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Comparison of Structure Design Between Bored Pile Foundations and Pile Foundations (Case Study: Industrial Worker I Batang Flower House Construction Project)

M Iqbal Surya Negara[1], Nasyiin Faqih[2], Agus Juara[3]

[1,2,3]*Civil Engineering, Faculty of Engineering and Computer Science, Universitas Sains Al-Qur'an*

Email: [1]suryaiqbal35@tgmail.com [2]nasyiin@unsiq.ac.id. [3]agusjuara182@gmail.com

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ABSTRACT

Field surveys and laboratories found dense soil layers up to a depth of 14 m, so an alternative to drilled pile or pile foundations was used. This study aims to compare the pile and drilled pile foundation plans with the same soil data, loads, and dimensions. Analysis by calculating the pile foundation plan compared to the drilled pile foundation so that the planning results are obtained, soil bearing capacity, pile group efficiency, number of piles and drilled piles, RAB (budget plan), and drilled pile plans. Compared to 50cm square piles and 40×40cm square piles, the bearing capacity of a single pile (Qult) is 44.5 tons, and the bored pile foundation is 54.72 tons. The pile resistance (f) is 38.79 tons for piles with a diameter of 40 x 40 cm and 38.79 tons for drilled piles with a diameter of 50 cm. One pile's allowable pressure-bearing capacity (Pa) is 14.48 tons, and one drilled pile is 17.48 tons. The permissible tensile strength (Pta) for one pile is 11.64 tons, and for one drilled pile is 14.46 tons. The pile foundation requires 263 piles, and the bored pile foundation requires 258 piles.

1. Introduction

The structural design of buildings consists in finding the optimal path to allow the transmission of loads to the ground.[1]Considering that this building is a workers' flat which is a very important infrastructure for the workers of the Batang Integrated Industrial Estate. Therefore the planning and manufacture of the type of substructure (foundation) need to be carefully calculated in order to avoid the decline or even collapse of the building.[2] Foundation

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construction usually accounts for one-third or even half of the whole project from the aspects of the working cycle and costs. An analysis of foundation construction on its carbon emissions in project design, raw materials, operational technology, and apparatus can facilitate accurate control of carbon emissions for the environment.[3]

Based on the type of soil, geographical conditions, location around the project, construction costs and ease of implementation in the field, the magnitude of the static and dynamic loads that work, the function of the building, and the number of building levels[4], the selection of foundations in the construction project of the Batang I Integrated Industrial Worker Flats building is the type of foundation deep; this foundation will channel the stresses that occur in the superstructure load into a hard layer of soil that can carry the construction load.[5] The results of field soil tests and in the laboratory obtained a layer of hard soil at a depth of 14 meters so that a deep foundation was used, which used two alternatives, namely bored pile foundation and pile foundation.[6] Based on the characteristics of the soil parameters and corresponding types of tests deployed in those methods, they could be categorized into two groups. The first group consists of methods using soil parameters associated with laboratory tests, e.g., cohesion and internal friction angle.[7]

The choice of the type of foundation is influenced by several factors, one of which, according to Suyono (1984), is the cost[8] of carrying[9] out work, such as the cost of controlling groundwater, ways to overcome it so as to minimize damage to nearby buildings and the time it takes to build it. Basically, time is directly proportional to the cost of implementation[10]; less time used can reduce project costs.[11]

Thus to be able to determine the efficient, safe, and strong foundation, a comparative analysis of the foundation will be carried out, taking the title "Comparison of Structural Planning between Bored Pile and Pile Foundations in the Batang I Industrial Flats Worker Development Project."

The objectives to be achieved in this study are to find out the use of bore piles or piles as a foundation, to analyze efficient and economic foundations, and to find out the number of costs required in bore pile work with piles.[12]

2. Methodology

The method and principles of pile foundation design in this geological condition were also discussed. This practice-oriented research may provide valuable insights into the understanding of post-uplift phenomena in the deep excavation in thick, soft clay and help for a satisfactory and safe design/construction.[13]

This chapter will explain the stages or research methodology to determine the results to be achieved in accordance with the existing objectives. Starting from research, data collection, data processing, and the parameters needed.[14]

In the analysis of the comparative planning method for the foundation structure between bored piles and piles, the method used is to compare the precast method with the conventional drilling method in terms of workmanship methods and implementation costs.

