ANALYSIS OF CONFIGURATION OF PILE GROUP ON SUPPORTING CAPACITY AND PILE EFFICIENCY IN TANJUNG BALAI FLAT CONSTRUCTION

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ABSTRACT

In the TanjungBalai Flats creation project, the inspiration used is a mini pile basis with a set pile device. The organization pile device on the inspiration withinside the creation of this flat is deliberate to have a exclusive wide variety of piles, particularly piles, 3 piles, 4 piles. Therefore, on this look at diverse pile configurations might be completed with the aid of using modelling exclusive configurations with the equal wide variety of piles as the development of this flat. Furthermore, the sporting ability and performance values might be as compared that is the first-class value. Calculations on this look at had been the usage of the direct method (Direct One) and the pile performance component for the evaluation of the pile bearing ability. The calculation is accomplished primarily based totally at the soil statistics received withinside the shape of sondir statistics. The significance of the pile performance value (Eg) in a pile organization is encouraged with the aid of using the pile arrangement, the wide variety of rows, the wide variety of piles in a single row, and the pile distance inclusive of the three pile configuration of the project (V3) has an performance value (Eg) = 0,817 and (Qg) = 205.27 whilst the evaluation of the layout pile (V3-1) has an performance value (Eg) = 0.861 and (Qg) = 216.32. From the calculation effects it could be concluded that the effect of organization pile configuration at the pile bearing ability is encouraged with the aid of using the significance of the pile performance (Eg), the more the pile performance, the more the sporting ability.

Keywords: *foundation; configuration; foundation bearing capacity; efficiency; sondir.*

ABSTRAK

Pondasi yang digunakan pada proyek pembangunan Rumah Susun Tanjung Balai adalah pondasi mini pile dengan sistem group pile. Sistem tiang pancang pada pondasi pada pembangunan rumah susun ini direncanakan memiliki jumlah tiang yang berbeda yaitu dua tiang, tiga tiang, empat tiang. Oleh karena itu, pada penelitian ini akan dilakukan berbagai konfigurasi tiang pancang dengan memodelkan konfigurasi yang berbeda dengan jumlah tiang yang sama dengan pembangunan rumah susun ini. Selanjutnya akan dibandingkan nilai daya dukung dan efisiensi yang merupakan nilai terbaik. Perhitungan dalam penelitian ini menggunakan metode langsung (*Direct One*) dan faktor efisiensi tiang untuk analisis daya dukung tiang. Perhitungan dilakukan berdasarkan data tanah yang diperoleh berupa data sondir. Besarnya nilai efisiensi tiang (Eg) pada kelompok tiang dipengaruhi oleh susunan tiang, jumlah baris, jumlah tiang dalam satu baris, dan jarak tiang seperti konfigurasi proyek 3 tiang (V3) memiliki nilai efisiensi (Eg) = 0,817 dan (Qg) = 205,27 sedangkan analisis desain tiang pancang (V3-1) memiliki nilai efisiensi (Eg) = 0,861 dan (Qg) = 216,32. Dari hasil perhitungan dapat disimpulkan bahwa pengaruh konfigurasi group pile terhadap daya dukung tiang dipengaruhi oleh besarnya efisiensi tiang (Eg), semakin besar efisiensi tiang maka daya dukung tiang semakin besar.

Kata kunci: *Pondasi, Konfigurasi, Daya tunjang pondasi, Efisiensi, Sondir*

1. INTRODUCTION

All construction engineered to rest on the ground must be supported by a foundation. The foundation is part of an engineering system that transmits the load supported by the foundation and its own weight into the soil and rock that lies below it.

The soil conditions in Tanjung Balai are generally in the form of soft peat slabs and the surface layer contains organic materials as a result of weathering of wood (original vegetation). This condition provides a low soil bearing capacity for a construction system to be built on it. Meanwhile, soil with better bearing capacity can only be found at a depth of 5 - 10 meters. To overcome the condition of the unfavourable soil bearing capacity, preliminary works are carried out to improve the bearing capacity of the soil, such as replacing the poor soil with better soil, using piles or stabilizing the soil with more appropriate methods.

