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Analysis of Structural Calculations of Pile Foundations on Bridge Abutment Working, BLOKANG, Serang Regency, Banten Province

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Abstract

The abutment planning on the Blokang bridge, Serang Regency, Banten Province, resulting in the calculation of bearing capacity based on physical and mechanical properties data from laboratory tests, on the results of the BH4 right abutment with 60 cm diameter piles, the bearing capacity Qu = 248,683.58 kg, while for the left BH support -1 is obtained Qu = 244.186.99kg., And taking into account the value of the N-SPT soil investigation on the right abutment BH-4 is obtained Qu = 261,680.45 kg and the N-SPT soil investigation on the left abutment BH-1 is obtained Qu = 335,674.28 kg . The cause of Qu is based on SPT field test data, where the right abutment is N-SPT = 21, while the left abutment is N-SPT 28. The greater the value of N-SPT = 28, the soil is better, stronger soil, harder.

Keywords: *N-SPT; Bearing Capacity; Abutment Pile*

1. Introduction

To realize the improvement of the community's economy, the Banten Provincial government undertake infrastructure development, including the construction of bridges as one of the transportation infrastructure, so that it is good condition and comfortable to be able to improve the economy with good infrastructure. Calculation of the bridge consists of two parts, namely the bottom and the top. For the upper part, it functions to carry the direct loads above it, such as traffic loads. For the lower part of the bridge to distribute the loads above it and pass it on to the hard soil layer, and what is currently being studied is the abutment planning, so that the abutment is stable and sturdy to be able to support the bridge. Knowing the bearing capacity of the piles on the abutments with predetermined dimensions. Based on the description of the background of the research, the problems are how to calculate the bearing capacity of the piles on the left and right abutments based on theoretical methods by analyzing the results of measurements and investigations of local soil properties as well as reports obtained directly by means of data on physical and mechanical properties from laboratory testing. While the empirical method, by calculating the bearing capacity of the piles on the left and right abutments by taking into value the value of the N-SPT test soil investigation. Laboratory test investigations aim to determine the characteristics of the soil that will be correlated with the results of field tests. Does not review in terms of implementation methods, cost analysis, architectural, and construction management.

2. Research Methodology

2.1. Abutment

The abutment or the head of the bridge is one of the parts of the construction located at

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the ends of the bridge, which functions as a support for the building to be erected and as a retainer for the oprit heap. The abutment construction is equipped with wing construction to hold the ground in a direction perpendicular to the axle. This abutment is the building under the bridge and is located on both sides or ends of the bridge that meet the ground level. Its function is to support the ends of the bridge as well as to provide support to the bridge and also to prevent sliding from the loaded soil structure.

2.2. Foundation

In planning the foundation, the first thing to do is to calculate the amount of effective load that will be transferred to the soil under the foundation. The second thing is to determine the value of the permit bearing capacity (Qu). The base area of the foundation is determined by dividing the total effective load by the allowable bearing capacity (Qu). Based on the pressure that occurs at the base of the foundation, structural design of the foundation can be undertaken, namely: by calculating the bending moments and shear forces that occur on the foundation plate. The selection of the type of foundation depends on the load to be supported, the condition of the subgrade, and the cost of making the foundation compared to the cost of the superstructure.

The foundation is the lowest building structure that serves to hold and distribute the load from above to the soil. The foundation is also useful for determining the location of the building structure above it in the form of a column (Candra, Yusuf, & F, 2018). Until now and in the future the foundation will still be the most important structure of a building, especially in buildings (Candra, Cahyo, et al., 2019). Although not new, foundation planning and calculations always require special considerations in order to get good quality and safety later (Candra, Gardjito, Cahyo, & Prasetyo, 2019). Based on the type of soil and the depth of hard soil, foundations are divided into two, namely shallow foundations and deep foundations.

Bowles (1997: 174) states that there are two general requirements that must be fulfilled in designing the foundation. First, the subgrade must be able to support the construction load without experiencing shear failure, and secondly, the settlement of the foundation that will occur must be within the allowable limit.