The stages of the research, in general, can be seen in the sequence of the research flowchart below:

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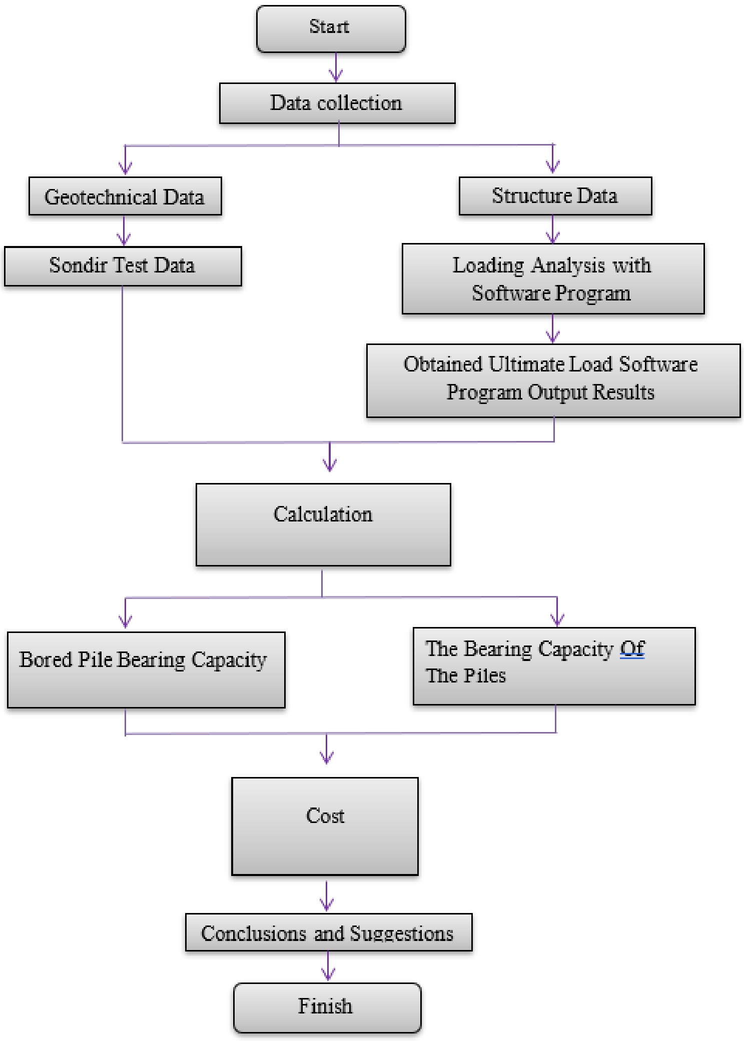

Figure 1. Research Flowchart for planning

3. Results and Discussions

To calculate the superstructure using the Etabs v18.1.1 software program [15]. The guidelines used in the calculation of the upper structure are SNI 1727-1989[16], namely Loading Regulations for Buildings [17] and SNI 1727-2013[18], namely Minimum Loads for the Design of Buildings and Other Structures, and SNI 1726-2012[19], namely Procedures for Planning Earthquake Resistance for Buildings.[20]

Table 1. Value of Foundation Load from Etabs

Joint	Load (Tons)	Joint	Load (Tons)	Joint	Load (Tons)	Joint	Load(Tons)
1	26.23	47	29.8	87	38.23	127	46.95
3	38.34	49	42	89	38.22	129	47.05
5	38.21	51	47.26	91	38.23	131	38.06
7	38.21	53	47.09	93	47.49	133	24.12
9	38.21	55	47.04	95	47.26	135	23.95
11	38.21	57	47.02	97	36.73	137	28.8
13	38.22	59	47.03	99	40.67	139	38.31
15	38.32	61	46.63	101	47.04	141	38.32
17	26.89	63	32.96	103	47.05	143	38.21
19	24.05	65	31.55	105	47.06	145	38.21
45	41.26	67	47.52	107	47.07	147	38.21
43	47.17	69	38.25	109	47.28	149	38.21

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Joint	Load (Tons)	Joint	Load (Tons)	Joint	Load (Tons)	Joint	Load(Tons)
41	47.1	71	38.23	111	41.94	151	38.33
27	23.98	73	38.24	113	29.98	153	28.2
29	38.16	75	38.33	115	41.71	156	22.16
31	47.07	77	31.12	117	47.49	159	25.46
33	46.97	79	20.36	119	47.58	160	28.16
35	46.98	81	20.11	121	47.08	160	1.67
37	46.99	83	31.28	123	46.97		
39	47	85	28.32	125	46.95		

Source : Etabs Output.

