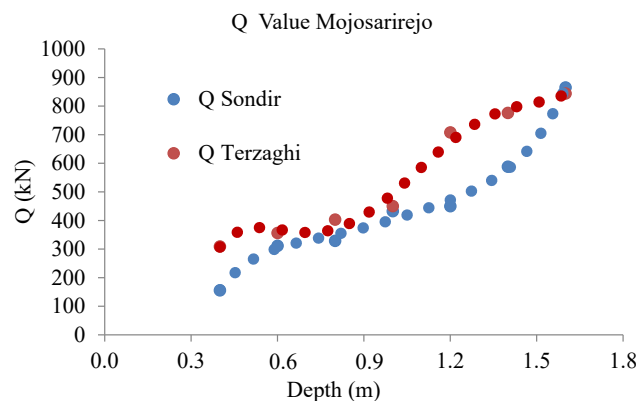


Fig. 8. The Bearing Capacity of Q_{Sondir} and $Q_{terzaghi}$ Site Mojasarirejo

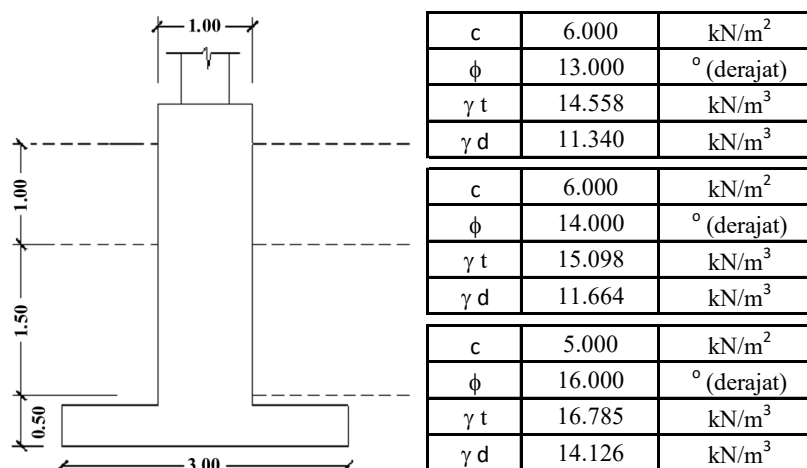


Fig. 9. Dimensions and types of soil layer at the Kebomas Site

The results of the calculation of the plate bearing capacity of the Terzaghi method with the application of formula (1) are presented in graphical form as in **Fig. 10**, which is presented in one image with a Sondir graph at the Kembangan Kebomas location.

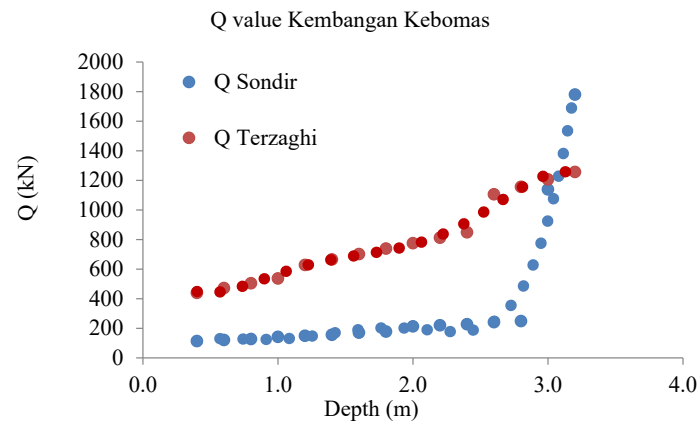


Fig. 10. The Bearing Capacity of Q_{Sondir} and $Q_{terzaghi}$ site Kebomas

The third study location was in Seromenganti, dimensions of the slab foundation and soil type in 2 layers (Fig. 11). The first layer at a depth of 0.0 to 1.0 m is brown clay, while the second layer is 1.0 to 3.0 m deep. The type of soil is brown clay. Location 3 is dominated by clay soil, so to calculate the bearing capacity of the foundation the Terzaghi method uses formula (1).

The results of the calculation of the plate bearing capacity of the Seromenganti location with formula 1 of the Terzaghi method are presented in the form of a plate bearing capacity graph as shown in Fig. 12, which is presented in one image along with the results of the Sondir graph at that location.

