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Designing and Construction of Piles Under Various Field Conditions

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ABSTRACT

Pile foundations are used to transmit super structure load to load bearing strata, to resist vertical, lateral, uplift load and also to minimize the settlement. In this study, an attempt is made to compare load carrying capacity of pile obtained by pile load test with that obtained by different analytical methods and numerical method using PLAXIS. In the first site, as per soil investigation report, the site was filled up soil up to depth of about 3m from the existing ground level. If open foundation is to be adopted, deep excavation is to be done for 22 columns, thus almost the entire site is to be excavated. The site is surrounded by residential buildings on all the three sides. Ground water table is at a depth of about 4.0m. Due to the such high water table, the soil below the foundations of surrounding building may flow in causing the damage to the surrounding buildings. To avoid this problem, it is desirable to adopt pile foundation for load bearing columns. There are two piles under each column to carry the vertical load and to resist the moments and also to account for negative skin friction due to filled up layers. In this study, safe load carrying capacity pile have been analysed using analytical methods such as IS CODE method, Meyerhof's approach, structural strength criteria and it is compared with field test results and also with numerical analyses using software Plaxis.

In the second site, it was proposed to construct shopping wall with 2 basements at Lalbagh road in Bangalore. This site is surrounded by residential apartment of 3 storeyed building on one side and Industrial Structure on other side and at the back side of the site a deep nalla is flowing. Hence site situation has created necessity to protect the sides of deep excavations. For this purpose, laterally loaded piles of 600mm dia. and depth varying from 8m to 12m was proposed and installed. Laterally loaded piles have been analysed using analytical method such as closed form solution, method and compared with numerical analyses using software plaxis.

1. INTRODUCTION

When the soil at shallow depth is not capable of supporting a structure, deep foundations are required to transfer the loads to deeper strata. If a firm stratum is so deep that it cannot be reached by open excavation, the deep foundation will be adopted. The most common types of deep foundations are Piles, Piers and Caissons. The mechanism of transfer of the load to the soil is essentially the same in these types of foundations. When piles and raft is both equal in cost, then piles are preferable to rafts as the settlement for piles is considerably less than that of a raft. Economy in pile foundation is achieved by designing the piles of suitable diameters such that the sum of safe capacity of piles

under a column should be almost equal to the load coming on the column. In one pile group there should be preferably only one diameter of piles. In a building, diameter of piles may vary under various columns depending on the magnitude of load being carried by the columns.

2. THE PROPOSED RESIDENTIAL BUILDING AT R.M.V, BANGALORE

General

As per soil investigation report, the site has filled up soil up to depth of about 3m from gl. If open foundation is adopted, an excavation of 3.5m is to be done for 22 columns. The site is surrounded by residential buildings on all three sides. Ground water table is at about 4.0m. Due to the such high water table, the soil from below the foundations of surrounding building may flow in causing the damage to the surrounding buildings. To avoid the above problem, it is desirable to adopt pile foundation for load bearing columns. Piles will be of bored cast in situ type; boring will be by using hydraulic rotary rig and concreting will be done by tremie method. There will be two piles under each column to carry the vertical load and to resist the moments and also to account for negative skin friction due to filled up layers. Diameter of pile will be 600mm and depth will be about 8m from gl.

Estimating the Safe Load Carrying Capacity of Pile Using Analytical Method

Depth varies from 0 to 4.0m

c = 4KN/m2

Ø = 30º, γ = 14 KN/m3

N = 15, Nc = 37.2, Nq = 22.5, N γ = 20.1

Layer 2:

Depth varies from 4.0 to 5.5m

c = 20 KN/m2

Ø = 20º, γ =16 KN/m3

N = 19, Nc = 17.7, Nq = 7.4, N γ = 4.4

Layer 3:

Depth varies from 5.5 to 8.0m

c = 10 KN/m2

Ø = 35º, γ = 17 KN/m3

N = 25, Nc = 43.55, Nq = 28.25, N γ= 30

Based on IS2911 (part1/sec) 1979

$Q_u = A_p (0.5D\gamma\ N_\gamma) + A_p (P_D\ N_q) +$" $K_i P_{D1} \tan\delta\ A_{si}$ -

Negative skin friction

Q_u = 2540KN

Q_{safe} = 750 KN

Meyerhoff's Method

$Q_u = (40NA_p) / 3 + (N\ A_s) / 5$

Q_u = 3000 KN

Q_u = 1200KN

Structural Strength

$P_u = 0.4f_{ck}\ A_c + 0.67f_y$ Asc or P_u = 4283KN

P_{safe} = 2140 KN

Minimum of the above three values is selected. Thus safe load=750kN.