Calculation of Boredpile Carrying Capacity

The bored pile data will be planned with the following data:[21]

Drill pile size = Diameter 50 cm
Bore pile circumference (Ast) = 3.14 x d = 3.14 x 50 = 157 cm
Area of bored pile (Ap) = 1/4 x 3.14 x d² = 0.25 x3.14 x 50² = 1963 cm2
Pole Weight (Wp) = concrete bj x 3.14 x r x r x depth
= 2400 kg/m x 3.14 x 0.25x 0.25 x 14m
= 6549 kg/m

The total load of the building = 4646819.9 kg/m2 = 4646.8 tons
Sondir data used at point S-8

Boring Pole Bearing Capacity

Qc = 250 kg/cm²
Ap = 1963 cm2
TF = 360.0 kg/cm
Ast = 157 cm
Qult = (Qc x Ap) + (TF x Ast)
Qult = (250 x 1963) + (360 x 157) = 54727 kg
= 54727 ≈ 54.72 ton

Blanket Resistance 1 Drill Pole

qc (side) = $\frac{17+18+25+42+37+94+28+48+84+70+111+142+120+250}{14}$
= 77.57 kg/cm
Fb = 3.5 (for drilled poles)
Fs = 7 (for drilled poles)
f = qc (side) x $\frac{Fb}{Fs}$
f = 77.57 x $\frac{3.5}{7}$ = 38.79 kg/cm

Permitted Bearing Capacity Press 1 Drill Pole

Qc = 250 kg/cm²
Ap = 1963 cm2
TF = 360.0 kg/cm
Ast = 157
FK1 = 3

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FK2 = 5

Pa $= \frac{Qc*Ap}{Fk1} + \frac{TF*Ast}{Fk2}$

Pa $= \frac{250*1963}{3} + \frac{360*157}{5}$= 17488.733 kg

Pa = 17488.733 ≈ 17.48 tons

Carrying Capacity of Pulling Permit 1 Drill Pole[22]

TF = 360 kg/cm

Ast = 157

FK2 = 5

Wp = bj beton x 3.14 x r x r x kedalaman

= 2400 kg/m x 3.14 x 0.25x 0.25 x 14m = 6549 kg/m

Pta $= \frac{(TF*Ast)*0.70}{Fk2} + Wp$

Pta $= \frac{(360*157)*0.70}{5}$ + 6549 = 14461.8 kg

Pta = 14461.8 ≈ 14.46 ton

Number of Drill Poles Requireds[23]

P (PC1) = 38.34 tons

Pa = 17.48 tons

Np $= \frac{P}{Pa}$

Np $= \frac{38.34}{17.48}$ = 2.19 = 3

P (PC 2) = 94.33 tons

Pa = 17.48 tons

Np $= \frac{P}{Pa}$

Np $= \frac{94.33}{17.48}$ = 5.39 = 6

Pa (PC3) = 230.39

Pa = 17.48 tons

Np $= \frac{P}{Pa}$

Np $= \frac{230.39}{17.48}$ = 13.18 = 14

The largest design load is taken for each type of pile group. So that the total number of drilled piles with a diameter of 50 cm is 258 columns.

Calculation of Pile Bearing Capacity

The pile data that will be planned with the following data:

Square shape pile

Pile size = 3.14 x d = 3.14 x 40 = 125 cm

Circumference of the pile (Ast) = 4 x S = 4 x 40 = 160 cm

Area of the pile (Ap) = S x S = 40 x 40 = 1600 cm2

Piles weight (Wp) = 2400 kg/m x 0.40 x 0.40 x 14m = 5376 kg/m

The total weight of the building = 4646819.9 kg/m2 = 4646.8 tons

Sondir data used at point S-8

Pile Bearing Capacity

Qc = 250 kg/cm²

Ap = 1600 cm2

TF = 360.0 kg/cm

Ast = 125 cm

Qult = (Qc x Ap) + (TF x Ast)

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Qult = (250 x 1600) + (360 x 125) = 44500 kg
= 44500 ≈ 44.5 tons

Blanket Resistance Carrying Capacity 1 Pillar

qc (side) = $\frac{17+18+25+42+37+94+28+48+84+70+111+142+120+250}{14}$
= 77.57 kg/cm

Fb = 1.75 (for prestressed piles)

