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Design of Pile Foundation for site in Sangli district of Maharashtra: Case study

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Abstract – *The foundation is an important part of the structure. The pile foundation is one of the very important type of deep foundations. Shallow foundations and deep foundations are important types of foundation. In this paper, OPD building in Sangli District has been considered as a case study. The soil has been found to be clayey soil. Piles have been designed for this building as bearing capacity of the soil is very low. The details of geotechnical design and details of structural design are explained in this paper.*

Key Words: Pile, static, design, foundation, bearing capacity

1. INTRODUCTION

Foundation is a part of structure which transfers building loads to the earth farther down from the surface. The loads can be transferred from shallow depth to large depth. Depending on the depth of foundation, the foundations are classified into two broad categories. Shallow foundations transfer the load to shallow depth while deep foundations transfer the load at deeper than shallow foundations. Common types of shallow foundation are isolated footing, combined footing, strip footing, strap footing etc. Common type of deep foundations is 'pile foundation'. A pile is defined as, vertical structural element of a deep foundation, driven or drilled deep into the ground at the building site. The pile foundation is recommended because of very large design loads, poor soil at shallow depth etc. Pile can be constructed by using timber, steel, reinforced concrete or presetrssed concrete.

2. Site details

The site considered in this study is an OPD building constructed in Vishrambag area of the city. It has various segments as male ward, female ward, waiting room etc. The site has been surveyed and the soil samples are collected from the site. The centre line plan of the building is shown in Figure 1, Figure 2 and Figure 3.

