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RE-ANALYSIS OF BUILDING FOUNDATIONS

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ABSTRACT

The carrying capacity of the foundation is the main thing that determines the ability of the foundation to withstand structural loads. A review of the re-analysis of the foundation in this study includes analysis of the allowable bearing capacity of the pile, planning the efficiency and bearing capacity of the group foundation by remodeling the superstructure using the Etabs V 13 program to get the reaction received by the foundation. The regulations used are SNI 03-2847-2002 regarding general regulations on structural planning and SNI 03-1726-2012 regarding earthquake resistance procedures for building buildings. From the results of the re-analysis of the structure, it is obtained that the bearing capacity of the group piles after the addition of the number of floors Q permit = 6298.45 <6549.77 kN (does not meet Q permit pile), P max = 915.75 kN > Supporting capacity of pile pressure permits = 749.816 kN (does not meet), so with these results it can be concluded that the piles used do not meet the priority factor.

INTRODUCTION

In planning the construction of high-rise buildings, several important aspects must be considered, such as environmental, social, and security aspects. In civil engineering, the security of a building is largely determined by its structural strength, both the upper structure and the base structure. The so-called substructure is the part of the building that is below ground level. The construction of the structure under this placement is called the foundation.

The construction of the Geary Hotel which is located on Jalan Kebon Kawung No. 12 Bandung, West Java Province is the construction of a multi-storey hotel building with an additional number of floors from the original plan of 5 floors to 7 floors with a height of 25.35 meters from the ground. Based on the results of ground survey data, the foundation used is the pile foundation.

LITERATURE REVIEW

Calculation of Soil Carrying Capacity

Terzaghi calculates the bearing capacity of the soil based on the shape of the foundation (square, round, strip) and based on the type of collapse (general shear and local shear).
The formula to use:

a. General shear : σ_{ult}= α.c.Nc + q.Nq + β.B.γ.Nγ
b. Local shear : σ_{ult}= α.c'.Nc' + q'.Nq' + β.B.γ'.Nγ'

where:
α and β are foundation form factors
Foundation lane (c): α = 1,0; β = 0.5
Square foundation (s): α = 1,3; β = 0.4
Round foundation (r): α = 1,3; β = 0.3
Nc, Nq, Nγ and Nc ', Nq', Nγ 'are: Soil bearing capacity coefficients for general and local shear
Foundation width (B)
The parameter values φ, c, γ are the parameters of the soil at the base of the foundation
Value of q (soil weight per meter above the base plane of the foundation per meter / load is evenly distributed)

a. If the soil is homogeneous q = Df.γ
b. If the soil is layered q = Df1.γ1 + Df2.γ2 + ...
c. For the part of the land below the groundwater table is used γ '

Pile foundation

Pile foundations are used to support buildings when the strong soil layer is very deep. Pile foundations are also used to support buildings that resist upward lifting, especially in high-rise buildings which are affected by wind-induced overturning forces.

Pole permit carrying capacity

The allowable pile bearing capacity is reviewed based on the allowable compressive strength and the allowable tensile strength.

Press permit carrying capacity

Analysis of the allowable bearing capacity of the pile foundation against soil strength affects the formula as follows:

a. Based on sondir data (Guy Sangrelat)

$$\text{Pa} = \frac{qc\ x\ Ap}{FK1} + \frac{T_f x A_{st}}{FK2}$$

where:
Pa = the allowable bearing capacity of the pile
Qc = resistance at the tip of the conus sondir
A_p = cross-sectional area of the pile
T_f = total friction / amount of adhesive resistance
A_{st} = circumference of the pile cross-section
FK1, FK2 = safety factor, 3 and 5

b. Based on N SPT data (Meyerhof)

$$Pa = \frac{qc\ x\ Ap}{FK1} + \frac{\sum l_i f_i x\ A_{st}}{FK2}$$

Where:
q_c = 20 N, for silt / clay
N = N SPT value
l_i = length of the observed pole segment
f_i = shear force on pile segment covers
= N maximum 12 ton/m^2, for silt / clay
= N/5 maximum 10 ton/m^2, for sand
FK1, FK2 = safety factor, 3 and 5