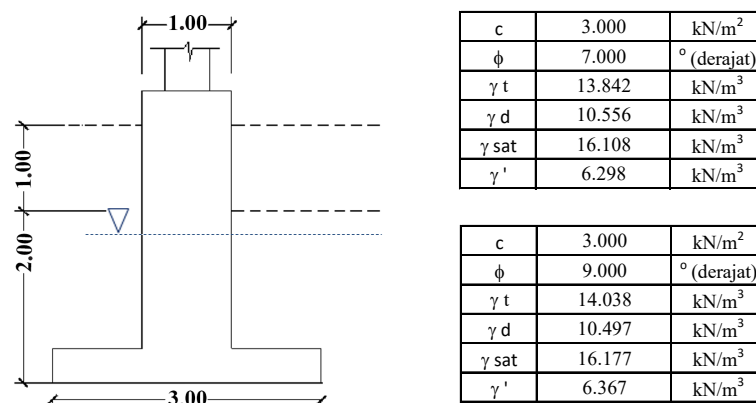


Fig. 11. Dimensions and types of soil layers at the Seromenganti Site

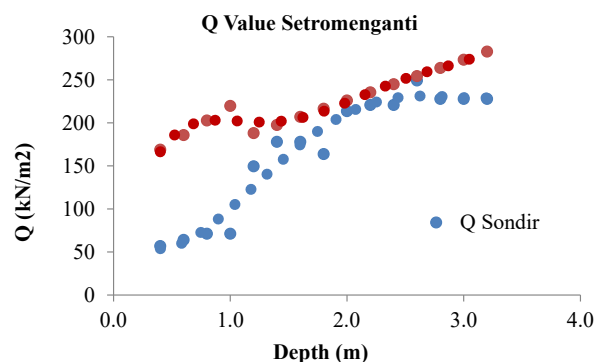


Fig. 12. The Baring Capacity of Q_{Sondir} and $Q_{terzaghi}$ Site Setromenganti

Recapitulation of the Q value of the Mojosariejo Sondir Site with a depth of 1.6 m is 864.92 kN, the Q value of the Kembangan Kebomas Site with a depth of 3 m is 1139.53 kN, and

the Q value of Sondir Site Setromenganti with a depth of 3 m is 227.91 kN. The calculation of carrying capacity based on laboratory data was carried out using Terzaghi analysis. The analysis of the carrying capacity of Terzaghi is based on the following assumptions, including (a) the foundation is infinitely elongated; (b) the soil under the foundation is homogeneous; (c) the weight of the soil above the base of the foundation is replaced by an evenly distributed load of $Po = Df\gamma$, where Df is the depth of the foundation base and γ is the weight of the volume of the soil above the base of the foundation. Ultimate bearing capacity (qu) is defined as the maximum load per unit area over which the soil can support the load without collapsing.

3. 3. Results of Comparison of Soil Bearing Capacity from Sondir and Laboratory Data

Comparative analysis of the bearing capacity of the foundation type of tread at the Mojasarirejo site with the type of sandy soil as shown in Fig. 13 at the beginning, the depth of the Q_{Sondir} value was 40 % < from $Q_{terzaghi}$ and increased to equal the $Q_{terzaghi}$ value at the foundation depth (102 %). So that the overall depth of 0.0 m to 1.6 m of watering, the difference in Q of the palm foundation is 9.58 %.

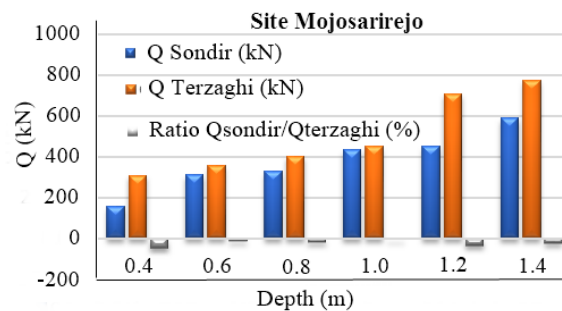


Fig. 13. The difference between the percentage of Q_{Sondir} and $Q_{terzaghi}$ Site Mojasarirejo

The Kembangan Kebomas site (Fig. 14) with brown clay and gravely clay on the foundation soil, at the initial depth of the Q_{Sondir} value tends to have a smaller difference (0 % from $Q_{terzaghi}$ and this condition persists to a depth of 2.8 m. Then Q_{Sondir} 's value equals $Q_{terzaghi}$'s value at the depth of the foundation base (94 %). The percentage difference in Q of the treads at this site starts from a depth of 0.0 m to 3.0 m by 69.93 %.

