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ANALYSIS OF BEARING CAPACITY OF SPUN PILE FOUNDATION IN LAMONG RIVER FLOOD CONTROL EMBANKMENT CONSTRUCTION PROJECT IN GRESIK DISTRICT

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ABSTRACT

The construction of a flood control embankment on the Lamong River, Gresik, requires a strong and stable foundation to cope with significant loads and water pressure. The purpose of this research is to analyze the bearing capacity of the spoon pile foundation used in the project. The methods used include geotechnical analysis through field penetration testing (SPT) and laboratory testing of project site soil samples. Analysis of test data to determine the bearing capacity of the soil and the bearing capacity of the pile foundation. Taken as a reference for the calculation of the pile bearing capacity of the S2 results the total bearing capacity of the pile = 67.984 kg. and also taken as a reference from the results of BH-1 and BH-2 the total bearing capacity of the pile = 65.36 kg. The results of this study indicate that the spoon pile foundation with a depth of 24 m is able to withstand the construction load. Including being able to withstand the maximum load that occurs during flooding. Furthermore, the slope stability was evaluated and the foundation system was found to be safe enough against possible structural failure. Therefore, the use of spoon pile foundation in the flood control embankment construction project at Lamong River in Gresik district is recommended as an effective solution to improve the durability and safety of the building against flood risk.

Keywords: Pile, Flood, Spun Pile

Introduction

The Lamong River is part of the Bengawan Solo River Basin Unit, which is managed by the Bengawan Solo River Basin Center. Administratively, the Lamong River watershed is located in Gresik, Lamongan, Mojokerto and Surabaya City. The upstream part of the Lamong River is located in Lamongan Regency and Mojokerto Regency and originates from the Kendeng Mountains, while the downstream part is located on the border between Surabaya City and Gresik Regency, and empties into the Madura Strait. Lamong River has a watershed area of ± 720 km2 with a river channel length of ± 103 km and has 7 tributaries. The Lamong river estuary is located at a distance of ± 15 km from the border bridge between Gresik City and Surabaya City.

Gresik is a regency in East Java Province. The capital city of Gresik is located in Kebomas District. The government center of Gresik is located 20 km north of the city of Surabaya. Gresik Regency is divided into 18 sub-districts consisting of 330 villages and 26 sub-districts. Government efforts to improve the comfort of the area free from a flood disaster have been carried out in many river planning programs. Among them have been built embankments, parapet cliff protectors and so on, so that community activities in carrying out life become effective and efficient.

However, due to changes in nature, including changes in river characteristics, almost every year we hear news of floods that drown local infrastructure, damage agricultural land and wash away residential areas. At the end of 2013, there was a major flood in the Lamong River that overflowed and inundated densely populated areas. This flood not only affected Gresik Regency, but also the entire Lamong River basin, including Surabaya City. Starting from the flooding incident, the Government through the Ministry of Public Works, especially the Bengawan Solo River Basin Center, will carry out Flood Control Supervision of the Lamong River in the form of increasing the Lamong River embankment with concrete parapet wall construction.

Infrastructure such as dams, levees and flood control projects are essential for maintaining environmental security, prosperity and sustainability. The embankment construction project on the Lamong river in Gresik regency, Indonesia, is one such large project that is attracting attention. The embankment is essential to protect the surrounding area from flooding and erosion, as well as other negative effects that can be detrimental to the local population and the surrounding environment. To overcome the above problems, it is necessary to build an embankment to prevent flooding due to the overflow of the Lamong River during the rainy season. With the embankment, the runoff from the river will be retained and the possibility of flooding will become smaller. In the embankment construction project on the Lamong River, Gresik Regency using a spun pile foundation.

Pile foundation is one type of deep foundation that is usually used in soft soil areas where hard soil is located at a considerable depth from the surface. The bearing capacity can be calculated theoretically with the concept of soil mechanics based on the results of soil investigation data in the field using SPT (Standard Penetration Test) test data.