c. Based on the strength of the material
Pa = σ'b x A_p

Where
σ'b = allowable stress of pile material

2.3.2 Carrying Capacity of Pulling Permits

Analysis of the bearing capacity of the pile foundation tensile permit against the strength of the soil uses the following formula:

a. Data sondir (Guy Sangrelat, Meyerhof)

$$P_{ta} = \frac{(T_f\ x\ A_{st})\ x\ 0,70}{FK2} + W_p$$

Where
P_{ta}= carrying capacity of the pile tensile permit
W_p= foundation weight

b. Data N SPT (Meyerhof)

$$P_{ta} = \frac{\left(\sum l_i\, f_i x\ A_{st}\right) x\ 0,70}{FK} + W_p$$

Number of pole required

The required number of piles is calculated by dividing the axial force that occurs with the bearing capacity of the pile.

$$np = \frac{p}{Pall}$$

Where
np = number of poles
p = the axial force that occurs
Pall = carrying capacity of the pole permit

2.3.4 Pole Group Efficiency

The calculation of the efficiency of the pile group based on the Converse-Labbarre formula from the AASHTO uniform Building Code is:

$$E_g = 1 - \theta \frac{(n-1)m+(m-1)n}{90mn}$$

Where
E_g = pile group efficiency
θ = arc tg (D / s) (degrees)
D = size of the cross section of the pole
S = distance between poles (axles to axles)
m = number of poles in 1 column
n = number of poles in 1 row
Pile group vertical bearing capacity = E_g x number of piles x allowable bearing capacity of piles.

Maximum pole load on group of pole

The axial loads and moments acting on the foundation will be distributed to the pile cap and pile groups based on the elasticity formula assuming that the pile cap is perfectly rigid, so that the effect of the working force does not cause the pile cap to warp or deform.

$$Pmaks = \frac{Pu}{np} \pm \frac{My.Xmax}{ny.\sum x^2} \pm \frac{Mx.Ymax}{n\,.\sum Y^2}$$

where
Pmaks = maximum pile load
Pu = the axial force that occurs (factored)
M_y = moment that works perpendicular to the y axis
M_x = moment acting perpendicular to the x axis
X_{max} = the farthest distance from the pole to the x axis
Y_{max} = the farthest distance from the pole to the y axis
$\sum X^2$ = sum of squares X
$\sum Y^2$ = sum of squares of Y
nx = many poles in one line with the x-axis direction
ny = many poles in a row with the y-axis direction

np = number of poles
If the maximum P that occurs is positive, then the pile gets a compressive force.
If the maximum P that occurs is negative, then the pile gets a tensile force.

Horizontal carrying capacity

In the horizontal force analysis, the piles are differentiated according to the bonding model with the pile cap into 2, namely:

a. Fixed end pile, which is a pole whose upper end is stuck (embedded) in the pile cap ≥ 60 cm deep

b. Free end pile of free end pile <60 cm

Horizontal bearing capacity on cohesive soil and pinched ends:

a. For short poles

H_u = 9 C_u D (Lp - 3D/2)
Mmax = H_u (Lp / 2 + 3D/2)

b. For medium mast

M_y = (9/4) (C_u 〖Dg〗 ^ 2-9C_uDf (3D/2 + f + g)
H_u is calculated by taking Lp = D/2 + f + g

Where
C_u = undrained strength
D = pole diameter
Lp = length of the embedded pole

Checks whether the maximum moment at depth (f+3D/2) is smaller than M_y. If M_{max} > M_y then the pole is a long pole. For long poles (M_{max} > M_y). H_u is represented by the equation:

$$H_u = \frac{2M_y}{\frac{3D}{2}+f/2}$$

Control of vertical pole deflection

Brom's (1964) method is considered a more thorough method in terms of calculating pile deflections. For piles in cohesive soils, the pile deflection is associated with a dimensionless factor βL, by:

$$B = (\frac{k_h D}{4E_{plp}})^{1/4}$$

The deflection of the pile tip at ground level (y_0) is represented by equations depending on the pile clamp type:

a. The free end pole as a short pole A (if βLp <1,5)

$$y_\circ = \frac{4H(1+\frac{1,5e}{Lp})}{k_h D Lp}$$

b. Clamp end pole as a short pole (when βLp <0.5)

$$y_\circ = \frac{H}{k_h D Lp}$$

c. The free end pole is a long pole (if βLp> 2,5)

$$y_\circ = \frac{2H\beta(e\beta+1)}{k_h D}$$

d. Clamp end pole as a long pole (if βLp> 1,5)

$$y_\circ = \frac{H\beta}{k_h D}$$

Mc Nulty (1956) suggested that the lateral displacement of the permit in buildings is 6 mm, while for other buildings such as transmission towers it is 12 mm or slightly larger.