The organization pile machine can't be separated from the pleasant configuration making plans to get a excessive cost of bearing potential and coffee agreement. Therefore, on this examine diverse pile configurations can be executed with the aid of using modelling one-of-a-kind configurations with the equal quantity of piles as the development of this flat. Furthermore, the cost of bearing potential and pile agreement can be as compared that is the pleasant cost in order that the end result of this multiplication can be used because the bearing potential of the foundation.
The purpose of writing this thesis is to determine the effect of group pile configuration on the pile bearing capacity and pile efficiency. The group pile system on the foundation in the construction of this flat has a different number of piles, namely two, three, and four piles. The group pile system cannot be separated from the best configuration planning to get a high value of bearing capacity and low settlement. Therefore, in this study various pile configurations will be carried out by modelling different configurations with the same number of piles as the construction of this flat. Furthermore, the

value of the carrying capacity and efficiency of the pile will be compared which is the best. From these known results, it is hoped that it can recommend the use of pile groups on soft soils that are more efficient and have better bearing capacity.

Pile

Piles are creation components fabricated from wood, concrete, and/or steel, which might be used to transmit (transmit) floor masses to decrease floor degrees withinside the soil mass [1]. The function and use of the pile foundation is to transfer or transfer loads from the construction above it (super structure) to a very deep layer of hard soil [2]. The angle of inclination that can be achieved by the pole depends on the tool used and is also adjusted to the plan.

Piles are generally used [3]:

1. To lift construction loads above the ground into or through a layer of soil. In this case vertical loads and lateral loads may be involved.
2. To oppose the upward force, the overturning force, as for the sole of the basement below the saturated water boundary or to support the tower legs against overturning.
3. Compresses loose cohesive deposits through a combination of pile displacement and thrust vibration. These piles can be pulled out later.
4. Controls deflection/sliding when the feet are spread out or the sole is on the edge of the soil or underlain by a layer of high compression.
5. As a safety factor for encroachment under bridge supports and/or pears, especially if erosion is a potential problem.
6. In offshore construction to transmit loads above the water surface through the water and into the soil underlying the water. This applies to piles that are embedded as and which are affected by both vertical and buckling loads and lateral loads.

Types and conditions of foundation supporting soil

Soil is a collection of particles of various sizes. Soil is produced as a by-product of mechanical and chemical weathering of rocks where some of these particles are given special names such as gravel, silt, clay and so on [4].

Soil consists of solid particles with water and air filling the empty spaces between the solid particles. Soil as a supporting medium for the foundation has different characteristics according to the type and condition of the soil. Various parameters that affect soil characteristics include: grain size, specific gravity, moisture content, density, void ratio, and so on which can be determined through laboratory investigations.

The value of the shear strength of the soil indicates the magnitude of the bearing capacity of the soil. The value of the shear strength of the soil is influenced by the soil cohesion and the shear angle of the soil. If the sheer force acts on a soil mass where the normal stress (σ) also acts, then the value of the shear stress (τ) will increase due to deformation until it reaches the limit value. If this limit value is connected with different normal stresses (σ), a straight line will be obtained. The shear strength of this soil can be simplified in the form of the following equation by Coulomb:

$$\tau = c + \sigma \tan \phi \quad (1)$$

Description:

τ : Soil shear strength (kg/cm2).
c : soil cohesion (kg/cm2).
σ : Normal stress on the ground (kg/cm^2).
ϕ : Ground shear angle (^{o}).

The cohesion value (c) is the magnitude of the attractive force between soil particles, while the soil shear angle (ϕ) is the resistance to shifting soil particles. The value of c and in a soil sample can be determined through soil shear testing in the soil mechanics laboratory. Soil shear strength can be divided into values that depend on the shear resistance between the soil particles and the surface cohesion of the soil particles.

Types and criteria for use of piles

In planning the foundation of a construction, several types of foundations can be used. The selection of the type of foundation used is based on several things:

1. The function of the superstructure to be borne by the foundation.
2. The magnitude of the load and the weight of the superstructure.
3. The condition of the land where the building is erected.
4. The cost of the foundation compared to the superstructure.

Of the several types of foundations that can be used, one of them is the pile foundation. Pile foundation serves to move or transfer loads from the construction above it to a deeper soil layer. Criteria for the use of piles used for a building foundation are very dependent on the following conditions [5]:

1. The sub grade under the building has no carrying capacity (eg offshore development).
2. The sub grade under the building is not able to bear the load of the building above it or hard soil that is able to carry the load away from the ground surface.
3. Development on uneven ground.
4. Meets the need to withstand the upward thrust.

5. Types of piles can be grouped according to the way the load is transferred into the ground and according to the load used.