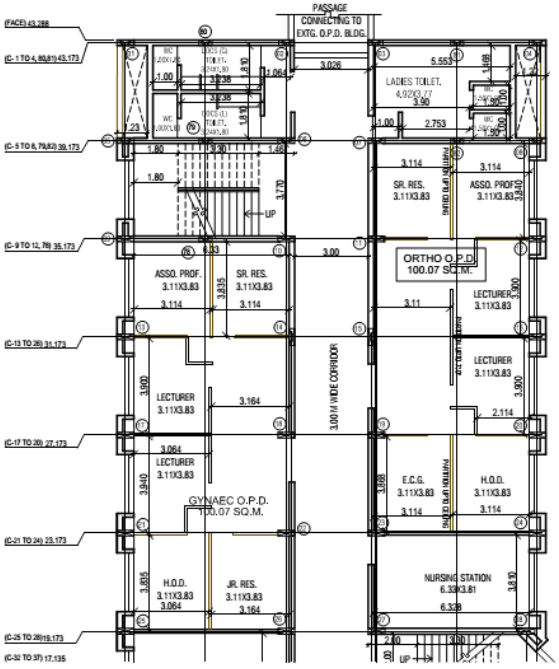

Figure 1 Layout of proposed OPD building

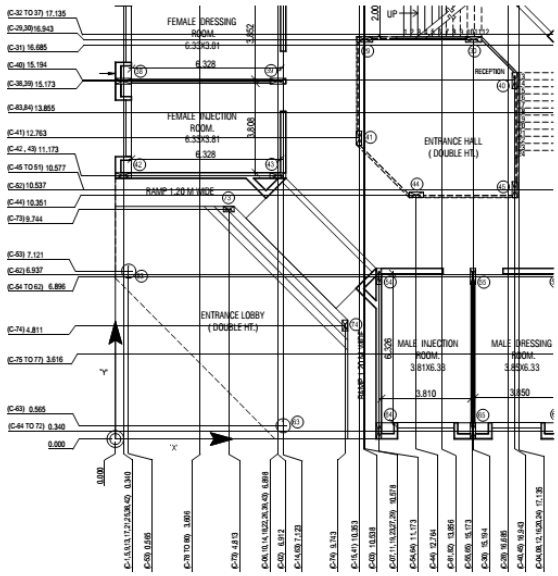

Figure 2 Layout of proposed OPD building

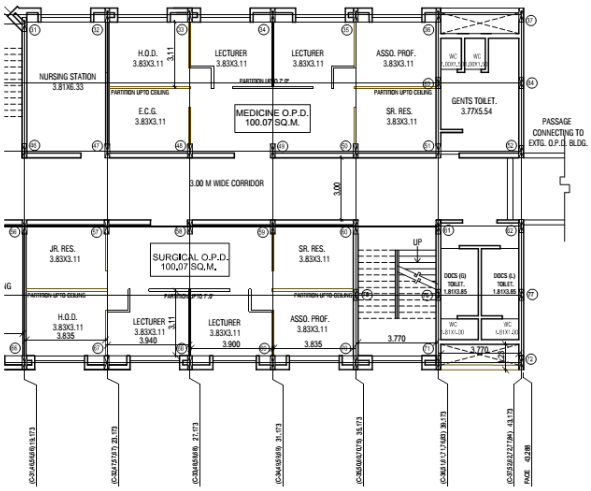

Figure 3 Layout of proposed OPD building

3. Soil test results

Soil samples from various test pits at a depth of 2 m have been collected. The soil was tested in order o determine the bearing capacity of the soil. Following initial tests were done on the soil:

Table 1 Properties of soil obtained from OPD site

Test	Result	Test	Result
In situ density of soil	17.584 kN/m^3	Plastic limit	14%
In situ water content	15.54%	Shrinkage limit	08%
Specific gravity of soil soilds	2.68	Soil classification	CL
Liquid limit	25%	Soil classification method	Cording to IS soil classification system

In order to determine the shear strength of the soil, direct shear test was performed. The graph of direct versus shear strength was obtained from the test results as shown in Figure 4. From the graph it has been observed that, the value of cohesion of 0.2 N/mm^2 (200 kN/m^2) and the value of angle internal friction of soil, ϕ = 26.56°.

4. Determination of shear strength parameters of soil

Building codes in various countries give allowable bearing capacity which can be used for proportioning footings. These values are called as "Presumptive bearing capacity". These are based on case history on similar soils. IS:1904-1978 recommends that, in absence of test data, the values of safe bearing capacity can be taken equal to the presumptive bearing capacity values given in Table 2, for different types of soils and rocks.

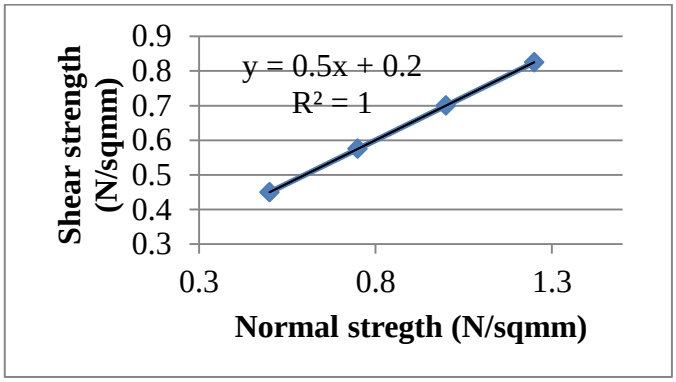

Figure 4 Results from direct shear test

Table 2 Presumptive bearing capacity values as per IS1904-1978

Type of soil/rock	Safe/allowable bearing capacity (kN/m^2)
Rock	3240
Soft rock	440
Coarse sand	440
Medium sand	245
Fine sand	440
Soft shell/Stiff clay	100
Soft clay	100
Very soft clay	50

5. Design Methodology for pile foundation

The decision of pile foundation has been taken on the basis of the type of soil available. Since, the soil present at the site has very low bearing capacity, the decision of pile foundation has been taken. Since, the load on the column is very large as compared to bearing capacity (based on Table 1), the piles are proposed. Design methodology for pile foundation in clay is explained.

5.1 PILES DRIVEN IN CLAY

The ultimate capacity of a single pile driven in clay is given by,

$$Q_u = Q_P + Q_s$$

The terms are expressed in Figure 5.