Drop of the pole group

Pile settlement in a group of poles is the amount of elastic decline or decline that occurs in the near future (immediate settlement or elastic settlement) Si and a settlement that occurs in a long period of time (long term consolidation settlement) Sc.

The total decrease is the sum of the two types of decline.

$$S = S_i + S_c$$

Where
S = total setlement
S_i = immediate settlement
S_c = consolidation settlement

Pile cap dimensions

Pile distance affects the size of the pile cap. The pile distance in the pile group is usually taken as 2.5D ~ 3D, where D is the diameter of the pile. The pile distance on the pile cap is described in Figure 1.

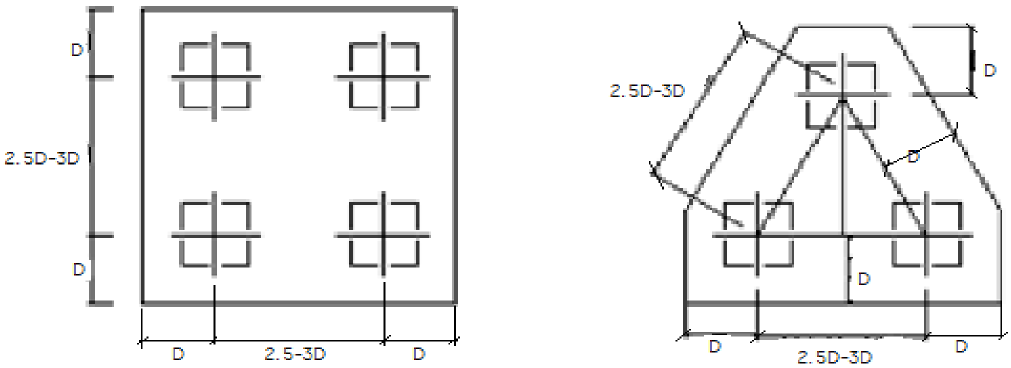

Figure 1 Pole distance

Calculation of reinforcement

Flexible reinforcement

Calculation of bending reinforcement using SNI-03-2847-2002. For non-prestressed structural components with binder reinforcement, the axial compressive strength Pn should not be taken more than:

Φ Pn (max) = 0.80. Φ. [0.85. fc '(Ag-Ast) + Ast.fy]

The minimum bending reinforcement must not be less than:

$$\text{As min} = \frac{\sqrt{fc'}}{4fy}\, b.d$$

and not less than:

$$\text{As min} = \frac{1,4.b.d}{fy}$$

Where
b = width of the beam
d = effective height of the blocks (height of the blanket – blanket concrete)
fc '= compressive strength of concrete
fy = the yield stress of steel

b. Shear reinforcement

According to SNI-03-2847-2002φVn ≥ Vu
Vn = Vc + Vs
Φ(Vc + Vs) ≥ Vu

Where
φ = shear strength reduction factor = 0,75
Vn = tegangan geser nominal
Vu = gaya geser terfaktor

Vc = nominal shear strength contributed by concrete
Vs = nominal shear strength contributed by

$$Vc = [1 + \frac{0,3Nu}{Ag}] \frac{\sqrt{fc'bw}\,.d}{6}$$

Where
Vc = nominal shear strength contributed by concrete
Fc '= compressive strength of concrete
Ag = cross-sectional area of concrete
Bw = width of the beam body
d = distance from the outer compressive fiber to the center of gravity of the longitudinal tensile reinforcement
Nu = factored tensile force

So that, Vs can be found with the formula:

$$\Phi = (Vs+Vc) \geq Vu$$
$$Vs = \frac{Vu}{ö} - \frac{Vc}{\varphi}$$
SNI-03-2847-2002 article 13.3.2
$$Vs = \frac{Av\,.fy\,.d}{s}$$