Driving equipment

To drive the piles into the ground, a pile is used. Basically, there are three types of piles, namely:

1. Drop hammer
   Drop hammer is a heavy hammer that is placed at a certain height above the hammer pole and then released and falls on the top of the pole, to avoid being damaged by this impact, a cap or cap is attached to the head of the pile as an energy barrier or shock absorber. Usually the stamp is made of wood.
2. Diesel hammer
   This type of pile driving tool is simpler than other hammers. The diesel hammer has a single cylinder with two diesel engines, pistons, or rams, fuel tank, oil tank, fuel pump, injectors, and engine lubricant.
3. Hydraulic Hammer
   The way this hammer works is based on the pressure difference in the hydraulic fluid. One of the hammers of this type is used to drive H steel pile foundations and steel slab foundations by gripping, pushing and pulling.

Static cone penetration test (Sondir)

Static cone penetration test or sondir test is widely used in Indonesia. This test is very useful for obtaining the value of variations in the density of sandy soils that are not compacted. In dense sandy soils and gravel and rocky soils, the use of sondir tools becomes ineffective, because they have difficulty penetrating the soil. The values of static cone resistance or cone resistance (qc) obtained from the test can be directly correlated with the bearing capacity of the soil and settlement of shallow foundations and pile foundations [6].

Advantages of sondir test:
- Quite economical and fast.
- Can be repeated with relatively similar results.
- Empirical correlation that is proven to be more reliable.
- The development is increasing, especially with the addition of sensors in electric sondir.

Disadvantages of sondir test:
- No soil samples were obtained.
- Limited penetration depth.
- Cannot penetrate gravel or dense layers of sand.

The Cone Penetration Test (CPT) or sondir (ASTM D-3441) is a method of assessing the stratigraphy of the subsurface layer associated with soft materials, organic materials (peat), materials that have the potential to melt (liquefiable) such as: clay, sand, and round rocks and landslides (landslides).

Carrying capacity

Carrying capacity analysis studies the soil in supporting the load on the foundation of the structure located above it. Bearing capacity expresses the shear resistance of the soil to resist settlement due to loading, i.e. the shear resistance that the soil can exert along its shear planes. According to Deka [7], regarding the Study of the Effect of Pile Group Configuration on the Carrying Capacity of Soil for Reinforcement of Road Foundations in Peat Soil, it is stated that in the science of soil improvement, several soil improvement methods have been known, both primitive/traditional and those already using advanced technology. Because development work is limited in cost, cheap but stable repair methods still require innovation that will continue to develop. An improvement method is usually only suitable for certain conditions, among others, according to the type of soil [8].

Bearing capacity of single pile

Pile bearing capacity is the ability or capacity of the pile to support the load. For pile bearing capacity of static cone test (CPT) or sondir [9]. Calculation of the pile bearing capacity is carried out using the direct method or direct one by Mayerhoff, Tomlinson, Begemann., with the following equation:

$$Qu = q_c \cdot A_p + JHL \cdot K_t \quad (2)$$

Description :
Qu = Single pile bearing capacity (ton)
qc = Prisoners end sondir (ton/m²)
Ap = Base cross-sectional area (m²)
JHL = Amount of sticky resistance or total friction
K = Pole circumference

Group pile bearing capacity

The value of the group pile bearing capacity can be obtained using the pile efficiency factor with *Converse Labarre* method expressed by the equation [10]:

Qg = Eg.n .Qu (3)

Description :
Qg = Group pile bearing capacity
Eg = Pile group efficiency
n = Number of poles in the group
Qu = Single pile bearing capacity

Pillar permit bearing capacity

To obtain the permissible bearing capacity of the pile, the ultimate bearing capacity of the pile is divided by a certain safety factor. The bearing capacity of the piles that have been widely used for the design of single piles by *Terzaghi* method is as equation follows:

$$Qa = \frac{Qu}{F} \quad (4)$$

Description:
Qa = Pile bearing capacity
Qu = Single pile bearing capacity
F = Safe factor value

Permitted pile bearing capacity that has been widely used for group pile design is as follows (4):

$Qga = \frac{Qg}{F}$ for Qu . n > Qg)

$Qga = \frac{Qu.n}{F}$ for Qu . n < Qg)

Description:
Qga = Pile group permit bearing capacity
Qu = Single pile bearing capacity
n = Number of poles per group

Safety factor

To obtain the capacity of the tip of the pile, it is necessary to have an ultimate capacity divisor which is called a certain safety factor. This safety factor needs to be given with the aim of:

1. To provide security against the uncertainty of the calculation method used.
2. To provide safety against variations in shear strength and compressibility of the soil.
3. To ensure that the pile material is safe enough to support the working load.
4. To ensure that the total settlement that occurs in a single pile or pile group is still within the tolerance limits.
5. To ensure that non-uniform settlement between piles is within tolerance limits.