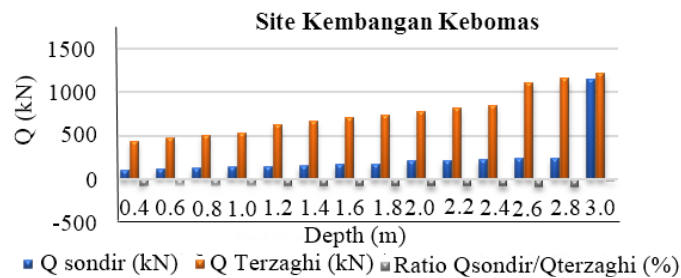


Fig. 14. The difference between the percentage of Q_{Sondir} and $Q_{terzaghi}$ at the Kembangan Kebomas site

The Setromenganti site (Fig. 15) is a type of brown clay soil with the effect of a water level of -1 m depth, at the initial depth of 0 to -1 m the Q_{Sondir} value tends to have a difference of < 34 % from $Q_{terzaghi}$, and survives this condition until it reaches the groundwater level. When it reaches a groundwater level to a foundation depth of -3 m, the Q_{Sondir} value almost equals the $Q_{terzaghi}$ value (80–95 % percentage). The difference in the percentage of the bearing capacity of the treads at this site from a depth of 0.0 m to 3.0 m is 27.62 %.

The comparison of the calculation of the bearing capacity of the tread foundation at 3 study locations (Fig. 13–15) shows that $Q_{Sondir} < Q_{terzaghi}$ with an average percentage difference of 26.50 %. The Mojasarirejo site is the smallest in terms of sand, this shows that the sandy soil

has no cohesion [10] so that the sticky Sondir or cone friction resistance is very small. But $Q_{terzaghi}$ becomes large because from Terzaghi's formula the shallow foundation coefficient (N) obtained from the friction angle in sandy soil is very large and a very shallow depth factor of 1.6 m, so the difference between Q_{Sondir} and $Q_{terzaghi}$ is not so significant. This phenomenon is very different for the other 2 locations because the watering is quite deep with a depth of 3 m.

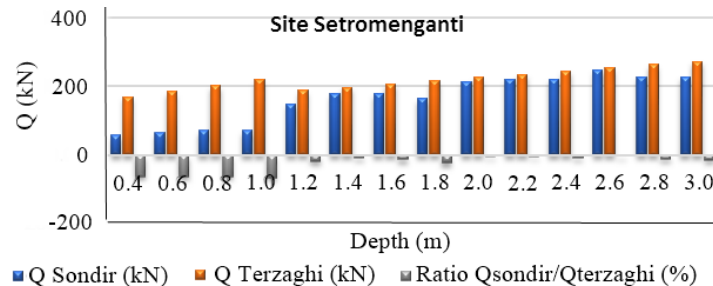


Fig. 15. The difference between the percentage of Q_{Sondir} and $Q_{terzaghi}$ Site Setromenganti

The results of the comparison of the bearing capacity of the plate foundation between the soil Sondir method in the field and laboratory data using the Terzaghi method in 3 study locations in Gresik, Indonesia are as shown in **Fig. 16**.

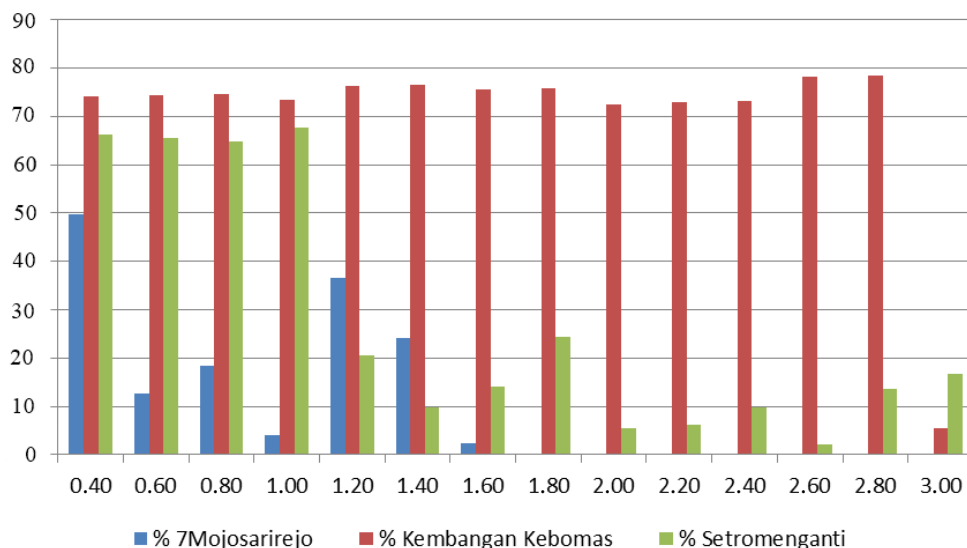


Fig. 16. The Comparison of Percentage Value of Q_{Sondir} Against $Q_{terzaghi}$ in Three Research Locations