Where
Av = area of shear reinforcement
fy = yield strength of reinforcement
d = distance from the outer compressive fiber to the center of gravity of the reinforcement longitudinal tensile
s = distance of shear reinforcement

c. Shear reinforcement distance
At both ends of the beam, the first stud shall be installed at a distance of not more than 20mm from the placement face along the distance l0 = 2 x the beam height measured from the placement face towards the span.
This stirrup must have spaces no more than:
- ¼ effective height of the beam
- 8 times the diameter of the smallest longitudinal reinforcement
- 24 times the diameter of the stirrup
- 300 mm
- Use the smallest size

METHODOLOGY

Research methodology

Research materials to be studied and known:
a. Draw a floor plan of the building structure
b. Land investigation report

Retrieval of data

The data obtained are in the form of secondary data, namely: building structure drawings, soil investigation report data, fin reinforcing steel certificates and data on the results of the implementation of ready mix concrete specimens.

Re-modeling of building structures

To determine the working force and the load received by the lower structure, a 3-dimensional remodeling and structural analysis was performed using the ETABS V 13 computer program. Supporting data refers to the material quality specifications used in the building construction project, which is adjusted based on SNI-Earthquake 1726: 2012 and SNI-03-2847-2002.

Determining land sites

In determining the land site, based on soil investigation report data from boring logs N SPT, the classification of the soil site at the building construction project location can be known.

Data analysis methods

The data collected from the data collection method and the results of the calculation of the structural computer program are then analyzed using a predetermined formula.

The analysis of these calculations includes:

a. Calculate the allowable bearing capacity of the pile based on the bearing capacity of the allowable pressure and the bearing capacity of the allowable tensile.

b. Efficiency of the pole group.

c. Single pile lowering and pile group lowering

Research flow stages

The work steps in this research are shown in the following research flow:

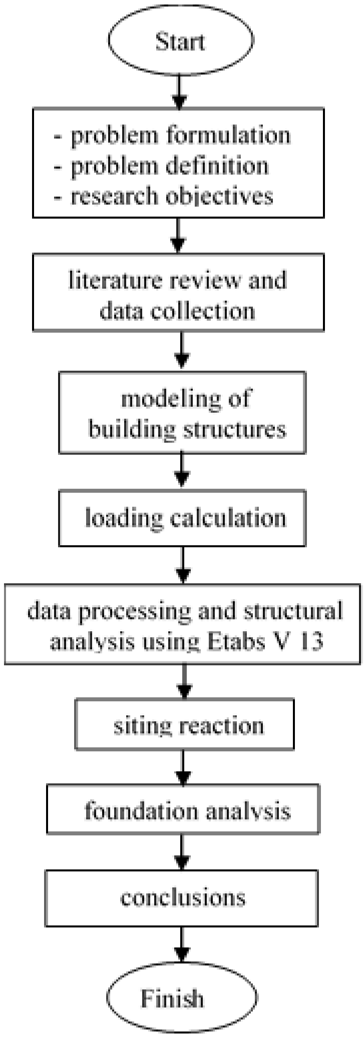

Figure 2 Stages of the Research Flow

DATA PROCESSING AND ANALYSIS

Data collection

To achieve the aims and objectives, research this Project carried out several stages which are deemed necessary and are broadly described as follows:

a. Conduct a review and literature study on text books and related journals regarding the foundation of piles, problems on the pile, pile cap, and beam sloof.

b. The implementation of secondary data collection obtained from PT. WIM Sejahtera, in the form of data:

- Ground investigation reports

The data obtained from the soil investigation report are data on the results of sondir investigation, soil drilling and soil conditions in terms of soil mechanics.

- Results of laboratory test specimens for readi mix concrete.
- Fin reinforcing steel certificate.
- Structural drawings

Data from structural drawings are in the form of architectural plans and structural plans in the form of: foundation plans, logging plans and portal structures.

c. Place of research location
d. Project Name: Geary Hotel Building
e. Project Location: Jl. Kebon Kawung No12, Bandung, West Java, Indonesia

Data processing

From the results of the soil investigation report obtained, the data processed are as follows:

Sondir test result data

From the results of soil investigation with the sondir test, 2 points of investigation were carried out with a qc value > 150 kg/cm^2 at a depth of 4 meters.