2. RESEARCH METHOD

Research sites

The location of this research was taken at the apartment construction project in TanjungBalai, Jalan SyehAgul, Sei Raja, Sei TualangRaso, TanjungBalai City. This location can be reached with a distance of about 1.8 km from TanjungBalai Train Station.

Figure 1. The photo of apartment project

Preparation phase

The preparation stage is an activity before collecting and managing data, at this stage the activities that must be carried out are arranged with the aim of making planning effective. Initial preparations made by the author to support the smooth preparation of the analysis are as follows:

1. Complete the administrative requirements of the Analysis.
2. Completing the literature study in the form of collecting material as a reference in data analysis.
3. Determine temporary data requirements.

Data processing

The data collection carried out in this study was in the form of secondary data collection. Secondary data is data obtained not from the results of the research itself. Secondary records withinside the shape of soil records, records types, dimensions also configuration of piles. The analysis in this study was carried out using the SAP2000 software.

a. Land Data
The data used in this final project was obtained from the contractor for the construction of the TanjungBalai Flats, namely PT. INDONESIAN GEO STRUCTURE. Soil data obtained in the form of soiltest work (sondir).

b. Structure Data
Structural data used in this final project is in the form of data on types, dimensions, and configuration of piles. The data was obtained from a consultant (PT. MITRAPLAN KONS) on the TanjungBalai Flats construction project.

Research steps

In this research, the authors analyze the configuration of the pile group on the carrying capacity and efficiency of the pile (Case Study of the TanjungBalai Flats Construction Project). Where there are several models of group pile variations that will be compared the results in the form of carrying capacity and pile efficiency. To achieve the aims and objectives of this study, several stages were carried out which were deemed necessary and are outlined as follows:

1. The first stage is to collect data, review and study the literature on text books and journals related to pile foundations, problems with pile foundations, with the design and implementation of pile driving.
2. The second stage is to visit the research location directly and determine the data collection location that is deemed necessary
3. Data collection Data of Land (Sondir), Kind of Pile, Dimension and Model Data of Pile Configuration
4. Calculation of living carrying capacity pile efficiency calculation carrying capacity calculation
5. Finding the results of the comparison of pile variations to pile carrying capacity
6. Make conclusions and suggestions

3. RESULT AND DISCUSSION

Data of land

The land investigation includes 2 sondir points in the TanjungBalai Flats construction project. The location of the investigation point for the sondir data is placed in an area that is estimated to represent local soil conditions. Then it can be determined which points will be used to analyze variations in pile configuration. The institution pile device on the muse withinside the production of this flat is deliberate to have a special wide variety of piles, specifically two, three, and 4 piles. The institution pile device can not be separated from the exceptional configuration making plans to get a excessive wearing capability cost and be greater efficient. Therefore, in this study various pile configurations will be carried out by modeling different configurations with the same number of piles as the construction of this flat. Furthermore, the value of the carrying capacity and efficiency of the pile will be compared which is the best.

Pile group configuration variations

The configuration of the pile group was obtained from the Tanjung Balai Flats Construction Project (V3 and V4) and the configuration variations that were planned by themselves (V3-1, V3-2, V4-1, V4-2, V4-3). In the following Figure 3 :