Fs = 3.5 (for prestressed piles)

f = qc (side) x $\frac{Fb}{Fs}$

f = 77.57 x $\frac{1.75}{3.5}$ = 38.79 kg/cm

Permitted Bearing Capacity Press 1 Pile

Qc = 250 kg/cm2 (Data Sondir)
TF = 360.0 kg/cm (Data Sondir)
Ap = 40 x 40 = 1600
Ast = 4 x 40 = 160
FK1 = 3
FK2 = 5

Pa = $\frac{Qc*Ap}{Fk1} + \frac{TF*Ast}{Fk2}$

Pa = $\frac{250*1600}{3} + \frac{360*160}{5}$ = 14485 kg

Pa = 14485 ≈ 14.48 ton

Carrying Capacity of Tensile Permit for 1 Pile[21]

TF = 360 kg/cm
Ast = 160
FK2 = 5
Wp = 1600 kg/m x 0.40x 0.40 x 14m = 3584 kg/m

Pta = $\frac{(TF*Ast)*0.70}{Fk2} + Wp$

Pta = $\frac{(360*160)*0.70}{5}$ + 3584 = 11648 kg

Pta = 11648 ≈ 11.64 tons

Number of Piles Required[23]

P (PC1) = 38.34 tons
Pa = 14.48 tons

Np = $\frac{P}{Pa}$

Np = $\frac{38.34}{14.48}$ = 2.64 = 3

P (PC2) = 94.33 tons
Pa = 14.48 tons

Np = $\frac{P}{Pa}$

Np = $\frac{94.33}{17.48}$ = 6.51 = 7

Pa (PC3) = 230.39
Pa = 14.48 tons

Np = $\frac{P}{Pa}$

Np = $\frac{230.39}{14.48}$ = 15.91 = 16

The largest design load is taken for each type of pile group so that the total number of piles with a diameter of 40x40 cm is 263 piles.

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Bored Pile Budget Plan

The processed results of the bored pile foundation calculation with a diameter of 50cm at a sonder depth of 14 meters RAB are:[8]

Total Cost = 3.189.961.525,-

The cost per point of bored pile work

$\frac{3.189.961.525,-}{258}$ = IDR 12,362,191

costs calculated according to the analysis of unit labor prices include:

1. bored pile foundation drilling (tool rental fee)
2. Boredpile foundation casting (ordinary casting and tool rental)

Piling Cost Budget Plan

The processed results of the calculation of the pile foundation with a diameter of 40x40 cm at a sonder depth of 14 meters RAB are obtained:

Total Cost = 2.630.510.000

Cost per pile point

$\frac{2.630.510.000}{263}$ = IDR 10.001.939,-

the cost plan, calculated according to the analysis of unit labor prices, includes costs of:

1. Procurement of piles
2. pile mobilization
3. erection of piles (at rental fees and workers' wage costs)

4. Conclusion and Suggestion

4.1 Conclusion

Based on the results of the calculation of the pile foundation with dimensions of 40x40 cm and the bored pile foundation with a diameter of 50 cm in the construction project for industrial worker flats I, it is obtained: The number of piles needed in the construction of industrial worker flats I with a structural weight of 4646.8 tons, 263 piles for pile foundations and 258 piles for bored pile foundations. From the calculation of the costs needed for the pile foundation, which totals 263 piles, it requires a budget of Rp. 2,630,510,000 and bored pile foundations with a total of 258 piles, Rp. 3,189,961,525. Thus this research was obtained in terms of the strength of the bored pile foundation bearing capacity being greater than the pile. But, from the cost efficiency of the pile foundation, it is smaller than the bored pile foundation with a cost difference of IDR 559,451,525.

4.2 Suggestion

After completing this thesis, the author would like to give some suggestions for future planners, including:

1. Soil investigations must be carried out in accordance with existing SNI standards, as well as data from sonder must be carefully calculated to get a good foundation calculation.
2. If the project work location is far from the residents' settlements, it is better to use a pile foundation because it is faster in work and can control all the materials that
3. will be used properly, but it needs to be considered in terms of access to mobilization. A thorough understanding of the stages in the planning process is needed to get accurate results, as well as the theories obtained in lectures and their application in the field.
4. Comparison of work costs between bore pile foundation alternatives and pile foundation alternatives only takes into account the total work costs that have changed due to the selection of alternative foundations and the cost of the foundation itself.
5. In order to know precisely what the price ratio is between the choice of alternative bore pile and pile foundations, the construction costs for the two foundations need to be analyzed

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in more detail by analyzing construction costs that have or have not been taken into account so as not to result in wastage in cost calculations.

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