Table 1 Investigations of Sondir

Point Sondir	Depth-Experiment	Qc max (kg/cm^2)	Ft max (kg/cm^2)	MAT
1	4.00 m	> 150	91	3.60 m
2	3.80 m	> 150	71	1.00 m

Soil drilling

Data reports on the results of soil drilling work carried out to a depth of 20.00 m.

Table 2 Soil Drilling Data

Drill point	Drill point depth	MAT (m)	SPT N-value	Depth (m)
			4 29 42 63/27cm	2.00 – 2.45 4.00 – 4.45 6.00 – 6.45 8.00 – 8.27

BH.1	20.00 m	1.20	64/40cm 62/40cm 69 60/26cm 62/40cm	10.00 – 10.40 12.00 – 12.40 14.00 – 14.45 16.00 – 16.26 18.0 – 18.40

Pole foundation data

Based on pile data:
Pile diameter (D) = 25 cm
Cross-sectional area (Ap) = 25x25 = 625 cm
Perimeter of cross section (Ast) = 100 cm
Pile length = 900 cm
Material quality: fc '= 24.9 Mpa, fy '= 400 Mpa
Number of pile groups = 12 poles
The distance between the poles (S) = 75 cm

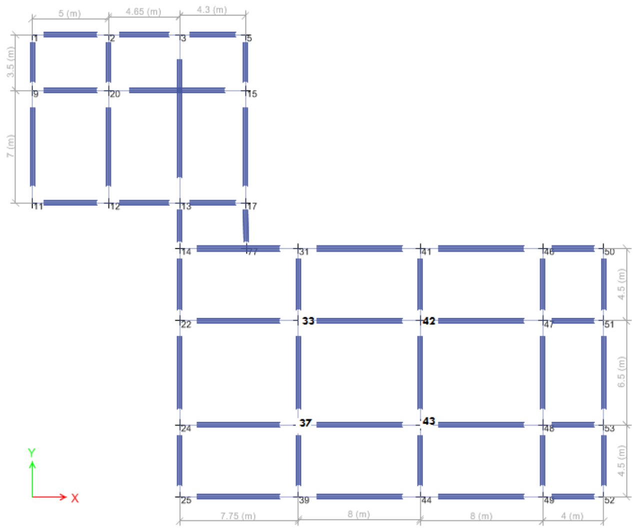

Figure 3 Foundation Plan

Determining the foundation reaction

The calculation was taken for the column foundation as B / 5 no 43, from the results of the Etabs V13 analysis, the placement reaction was obtained as follows:
Before there was an increase in the number of floors, a total of 5 floors.

Table 3 Placement Reaction on The Join Label 43

Story	Load Case/Combo	FX	FY	FZ	MX	MY	MZ
		kN	kN	kN	kN-m	kN-m	kN-m

BASE	COMB10	278.7	1646.2	4865.5	-5170.2	553.2	-46.0

After there is an increase in the number of floors to 7 floors, the siting reaction obtained becomes:

Table 4 Placement Reaction Output

Story	Joint Label	Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
BASE	33	COMB9	583.2	-2510.9	7351.2	7379.1	1112.0	32.7
BASE	37	COMB8	-773.2	2535.9	6598.3	-7396.2	-1434.7	-32.6
BASE	42	COMB9	613.9	-2115.7	7095.0	6519.5	1144.1	32.7
BASE	43	COMB10	337.5	1995.5	6549.8	-6300.9	670.9	-56.4