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Verifying the Safe Load on Pile by Conducting Full Scale Tests

Design was done by using analytical method and was confirmed by conducting routine vertical load test. The testing arrangements and procedure adopted are in confirmation with that mentioned in relevant I.S.Codes. It was observed that the maximum total settlement at a load of 1125kN (one and half times 750kN) was 0.93mm only, as against the permissible settlement of 12mm as per IS 2911 – Part – IV. Since the total maximum settlement was less than 12mm for a load of 1125kN, the pile is safe for design load of 750kN.

3. THE PROPOSED COMMERCIAL BUILDING AT LALBAGH ROAD, BANGALORE

General

There was proposed to construct shopping mall with 2 Basement at Lalbagh road in Bangalore. This site is surrounded by residential apartment of 3 storeyed building on one side and Industrial structure on other side.At the backside of the site deep nalla is flowing. Hence site situation has created necessity to protect the sides of deep excavations. For this purpose Touch Pile of 600mm dia. and depth varying from 12m to 8m was proposed and hence pile were installed.

Design For Sheet Pile by using Closed Form Solution (Fig.1)

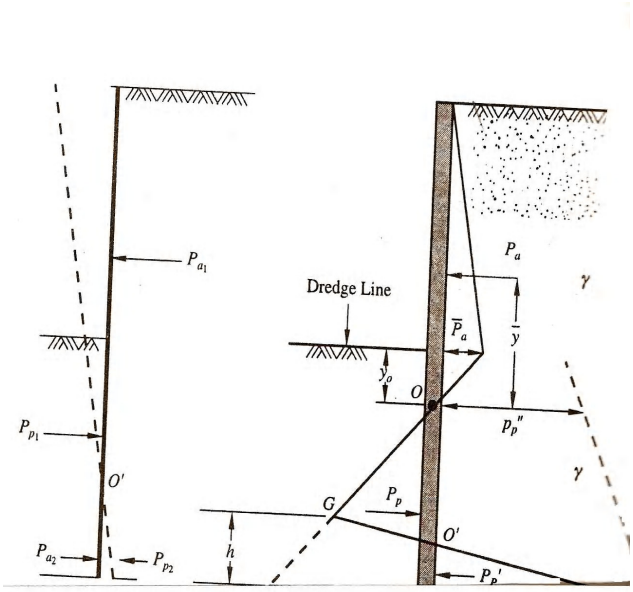

Fig. 1: Typical Pressure Diagram on Cantilever Wall

Data

Depth of Pile = 12.0m

Ø = 35°, γ = 20KN/m^3

$K_a = \tan^2(45- Ø/2) = \tan^2(45- 35 /2)$

$K_a = 0.27$

$K_p = 1/ K_a = 1/0.27 = 3.69$

Solving using closed form equations and increasing the depth of embedment by 20%,

D = 10.19m.

Bending moment and shear force works out to be,

BMD = 146.4 KN m

SFD = 64.7 KN

Analysis of Sheet Pile using 2D Plaxis 8.0

The material properties used are shown in Table 1.

Table 1: The Material Properties of Pile for Laterally Loaded Pile

EA	*EI*	*w*	*Mp*	*Np*
[kN/m]	[kNm²/m]	[kN/m/m]	[kNm/m]	[kN/m]
1.211E7	2.72E5	12.46	1E15	1E15

Table 2: Comparison Between Analytical and Numerical Method

Sl.No	*Particulars*	*Closed form solution*	*Numerical Method*
1.	Deformation	19.18mm	12.75mm
2.	BMD	146.4KNm/m	78.92KNm/m
3.	SFD	64.7 KN/m	43.04 KN/m

Results obtained from PLAXIS are compared with closed form solution (Table 2). There is reasonable comparison of results. Result from closed form solution seems to be more conservative compared to numerical method. These may be due to some of the following reasons:

In closed form solution method, it is assumed that whole excavation is done in one stage and soil parameters are normally assumed uniform but in the numerical method the layered system is been analyzed by discretizing the soil media and interface's element are been used to transfer the stress oblique forces to pile system based on the stiffness factor. Further the stage wise excavation can be taken up for analysis. This aspect resembles the actual procedure being carried out in the field. At every stage of excavation displacement, moment, and shear force can be calculated.

CONCLUSIONS

Based on the study, following broad conclusions are drawn.

1. The Design of piles have been made using various methods for practical cases in some sites at Bangalore.
2. As per load calculation piles have been installed and load test have been conducted. There is good comparison of load carrying capacity of pile obtained by analytical methods with that obtained by field pile load test.
3. From above study, it can be concluded that the Numerical analysis of sheet piles by using software like Plaxis are more economical and accurate.
4. In this computer age use of software like Plaxis give better and faster results and approach of analysis represents actual soil conditions.

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