2.3. Soil Bearing Capacity Analysis

The soil must be capable of supporting and sustaining the loads of any planned construction on the soil without a shear failure and with the resulting compressed deflection being tolerable for the construction. There are several equations proposed by previous researchers to analyze the bearing capacity of the soil. Some of them are the bearing capacity equation proposed by Terzaghi (1943), Meyerhof (1951, 1963). The results of foundation planning in the form of type, depth, and dimensions of the foundation based on SPT value data can be compared with the results obtained based on physical and mechanical properties data from laboratory tests. Calculation of the bearing capacity of the foundation based on laboratory data can use the Terzaghi method or the Meyerhof method. The Meyerhof or Terzaghi bearing capacity calculation method is based on the value of phi (□) and cohesion c as well as the weight of the soil volume (□s). For drilling locations that have UDS samples in the form of clay, the consolidation properties are also tested, so that the settlement potential and duration can also be calculated. the time of decline that will occur bearing capacity based on field test data can use SPT or CPT data as suggested by Bowles (1997).

Single Pile Bearing Capacity From SPT Results Single Pile Bearing Capacity Based on Standard Penetration Test (SPT) According to Meyerhof End bearing capacity of non-cohesive soils.

$$Q_p = 40*N\text{-}SPT*Lb/D*A_p \leq 400*\ N\text{-}\ SPT*\ \ A_p \quad (1)$$

Pile blanket shear resistance in non-cohesive soil

$$Q_s = 2*\ N\text{-}SPT*p*Li \quad (2)$$

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Pile end bearing capacity on cohesive soil cu

$Q_p = 9 * c_u * A_p$ (3)

Pile blanket shear resistance in cohesive soil cu

$Q_s = \alpha * c_u * p * Li$ (4)

with:

Q_p	= ultimate bearing capacity (kg),
Q_s	= Pile blanket bearing capacity (kg)
c_u	= soil cohesion (kN/m^2)
	= N-SPT*2/3*10,
A_p	= Pile cross-sectional area (m^2),
α	= Coefficient of adhesion between soil and pile
p	= Pole circumference (m)
Li	= Soil length (m).

with:

Qp	= ultimate bearing capacity (kg),
Qs	= Pile blanket bearing capacity (kg)
cu	= soil cohesion (kN/m2)
	= N-SPT*2/3*10,
Ap	= cross-sectional area of the pile (m2),
	= Coefficient of adhesion between soil and pile
p	= Perimeter of the pile (m)
Li	= Length of soil layer (m).

2.4. Based on Laboratory Data

Soil samples that have been examined in the laboratory will produce the value of the bulk density of the soil, the value of soil cohesion and the angle of shear of the soil. Based on this data, it is possible to estimate the bearing capacity of the foundation. The bearing capacity of pile foundations on sandy and silt soils from laboratory data based on the shear strength parameter data using the Meyerhoff method: End bearing capacity

For cohesive soil:

$Q_p = A_p \, . \, c_u \, . \, Nc*$ (5)

For non-cohesive soils:

$Q_p = A_p \, . \, q' \, (Nq* - 1)$ (6)

with :

Q_p	= End resistance per unit area(kg)
A_p	= The cross-sectional area of the pile (m2),
c_u	= Undrained cohesion (kN/m^2) ,
q'	= Effective vertical pressure (kg/m2),
Nq*	= Soil bearing capacity factor
Nc*	= Soil bearing capacity factor

To find the value of cu (Undrained cohesion),

equation can be used: $\alpha* = 0{,}21 + 0{,}25 \, (p_a / c_u) < 1$ (7)

with:

α*	= Adhesion factor = 0,4 ,
p_a	= atmospheric pressure
	= 1,058 ton/ft^2 = 101,3 (kN/m^2).

Pile blanket bearing capacity skin friction).