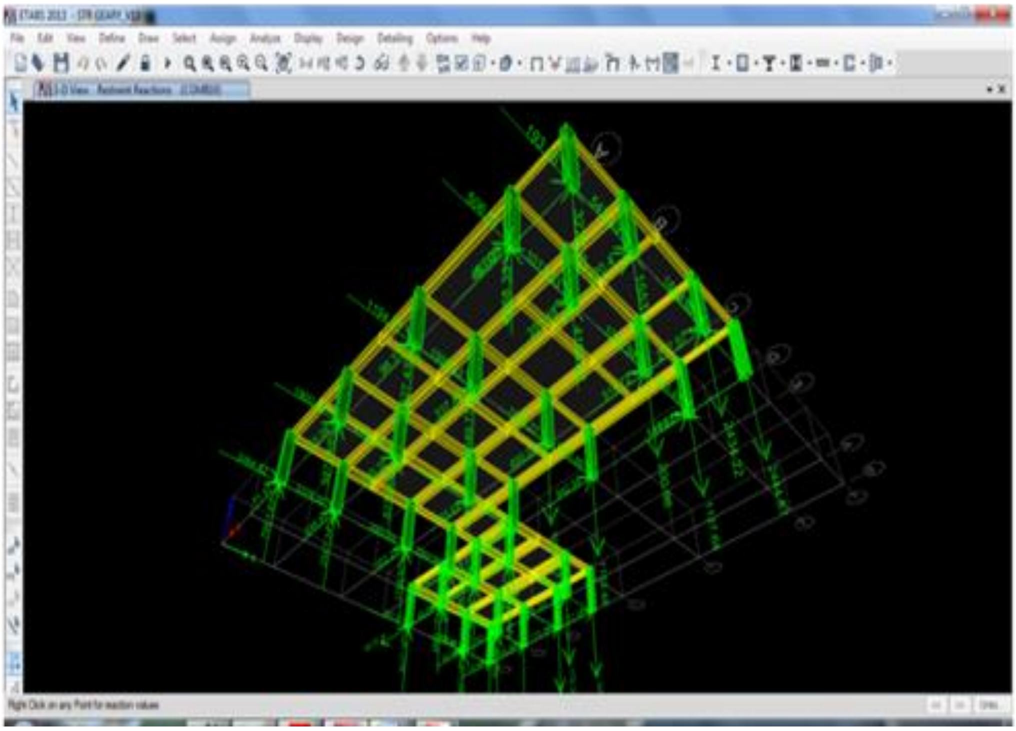

Figure 4 Output Base Reaction Results

A_p = 0.0625 m^2
l_i = 2 m
f_i = 10 t/m^2 (sand)
A_{st}= 1m
q_c = 40 x 62 = 2480 t/m^2
$P_a = \frac{qc\ x\ A_p}{FK1} + \frac{\sum l_i f_i\ x\ A_{st}}{FK2}$
$P_a = \frac{2480\ x\ 0.0625}{3} + \frac{124x1}{5}$ = 76,46 ton / 749,816 kN

Calculation of the compressive bearing capacity of the pile based on SPT data at each depth can be seen in Table 5.

Table 5 Pile Compressive Bearing Capacity

Depth	li m	N SPT	qc t/m	Ap m^2	Ast m	fi t/m^2	li fi t/m	∑ lifi t/m	Pall ton
2	2	4	80	0.0625	1	4	8	8	3.267
4	2	29	580	0.0625	1	12	24	32	18.48
6	2	42	840	0.0625	1	12	24	56	28.7
8	2	63	1260	0.0625	1	12	24	80	42.25
10	2	64	1280	0.0625	1	12	24	104	47.46
12	2	62	2480	0.0625	1	10	20	124	76.46
14	2	69	2760	0.0625	1	10	20	144	86.3
16	2	60	2400	0.0625	1	10	20	164	82.8
18	2	62	2480	0.0625	1	10	20	184	88.46

Group pile supporting capacity

In carrying the axial load in groups, the bearing capacity of the pile foundation has decreased due to the implementation of the pile so that the group strength analysis must be multiplied by the efficiency.

The number and formation of piles are taken based on the plan of the foundation structure at as B / 5 join 43.