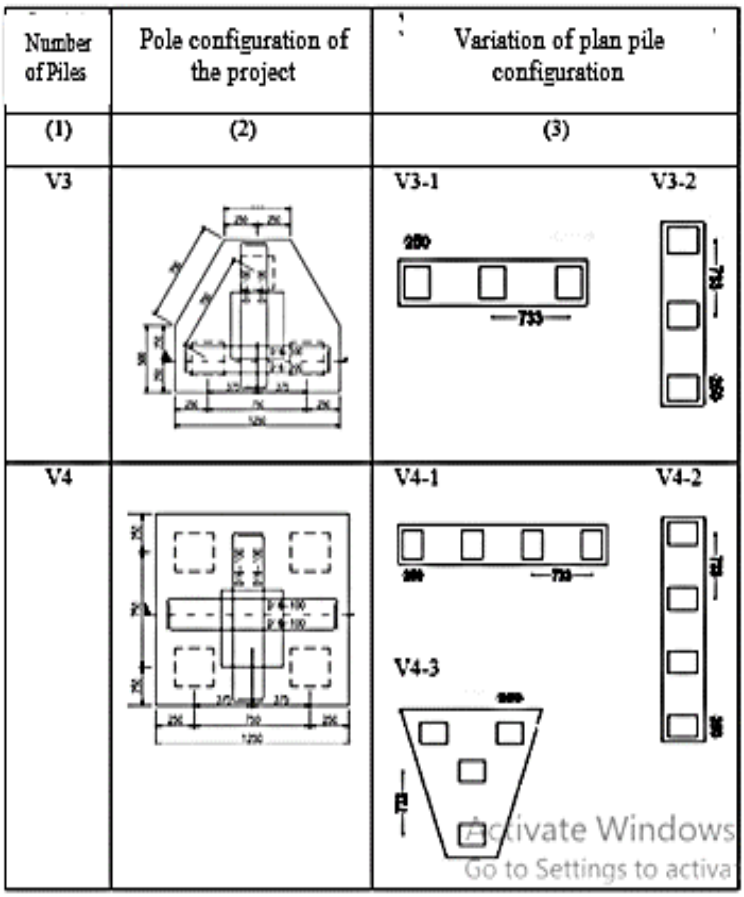

Figure 2. Pole Configuration and Varioation Pile Configuration

Calculation of single pile bearing capacity (Qu)

The calculation of the single pile bearing capacity in this study uses the direct one method where in this study using the same pile in the form of a rectangle with a size of 25 x 25 cm.

Qu = Qc . Ap + JHL . k

= 540 . 0,0625 + 50 . 1

= 83,75 ton

$$Qa = \frac{Qu}{F}$$

$$Qa = \frac{83,75}{3}$$

= 27,91

Pole efficiency calculation (Eg)

By analyzing the variation of pile configuration in this final project, the calculation of pile efficiency is very influential in determining the effect of pile variations, especially in calculating the carrying capacity of group piles.

$$Eg = 1 - \frac{(n'-1).m+(m-1).n'}{90.m.n'}$$

Pole efficiency calculation with 3 pole configuration

- 3 Pole Configuration of Project (V3) = 0,817
- Pole Configuration (V3-1) = 0,861
- Pole Configuration (V3-2) = 0,861

Pole efficiency calculation with 4 pole configuration

- 4 pole configuration of Project (V4) = 0,817
- Pole Configuration (V4-1) = 0,844
- Pole Configuration (V4-2) = 0,844
- Pole Configuration (V4-3) = 0,756

Calculation of group pile bearing capacity (Qg)

The calculation of the group pile bearing capacity in this final project uses the pile efficiency factor.
Qg = Eg . n . Qu

Calculation of group pile bearing capacity with 3 pole configuration

- V3 → Qg = 0,817 x 3 x 83,75
  Qg = 205,27
- V3-1 → Qg = 0,861 x 3 x 83,75
  Qg = 216,32
- V3-2 → Qg = 0,861 x 3 x 83,75
  Qg = 216,32

Calculation of group pile bearing capacity with 4 pole configuration

- V4 → Qg = 0,817 x 4 x 83,75
  Qg = 273,69
- V4-1 → Qg = 0,844 x 4 x 83,75
  Qg = 282,74
- V4-2 → Qg = 0,844 x 4 x 83,75
  Qg = 282,74
- V4-3 → Qg = 0,756 x 4 x 83,75
  Qg = 253,26

Results of comparison of pile variations on bearing capacity and pile efficiency

Based on the result above, here is the result of comparison of Pile Variation on Bearing Capacity and Pile Efficiency in table 1 below:

Table 1. Configuration of 3 Poles

3 Poles Configuration	Poles Eficiency (Eg)	Group carrying capacity (Qg) (ton)	Group permit carrying capacity (Qga) (ton)
V3	0,817	205,27	68,42
V3-1	0,861	216,32	72,10
V3-2	0,861	216,32	72,10