$Q_s = f\,i. \, Li \, . \, p$ (8)

with:

fi	= Resistance unit skin (kg/m2),,
Li	= Length of soil layer (m),
P	= Perimeter of the pile (m),

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Qs=Pile blanket bearing capacity (kg).
On cohesive soils:

$f = \alpha i^* \cdot cu$ (9)

with:

αi* = Adhesion factor, 0.55
c_u = Undrained cohesion, (kN/m^2)

On non-cohesive soils:

$f = K0 \cdot \sigma v' \cdot \tan \delta$ (10)

with:

K0 = Ground pressure coefficient
K0 = 1 – sin φ

σv' = The effective vertical stress of the ground,,kg/m^2
(σv' = γ . L' L' = 15D)δ = 0,8 . φ

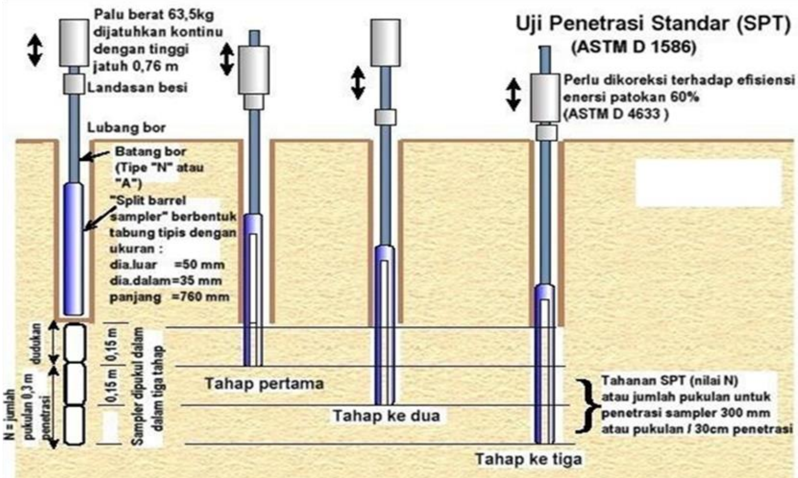

Figure 1. Penetration test sequence scheme Standard (source SNI 4153-2008)

Standard Penetration Test (SPT) was undertaken to obtain N-Vallue from representative soil samples. The SPT test is undertaken at each drill hole, with an interval of 2 m depth, the SPT test was undertaken every 2 or 3 meter intervals (as needed); or at each change of soil layer type. If at a certain depth the SPT must be undertaken adjacent to the UDS undisturbed sampling, then the SPT test is undertaken after the UDS sampling. The test method follows the ASTM standard. D 1586

2.5. Research sites

The location of this research is in Serang Regency, Banten Province. The location of this research can be seen in Figure 2.

Figure 2. Research site map (google earth) Source: maps.google.com

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This study uses secondary data in the form of data obtained through the planning consultant for the Blokang Bridge construction. Data The types and sources of secondary data are based on the Standard Penetration Test (SPT), laboratory tests, pile foundation plans, general project data.

3. Results and Discussion

3.1. Pile Bearing Capacity for Right Abutment

Pile Foundation Dia.60 - 30m' :
is used

a) diameter = 60 cm
b) long = 3000 cm
c) The cross-sectional area of the pile (A) = 2.826,00 cm
d) Pole circumference (K) = 188,40 cm

Drilling Log Bh-4

From the results of the soil test, obtained:
C = 0,34 kg/cm2
CA = 0,26 kg/cm2
F = 10,00
Qult = Pile end resistance + Pile attachment to the ground
Qult = (CxNcsxpx R2) +(CAx 2 px Rx L)

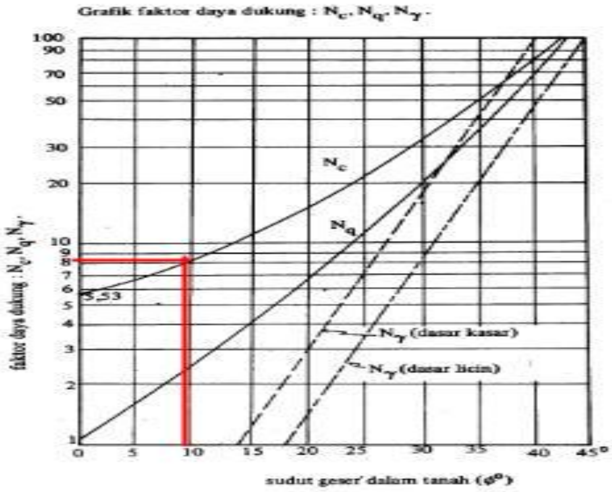
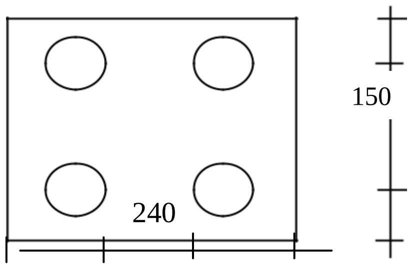