Research Methods

In this research, the method used is quantitative method. This research discusses the bearing capacity of spun pile foundations. The bearing capacity referred to in this study is the ability of the foundation to withstand the soil load above it which is influenced by several research parameters:

1. Spun pile foundation bearing capacity criteria, related to the highest amount of load that a spun pile foundation can support before significant settlement or structural failure occurs, measured in tons or kN.
2. Standard Penetration Test (SPT) parameters to determine indices of soil hardness and durability based on SPT data. The N value, which is the number of SPT hammer blows for every 30 cm of penetration, is used as an indicator of soil hardness, a description of soil type (such as sand or clay) and soil condition using SPT classification standards.
3. Soil properties that affect the soil characteristics around the spun pile foundation. Identify the soil type, cohesivity value, friction angle, and other geotechnical information obtained from the interpretation of SPT data.
4. Pile depth is related to the penetration depth of the spun pile foundation. Pile depth is measured from the ground surface to the tip of the spun pile foundation, and can be measured in meters.
5. Supportability analysis is performed based on SPT by involving calculation or analysis using empirical formulas or numerical methods that use SPT parameters, such as the Meyerhof equation, Terzaghi, or other methods. And in this research using the method of luciano decourt (1982,1996).

In the sampling technique in this study there are two kinds, namely: Pengambilan sampel dengan sondir

1. The Cone Penetration Test (CPT) implementation refers to the SNI 2827:2008 standard "How to Test Field Penetration with Sondir Tools". The lightweight sondir tool used was a Dutch Cone Penetrometer with a capacity of 250 kg/cm^2 using the Biconus Patent from Delft. Tests were

conducted at every 20 cm interval, with a crank rotation speed of 10 to 20 mm/s.

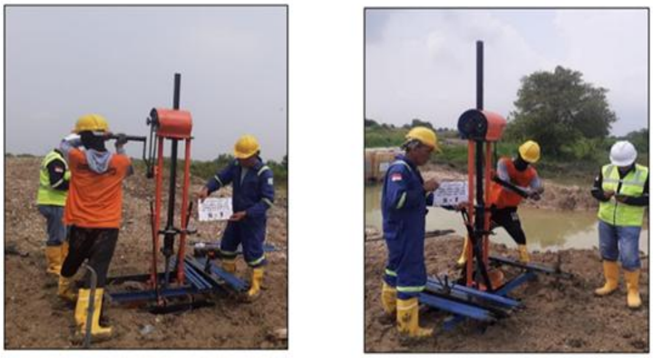

Figure 1. Sampling using Sondir.

2. Boring Sampling

Boring sampling in the field was conducted in accordance with ASTM D-1586-84; "Standard Method for Penetration Test and Split Barrel Sampling of Soil". Drilling was carried out by taking undisturbed samples and conducting SPT every 2 meter interval (the first SPT was carried out at a depth of - 2.00 meters from the original ground level). The SPT was stopped after the price of SPT > 60 for 3 consecutive times as high as 45 cm up to a minimum thickness of 6 meters or adjusted according to demand.

Figure 2. Deep Drill Sampling (Boring)

Data analysis technique is a step that really determines the results of a study. Because data analysis serves to provide conclusions on the results of research. Therefore, the author briefly explains the data analysis used in this study. Looking for the bearing capacity of the foundation. Then calculate and after seeing the final result whether the foundation is able to withstand the load carried.

Calculating the bearing capacity of piles on each of the three sondir results. Then calculate the bearing capacity of piles with booring based on the results of the Standard Penetration Test (SPT) using the method of Luciano Decourt (1982, 1996).

$$Q_L = Q_p + Q_s = [\alpha \times N_p \times K . \times A_p] + \left[\beta \times \left(\frac{N_s}{3} + 1\right) \times A_s\right]$$

Qp= bearing capacity of point bearing element.
Qs = bearing capacity of skin friction element.
Np = average price of SPT at about 4B above and below the base of the foundation (B = diameter of foundation pile).
Ns = average price of SPT along the immersed pile, with the limit of 3≤ N ≤ 50.
Ap = cross-sectional area of the pile base (m2).
As = pile blanket area = π . B . D (m2).
α = base coefficient.
β = shaft coefficient.
K = soil characteristic coefficient (12 t/m^2 for clay, t/m^2 for clayey silt, 25 t/m^2 for sandy soil, 40 t/m^2 for sandy).