From table 1, it can be seen that the configuration affects the efficiency of the pile, thus the bearing capacity of the pile group also has an effect. The highest difference in the calculation results for the variation of the 3 pile configuration on the group permit bearing capacity is 3.68 tons. From the calculation results obtained the value of the largest permit bearing capacity in the variations V3-1 and V3-2 worth Qga = 72.10 tons. So, it may be concluded that withinside the three pile configuration, the variation of the V3-1 configuration is the best variation because it has the largest group permit bearing capacity of Qga = 72.10 tons and the configuration variation of V3-1 is better than the configuration obtained from the Tanjung Balai or V3 Flats construction project while the configuration of 4 poles can be seen as table 2:

Tabel 2. Configuration of 4 Poles

3 Poles Configuration	Poles Eficiency (Eg)	Group carrying capacity (Qg) (ton)	Group permit carrying capacity (Qa) (ton)
V4	0,817	273,69	91,23
V4-1	0,844	282,74	94,24
V4-2	0,844	282,74	94,24
V4-3	0,756	253,26	84,42

From table 2. it can be seen that the configuration affects the efficiency of the pile so that the carrying capacity of the group also has an effect. The highest difference in the calculation results for the variation of the configuration of 4 piles on the carrying capacity of the group permit is 9.82 tons. However, when compared to the project configuration with the planned configuration variation model, the biggest difference for the permit carrying capacity is 6.81 tons. From the calculation results obtained the value of the largest permit bearing capacity in the variation of V4-1 and V4-2 worth Qga = 94.24 tons. So, it can be concluded that in the 4-pole configuration, the V4-1 configuration variation is the best variation because it has the largest group permit bearing capacity of Qga = 94.24 tons. And the variation of the V4-1 configuration is better than the configuration obtained from the Tanjung Balai Flats or V4 construction project.

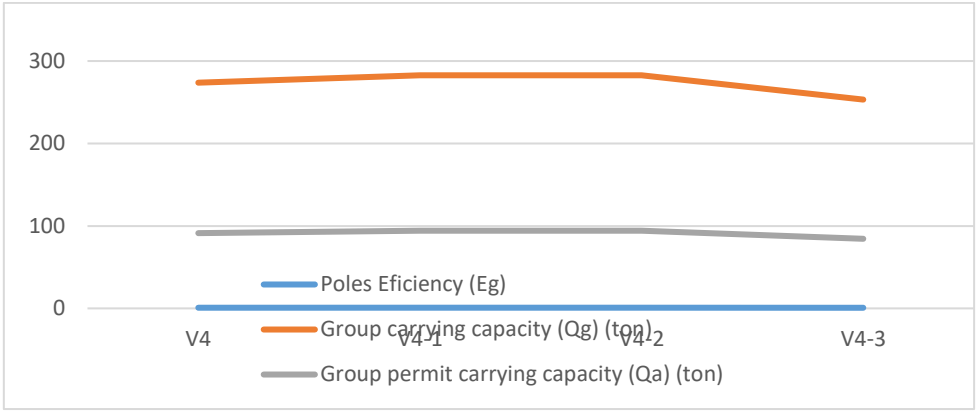

Figure 3. Graph of the relationship between pile efficiency and bearing capacity

4. CONCLUSION

From the consequences of the calculation of the version of institution pile configurations, it is able to be concluded that the effect of group pile configuration on the pile bearing capacity is influenced by the magnitude of the pile efficiency (Eg). The value of the pile efficiency (Eg) in a pile group is influenced by the pile arrangement, the number of rows, the number of piles in one row, and the pile spacing as follows: Configuration of 3 Poles Analysis of the Project (V3) : Eg = 0,817 Qg= 205,27, Plan Pillar Analysis (V3-1): Eg = 0,861 Qg = 216,32, Configuration of 4 Poles Analysis of the Project (V4): Eg = 0,817 Qg = 273,69, Plan Pillar Analysis (V4-1): Eg = 0,844 Qg = 282,74

The calculation results show the highest difference range from the 3 pile configuration for the group permit bearing capacity (Qga) of 3.68 tons. And the 4-pole configuration is 9.82 tons. So, the greater the pile group efficiency value, the better it is because the greater the group carrying capacity value produced in a pile group configuration.

Suggestions

In determining the configuration of the pile group, it is best to pay attention to the pile arrangement, distance, width of the pile group, the position of the available land in order to get a configuration that has high carrying capacity and efficiency. The configuration of the pile group greatly affects the carrying capacity and efficiency of the pile group.

So, if the reader wants to follow up on the configuration of the pile group, the reader can try it with other methods according to the available data, so that many comparisons will be obtained in order to complete this final project.

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