Figure 3. Bearing Capacity Factor N_c', N_q', N_γ'

NCS factor value to see chart above
Ncs = 8,20
Qult = (CxNcs xp x R2)+ (CAx 2 pxRxL) = 325.419,55 kg

Pile Efficiency



$$Eff = 1 - \frac{ø}{90^0} \frac{[(n-1)m + (m-1)n]}{m.n}$$

where:

ø = arc tan d/s
m = number of direction lines x = 2bh
n = number of lines direction y = 5bh
d = pile size/diameter = 60 cm
s = distance between piles = 240 cm
ø = arc tan d/s = arc tan [60/240] = 13.82 ^{0}
Eff = 1 — [0,154 x 1] = 0.800

Pile Bearing Capacity

Q = 325.419,55 x 0,800 = 260.458,58 kg
Reduce your own weight = 11.775,00 kg
Qu = 248.683,58 kg

3.2. Pile Bearing Capacity for Left Abutment

Pile Foundation Dia.60 - 30m' :
is used

a) diameter = 60 cm
b) long = 3000 cm
c) Pile cross-sectional area (A) =2.826,00 cm
d) Pole circumference (K) = 188,40 cm

Drilling Log Bh-1

From the results of the soil test, obtained:
C = 0,29 kg/cm2
CA = 0,26 kg/cm2
F = 8,60
Qult = Pile end resistance + Pile attachment to the ground
Qult = (CxNcsxpx R2) +(CAx 2 px Rx L)

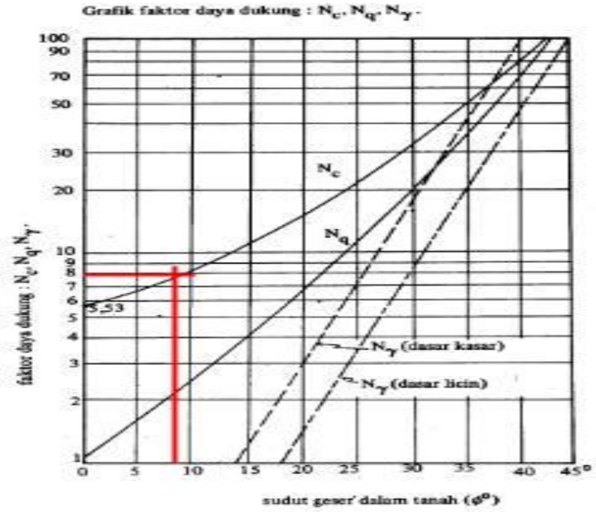
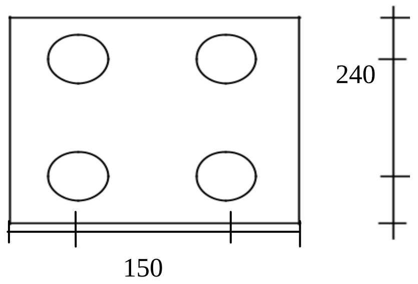


Figure 4. Bearing Capacity Factor N_c', N_q', N_γ'

NCS factor value to see chart above
Ncs = 7,90
Qult = (CxNcs xp x R2)+ (CAx 2 pxRxL) = 319.801, 46 kg