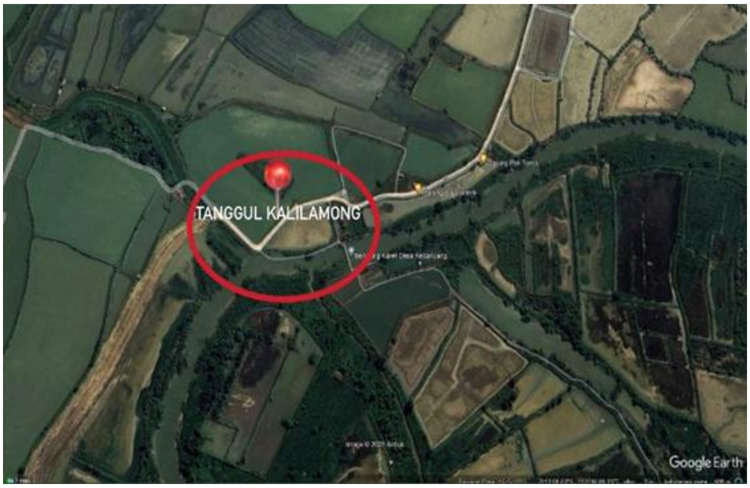

Figure 3. Research location in Kedanyang Village, Kebomas Sub-district, Gresik Regency

Results and Discussion

From the results of the CPT and SPT tests in the field, the data obtained from the sondir results at Sondir Point S1 (67734 E, 920361 N), Sondir Point S2 (67734 E, 9203636 N) and Sondir Point S3 (677569 E, 9203591 N) can be seen in the following table:

Table 1. Sondir Results at Point S1

Depth (m)	QC (kg/cm2)				JHP (kg/cm)
(1)	(2)	(3)	(4) (3)-(2)	(5) (4)x2	(6) komulatif
22.20	18	27	9	18	1282
22.40	20	32	12	24	1306
22.60	21	33	12	24	1330
22.80	20	31	11	22	1352
23.00	21	33	12	24	1376
23.20	22	34	12	24	1400
23.40	22	35	13	26	1426
23.60	21	34	13	26	1452
23.80	23	36	13	26	1478
24.00	22	34	12	24	1502
24.20	23	37	14	28	1530
24.40	22	35	13	26	1556
24.60	21	33	12	24	1580
24.80	19	31	12	24	1604
25.00	21	32	11	22	1626

Table 2. Sondir Results at Point S2

Depth (m)	QC (kg/cm2)				JHP (kg/cm)
(1)	(2)	(3)	(4) (3)-(2)	(5) (4)x2	(6) komulatif
22.20	20	31	11	22	1132
22.40	19	28	9	18	1150
22.60	21	33	12	24	1174
22.80	20	31	11	22	1196
23.00	22	34	12	24	1220
23.20	21	32	11	22	1242
23.40	22	35	13	26	1268
23.60	19	27	8	16	1284
23.80	21	33	12	24	1308
24.00	22	34	12	24	1332
24.20	22	35	13	26	1358
24.40	24	36	12	24	1382
24.60	23	35	12	24	1406
24.80	24	37	13	26	1432
25.00	22	35	13	26	1458

Table 3. Sondir Results at Point S3

Depth (m)	QC (kg/cm2)				JHP (kg/cm)
(1)	(2)	(3)	(4) (3)-(2)	(5) (4)x2	(6) komulatif
22.20	21	35	14	28	1130
22.40	21	34	13	26	1156
22.60	20	33	13	26	1182
22.80	20	34	14	28	1210
23.00	21	35	14	28	1238
23.20	19	31	12	24	1262
23.40	20	33	13	26	1288
23.60	21	34	13	26	1314
23.80	22	36	14	28	1342
24.00	23	36	13	26	1368
24.20	22	35	13	26	1394
24.40	22	34	12	24	1418
24.60	23	36	13	26	1444
24.80	23	37	14	28	1472
25.00	21	35	14	28	1500