Bearing capacity of group piles before adding the number of floors

Pole length = 9 m
D = 25 cm
S = 75 cm

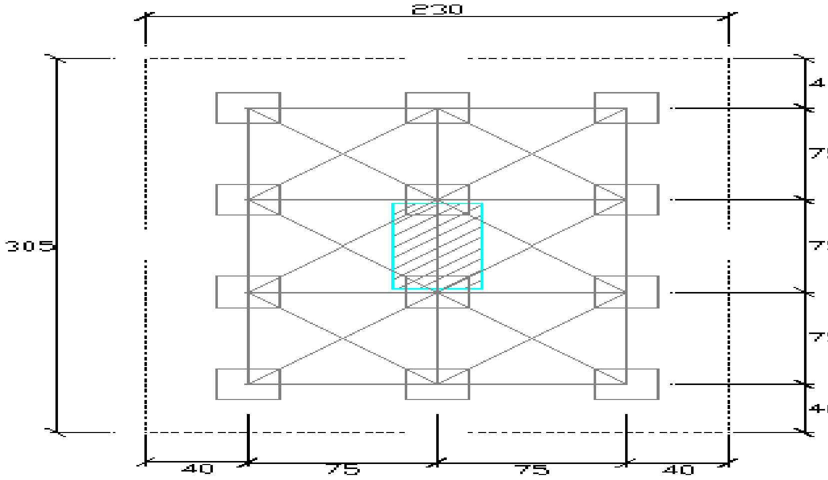

Figure 5 Pile Distance

The carrying capacity of the group foundation according to Converse Labarre is:

$$Eg = 1 - \theta \frac{(n-1)m+(m-1)n}{90mn}$$

Q = arctg $\frac{D}{s}$
m = 4
n = 3
s = 75 cm
θ = arc tg (25/75)= 18,43°
Eg = 1 – 18,43 $\frac{(3-1)4+(4-1)3}{90\ x\ 4\ x\ 3}$ = 0,70

So that:

Q_{ijin} = Eg x n x $Q_{permit\ pole}$
= 0,70 x 12 x 749,816
= 6298,45 ≥ 4865,55 kN (OK)

The moment that acts on the pole due to the horizontal force:

$$Pi_{maks} = \frac{\sum V}{np} \pm \frac{Mx.Ymax}{nx.\sum y^2} \pm \frac{My.Xmax}{ny.\sum x^2}$$

n = 12, ny = 4, nx = 3
$\sum X^2$= 8. (0,75^2) = 4,5 m^2
$\sum Y^2$= 6.$(0,75^2)$ + 6.$(0,375^2$)= 4,21 m^2

Moment that works:

Mx = M_{ux} + ($F_y . t_{poer}$)
= -5170,28+ (1646,24. 0,7) = -4017,91 kN

My $= M_{uy} + (F_x . t_{poer})$
$= 553,25 + (278,72.\ 0,7) = 748,345$ kN

Calculation of the Maximum Axial Load of piles in a pile group:

Column reaction= 4865,55 kN
Poer weight = 2,3 x 3,05 x 0,7 x 2400
= 11785 kg, 115,57 kN
Total weiht (∑V) = 4981,12 kN ≤ 6298,45 (OK)

So that, it is obtained:

$P_{12} = \frac{4981,12}{12} - \frac{-4017,91\ .1,125}{4.\ 4,5} + \frac{748,345\ .0,75}{3.\ 4,21}$
= 710,64 kN
P_{12} = Pmax = 710,64 ≤ P_{permit} = 749,816 kN (OK)

Bearing capacity of group piles after the addition of the number of floors

Q_{permit} = Eg x n x $Q_{permit\ pole}$
= 0,70 x 12 x 749,816
= 6298,45 ≤ 6549,77 kN
(does not meet the $Q_{permit\ pole}$)

The moment that acts on the pole due to the horizontal force:

$Pi_{max} = \frac{\sum V}{np} \pm \frac{Mx.Ymax}{nx.\sum y^2} \pm \frac{My.Xmax}{ny.\sum x^2}$
n = 12, ny = 4, nx = 3
$\sum X^2$ = 8. $(0,75^2)$ = 4,5 m^2
$\sum Y^2$ = 6.$(0,75^2)$ + 6.$(0,375^2)$ = 4,21 m^2

Moment that works:

Mx $= M_{ux} + (F_y . t_{poer})$
= -6300+ (1995,52. 0,7)
= -4903,13 kN
My $= M_{uy} + (F_x . t_{poer})$
= 670,917 + (337,46. 0,7)
= 907,13 kN