4. Discussion

Analysis of the percentage comparison of the bearing capacity of the foundation type of palm in the three research locations as shown in **Fig. 16**. The largest percentage comparison is at the Kembangan Kebomas Site with clay soil types (red graph) of 69.93 %, then Setromenganti Site with water saturated clay types (graph in green color) with a percentage difference of 27.62 %. and the smallest is the Mojosarirejo site with the type of sandy soil (blue graph) which has a large percentage difference between Q_{Sondir} and $Q_{terzaghi}$ is only 9.58 %. This phenomenon shows that the use of Sondir data more accurate than laboratory data for calculating the bearing capacity of treads on clay or fine-grained soils. But for sand or coarse grained soils, the use of Sondir data and laboratory data for the calculation of the carrying capacity of the tread foundation is not much different even though the Sondir data is still more accurate than laboratory data, so in general that the calculation of the carrying capacity of Sondir is smaller than the carrying

capacity of the data calculation. Laboratory (Terzaghi method), then the use of Sondir can be used in planning the tread foundation and will provide greater security guarantees for the structure to be supported.

In the field, foundation planning is carried out on all building foundations, both shallow and deep foundations. Practitioners' activities to engineer deep foundations such as drill pile foundations or piles, it is not enough to carry out soil investigations with Sondir to calculate the bearing capacity of the foundation, but soil samples must be taken for laboratory tests so that the analysis results given are more accurate.

Sondir data is very good for calculating the bearing capacity of shallow foundations, but for calculating the bearing capacity of deep foundations, to obtain a more accurate analysis, Sondir data must be combined with laboratory data. So that for the development in designing the bearing capacity of the foundation, a combination of Sondir data and laboratory data is carried out through soil inspection using a machine drill and SPT (Standard Penetration Test).

5. Conclusion

1. The results of the calculation of the bearing capacity of the tower foundation using Sondir data at the Mojosarirejo site, the Conus penetration of 250 kg/cm² is at a depth of 1 m (S1) and a depth of 1.6 m (S2). As a safety consideration, the analysis used Sondir S2 data, with a Q_{Sondir} value of 864.92 kN. Site Kembangan Kebomas, Conus Penetration 250 kg/cm² at a depth of 3.2 m (S1), and a depth of 2.6 m (S2), as the analysis used Sondir S1 data, with a Q value of 1139.53 kN Sondir. Site Setromenganti, Conus Penetration 250 kg/cm² is at a depth of 8.6 m (S1) and a depth of 9.0 m (S2). For safety considerations, the analysis used Sondir S2 data, and at a depth of 3.0 m with a Q value of 227 Sondir, 91 kN.

2. The results of the calculation of the bearing capacity of the tower foundation using laboratory data Q_{terzaghi} Site Mojosarirejo, at a depth of 1.6 m (S2), the value is 844.18 kN. Site Kembangan Kebomas, the calculation of the carrying capacity of Q_{terzaghi} at a depth of 3.2 m (S1) obtained a value of 1257.22 kN. Setromenganti site, the calculation of the carrying capacity of Q_{terzaghi} at a depth of 3.0 m (S2), obtained a value of 273.34 kN.

3. Comparison of carrying capacity values, Mojosarirejo Site with sandy soil types, the value of $Q_{\text{Sondir}} < 9.58\%$ of Q_{terzaghi} . Site Kembangan Kebomas with brown clay and gravelly clay, the value of $Q_{\text{Sondir}} < 69.93\%$ from Q_{terzaghi} . Site Setromenganti with brown clay soil type with the influence of water level depth of -1 m, the value of $Q_{\text{Sondir}} < 27.62\%$ of Q_{terzaghi} . Overall from 3 study locations $Q_{\text{Sondir}} < 26.50\%$ from Q_{terzaghi} .

4. The value of Q_{terzaghi} is relatively greater than Q_{Sondir} at each depth. Because the calculated value of the bearing capacity of the foundation with Sondir data is smaller than the calculation of the bearing capacity of the foundation with laboratory data (Terzaghi method), the use of Sondir data is more accurate to use in foundation planning and will provide a greater number of safety for the monopole-type telecommunication tower foundation structure.

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