From the test results at the three points, the effective depth of the Spun Pile = - 23.60 m.
Point S1 is obtained:
Correction Value Cn -23.60 = (Cn - 22.40 + Cn - 24.8)/2
= (20+19)/2= 19.50 kg/cm² with JHP - 23.60 = 1452 kg/cm
S2 point obtained:
Value Correction Cn - 23.60 = (Cn - 22.40 + Cn - 24.8)/2
= (19+24)/2= 21.50 kg/cm² with JHP - 23.60 = 1284 kg/cm
Point S3 is obtained:
Value Correction Cn - 23.60 = (Cn - 22.40 + Cn - 24.8)/2
= (21+23)/2= 22.00 kg/cm² with JHP - 23.60 = 1314 kg/cm

Taken as a reference for the calculation of the pile support capacity of the S2 evaluation results, the total pile support capacity = 67,984 kg. Evaluation of Vertical Load and Rolling Load of Parapet Construction as follows (Review of segmental group TP calculation per 3 meters)

Table 4. Calculation of Pile Support Capacity

Lokasi	Luas TP Cm²	Cn Kg/cm²	*Safety Factor*	Dy Dkg TP kg	Kell TP Cm	JHP Kg/cm	*Safety Factor*	Dy Dkg TP kg	Total Dy Dkg TP
1	2	3	4	5=(2x3)/4	6	7	8	9=(6x7)/8	10=5+9
S1	1.256	19,50	2	12.246	126	1.452	2.5	73.181	85.427
S2	1.256	21,50	2	13.502	126	1.284	2.5	54.482	67.984
S3	1.256	22,00	2	12.816	126	1.314	2.5	66.226	79.042

Table 5. Calculation of Overturning Support Capacity of Piles

B.Parapet kg	Dy Dk TP kg	Status	B.Guling Kgm	Dy Dk TP kg	Jarak (m)		Dy Dk Guling TP kg	Status
					SP 1 m	SP 2 m		
1	2	3	4	5	6	7	8=5x6+5x7	9
55.680	135.968	OK	181.420,80	67.984	1,20	2,90	278.734,40	OK

Results of Soil Support Calculation at the Job Site with Booring. The maximum bearing capacity of a foundation pile is calculated based on the results of the Standard Penetration Test (SPT) using the method of Luciano Decourt (1982, 1996) which obtained the following results:

Table 6. Calculation results of Support Capacity of 1 Foundation Pole

Bore Hole	Np	K	Ap	α	Qp (ton)	Ns	As	β	Qs (ton)	QL (ton) (Qp+Qs)
BH 1	2	20	0,126	1	5,04	3	30,16	1	60,32	65,36
BH2	2	20	0,126	1	5,04	3	30,16	1	60,32	65,36
BH3	2,5	20	0,126	1	6,3	3	30,16	1	60,32	66,62

Taken as a reference for the calculation of the pile support capacity of the evaluation results of BH 1 & BH 2, the total pile support capacity = 65.36 Kg. Evaluation of Vertical Load and Rolling Load of Parapet Construction as follows: (Review of the calculation of segmental group TP per 3 meters)

Table 7. Calculation of Segmental Group TP per 3 Meters

B.Parapet kg	Dy Dk TP kg	Status / SF	B.Guling Kgm	Dy Dk TP kg	Jarak (m)		Dy Dk Guling TP kg	Status/SF
					SP 1 m	SP 2 m		
1	2	3	4	5	6	7	8=5x6+5x7	9
55.680	130.720	OK / 2,34	181.420,80	65.360	1,20	2,90	267.976	OK / 1,477

Conclusion

Sondir and boring results have shown that the soil is solid. For swampy terrain a spun pile foundation is a very appropriate choice to support the construction of the Lamong River flood control embankment. The use of valid Geotechnical data will ensure good bearing capacity and can adapt to various types of soil. Based on the number of values that have been determined or calculated, it has been fulfilled, that the bearing capacity of the pile is = 67,984 Kg.

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