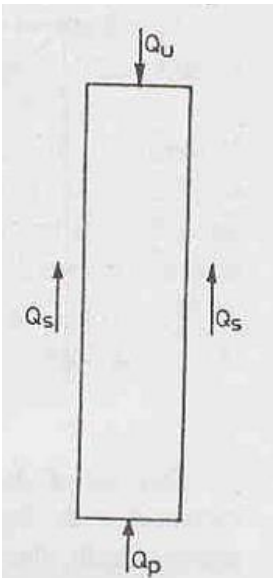

Figure 5 Mechanism of load transfer for single pile (Arora, 2004)

5.1.1 Method for determining tip resistance (Q_P)

The ultimate bearing capacity at the pile tip can be computed in the same way it is calculated for pile embedded in clay. It is given by,

$$Q_p = q_p A_P$$

where,

q_p is unit point resistance and A_p is area of pile tip

For cohesive soils, ϕ = 0, and hence the equation for qu is given by,

$$q_u = cN_c + qN_q$$

Since, N_q = 1 and $Q_p = Q_u - q$, we get,

$q_p = cN_c$ and from this we get,

$$Q_p = cN_c A_p$$

Where, c is cohesion of the surrounding soil, N_c is bearing capacity factor for deep foundation.

The value of N_c depends on (L/B) ratio and value of N_c = 9 is usually used in case of piles embedded in clay.

5.1.2 Method for determining skin friction (Q_s)

The skin resistance Qs for pile embedded in clay is given by,

$$Q_s = c_a A_s$$

Where c_a is unit cohesion and A_s is area of pile surface

Ca is given by, $c_a = \alpha \bar{c}$, where $\bar{c}$ is average cohesion along the shaft length

Therefore, the total pile load carrying capacity is given by,

$$Q_u = cN_c A_p + \alpha \bar{c} A_s$$

The value of α depends on the consistency of the clay. For normally consolidated ckays, the of value of α is taken as unity (i.e. α = 1). It may be noted that, for normally consolidated clay (i.e. c less than 50 kN/m^2), α can be taken as unity.

Based on the information available in the literature, the piles have been designed and the details of pile design are given in Table 2.

6. Design of pile foundation

Based on the above information, the pile foundation has been designed. The piles have been grouped into five groups. In group I, pile diameter is 600mm, in group II pile diameter is 450 mm. Similarly diameters of pile are 450 mm, 530 mm and 600 mm in group III, IV and V respectively. The length of the piles is 10 m in all groups. The reinforcement details of the pile are shown in Table 2. Since, the load on the each pile is less than, working load, the design is said to be safe.

Table 2: Details of pile foundation

COLUMN NO.	GROUP NO.	TYPE	NO. OF PILES	PILE SIZE	PILE DEPTH	LONGITUDINAL STEEL	LATERAL TIES	REMARK	WORKING LOAD ON SINGLE PILE
C– 75 TO 84	I	PRESSURE PILE	1	600ø	D	10–16#	8#@150C/C	REFER SKETCH NO.1	920 KN.
C– 2,3,41,44,52,62	II	PRESSURE PILE	2	450ø	D	10–12#	8#@150C/C	REFER SKETCH NO.2	490 KN.
C– 1,4 TO 40,42,43,45 TO 51, 54 TO 61, 64 TO 72	III	PRESSURE PILE	2	450ø	D	12–12#	8#@150C/C	REFER SKETCH NO.2	540 KN.
C– 73,74	IV	PRESSURE PILE	1	530ø	D	8–12#	8#@150C/C	REFER SKETCH NO.1	645 KN.
C– 53,63 (ROUND)	V	PRESSURE PILE	1	600ø	D	10–16#	8#@150C/C	REFER SKETCH NO.1	980 KN.

7. Conclusions

The site located in for a OPD building for civil hospital, Sangli, has been studied in this paper. The soil is tested and it has been observed that, the site is with cohesive soil. The bearing capacity of the soil from the presumptive bearing capacity has been found to be very low. This has been confirmed by direct shear test. Hence, pile foundation has been proposed. Piles with 10 m length and diameters of 600 mm, 450 mm, 530 mm have been proposed. The reinforcement details of the piles are also explained in this paper.

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