Pile Efficiency



ø = arc tan d/s

= arc tan [60/240] = 13.82 ^{0}

Eff = 1 – [0,154 x 1] = 0.800

Pile Bearing Capacity

Q = 319.801,46 x 0,800 = 255.961,99 kg

Reduce your own weight = 11.775,00 kg

Qu = 244.186,99 kg

3.3. Pile Bearing Capacity for Right Abutment (taking into value N– NSPT)

Pile Foundation Dia.60 - 30m' :

Is used :

a) diameter = 60 cm
b) long = 3000 cm
c) Pile cross-sectional area (A) =2.826,00 cm
d) Pole circumference (K) = 188,40 cm

Drilling Log Bh-4

From the results of the soil test, obtained :

C = 0,34 kg/cm2

g = 1,58 T/m^3

f = 10,00

N–SPT = 21.00

Pile end bearing capacity in cohesive soil

Qp = 9 x C_u x A_p

= 9 x 14280 x 0.28

= 36,319.75 kg

Where :

Q_p = End bearing capacity

Cu = Undrained Cohesion

C_u = Kohesi Undrained

= N – SPT x 2/3 x 10

= 140.00 k N/m^2

= 14,280.00 kg/m2

Ap = Pile cross-sectional area

Pile blanket shear resistance in cohesive soils;

Qs = a x Cu x K x Li

Where:

A = The coefficient of adhesion between the soil and pile

Cu = undrained cohesion
= 14,280.00 kg/m2
K = Pole circumference (m)
Li = Soil length (m)

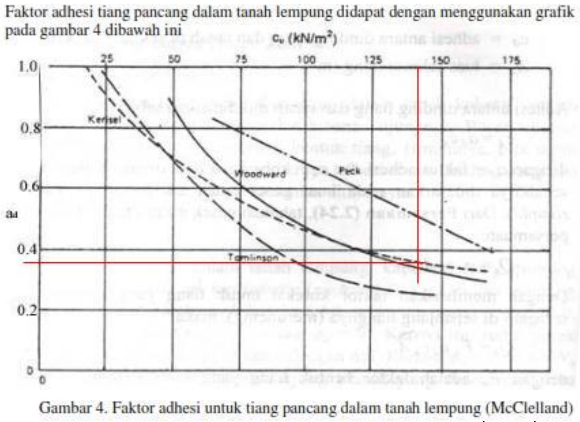


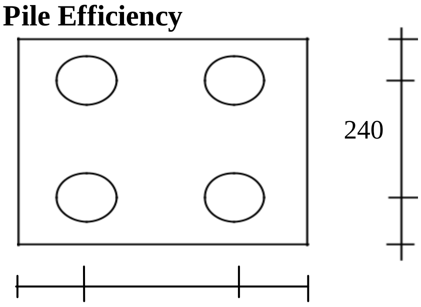
Figure 5. Bearing Capacity Factor N_c', N_q', N_γ'

Value a = 0.38
Qs = a x Cu x K x Li = 306,700.13 kg

Permit Bearing Capacity
Qult = Pile end resistance + Pile attachment to the ground
=343,019.88 kg

Permit Bearing Capacity
Qult = Pile end resistance + Pile attachment to the ground

Pile Efficiency



$$Eff = 1 - \frac{ø}{90^0} \frac{[(n-1)m + (m-1)n]}{m.n}$$

where :
ø = arc tan d/s
m = number of direction lines x = 2bh
n = number of direction lines y = 5bh
d = pile size/diameter = 60 cm
s = distance between piles
= 240 cm
ø = arc tan d/s
= arc tan [60/240] = 14.04^0
Eff = 1 − [0,154 x 1] = 0.797

Pile Bearing Capacity
Q = 343,019.88 x 0.797 kg = 273,455.45 kg
Reduce your own weight = 11.775,00 kg
Qu = 261,680.45 kg

3.4. Pile Bearing Capacity for Left Abutment (taking into value N– NSPT)

Pile Foundation Dia.60 - 30m' :
Is used:

a) diameter = 60 cm
b) long = 3000 cm
c) Pile cross-sectional area (A) =2.826,00 cm
d) Pole circumference (K) = 188,40 cm