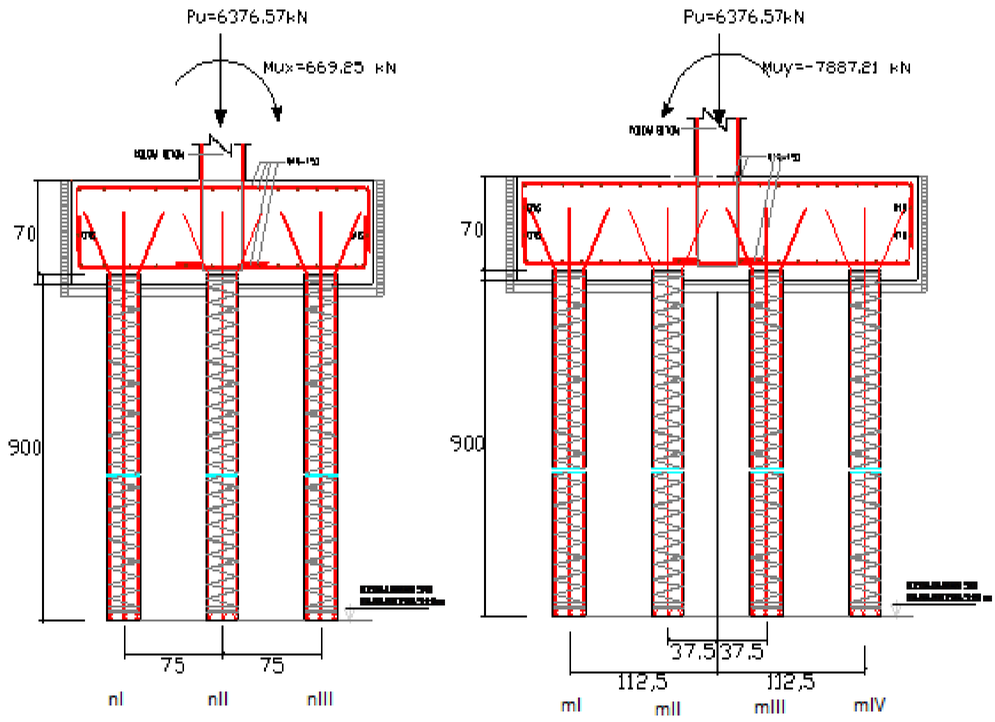

Figure 6 Distance Between Poles

Calculation of the Maximum Axial Load of piles in a pile group:

Column reaction = 6549,77 kN
Poer weight = 2,3 x 3,05 x 0,7 x 2400
= 11785 kg, 115,57 kN
Total Weight (∑V) = 6665,34 kN ≥ 6298,45

So that, it is obtained:

$$Pi_{max} = \frac{\sum V}{np} \pm \frac{Mx.Ymax}{nx.\sum y^2} \pm \frac{My.Xmax}{ny.\sum x^2}$$

$$P_1 = \frac{6665,34}{12} + \frac{-4903,13 .1,125}{4.\ 4,5} - \frac{907,13 .0,75}{3.\ 4,21}$$
= 195,13 kN

It is calculated the same way it is obtained:

P_2= 248,99 kN, P_3= 302,86 kN, P_4= 399,42 kN
P_5= 453,29 kN, P_6= 507,16 kN, P_7= 603,72 kN
P_8 = 657,59 kN, P_9= 711,46 kN, P_{10}= 808,02 kN
P_{11}= 861,89 kN, P_{12}= 915,75 kN

So that, it is obtained:

P12= Pmaks = 915,75 kN ≥ The bearing capacity of the pile permits = 749,816 kN

Because the axial force P is greater than the bearing capacity of the pile group, it does not meet the allowable bearing capacity of the pile group.

CONCLUSION

Based on the overall analysis that has been carried out in the preparation of this Final Project, several conclusions can be drawn as follows:

a. In a planning need guidance on existing regulations in accordance with the place where these regulations apply. In this case the regulations used are SNI 03-2847-2002 regarding general regulations on structural planning and SNI 03-1726-2012 regarding earthquake resistance procedures for building buildings.

b. 2.From the results of re-analysis of the ETABS V13 structure, the following data are obtained:

▪ Bearing capacity of group piles before adding the number of floors:
- Pmax = 710.64 <Pijin = 749,816 kN (OK)
- Q_ijin = 6298.45> 4865.55 kN (OK)

▪ The carrying capacity of group piles after the addition of the number of floors:
- Qijin = 6298.45 <6549.77 kN (does not meet the Qijin pole)
- Pmaks = 915.75 kN> Supporting capacity of pile pressure = 749.816 kN (not fulfilling)

c. This analysis is adjusted to the SNI SNI 03-2847-2002 and 03-1726-2012 guidelines, so that with these results it can be concluded that the piles used do not meet the priority factor.

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