Drilling Log Bh-1
From the results of the soil test, obtained:
C = 0,29 kg/cm2
f = $8,60^0$
g = 1.63 t/m3 = 1,630.00 kg/m3
N-SPT = 28.00

Pile end bearing capacity in cohesive soil
Qp = $9 \times C_u \times A_p$
= 9 x 19040 x 0.28
= 48.426,34 kg
Where :
Qp = End bearing capacity
Cu = Kohesi undrained
= N-SPT x 2/3 x10
= 186.67 kN/m2
Cu = 1.90 kg/cm2
= 19,040.00 kg/m2
Ap = Pile cross-sectional area

Pile blanket shear resistance in cohesive soils;
Qs = a x Cu x K x Li

Where :
a = Coefficient of adhesion between soil and pile
Cu = Undrained Cohesion
= 19,040.00 kg/m2
K = Pole circumference (m)
Li = Soil length (m)

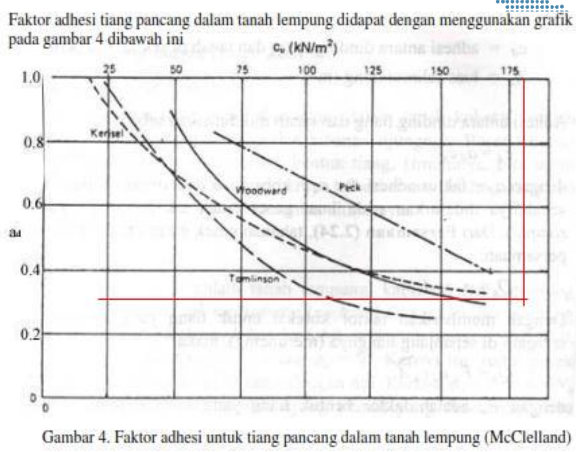
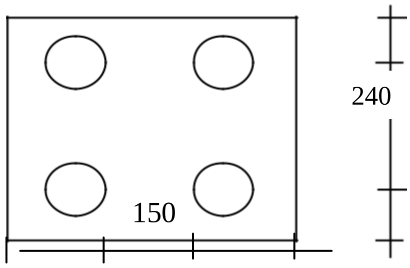


Figure 6. Bearing Capacity Factor Nc', Nq', Nɣ'

Value a = 0,36
Qs = a x Cu x K x Li
= 387.410,69 kg

Permit Bearing Capacity
Qult = Pile resistance + Pile attachment to the ground = 435,837.02 kg

Pile Efficiency



$$Eff = 1 - \frac{ø}{90^0} \frac{[(n-1)m + (m-1)n]}{m.n}$$

Where :
Ø = arc tan d/s
m = number of direction lines x = 2bh
n = number of direction lines y = 5bh
d = pile size/diameter = 60 cm
s = distance between piles = 240 cm
ø = arc tan d/s
= arc tan [60/240] = 14, 4 ^{0}
Eff = 1 – [0,154 x 1] = 0.797

Pile Bearing Capacity
Q= 435,837.02 x0.797 = 347,449.28 kg
Reduce your own weight = 11.775,00 kg
Qu = 335,674.28 kg

3.5. Calculation Recapitulation Bearing Capacity

No. Description	Bearing Capacity	
	Method-1 (kg)	**Method-2 NSPT) (kg)**
1. Right Abutment	**248.683,58**	**261.680,45**
2. Left Abutmen	**244.186,99**	**335.674,28**

4. Conclusions

The following conclusions were obtained calculation of bearing capacity based on data on physical and mechanical properties from laboratory tests, on the results of the BH4 right abutment pile with a diameter of 60 cm, the bearing capacity is Qu = 248.683.58 kg, while for the left abutment BH-1, it is obtained Qu = 244.186.99 kg.,And taking into account the value of the N-SPT soil investigation on the right abutment BH-4, it is obtained Qu = 261,680.45 kg and the soil investigation N-SPT on the left abutment BH-1 obtained Qu = 335,674.28 kg.

It is necessary to analyze other methods in calculating the bearing capacity. The bearing capacity of the foundation design must be greater than the stress due to the maximum working load

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