Effect Of Depth Of Footing And Water Table On Bearing Capacity Of Soil

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ABSTRACT

Soil is a universally available natural material derived mostly from rocks and rocky minerals. As soil is a product of nature, possess an inherently variable and complex character. The bearing capacity is the most important soil property, which governs the design of foundation. Soft clay strata are often unable to bear the load transferred from the superstructure to the foundation. Bearing capacity and the settlement are the two important parameters in the field of geotechnical engineering. Civil engineering projects such as buildings, bridges, dams and roadways require detailed subsurface information as part of the design process. Bearing capacity is affected by various factors like change in level of water table, eccentric loads, inclined loads, dimensions of the footings, *etc*.

The effect of water table on bearing capacity of soil determined by Terzaghi's method and IS Code method for rectangular footings are considered.

Keywords : Bearing capacity, Depth, Water table, Soil.

1. INTRODUCTION

Soil is considered by the engineer as a complex material produced by weathering of the solid rock. Soil is the most important material, which is in use for construction of civil engineering structures. Amongst all parameters, the bearing capacity of soil to support the load coming over its unit area is very important. There are various methods for calculation of bearing capacity of soil put forth by scientists like Prandtl, Terzaghi, Meyerhoff, Hansen, vesic and others. Principal factors that influence ultimate bearing capacities are type of soil, width of foundation, soil weight in shear zone and surcharge. Structural rigidity and the contact stress distribution do not greatly influence bearing capacity. Bearing capacity analysis assumes a uniform contact pressure between the foundation and underlying soil.

With other factors unchanged the type of failure of soil, depth of foundation, and effect of water table also governs the bearing capacity of soil. Soil is the most important factor in the construction world, in which the property of bearing loads coming upon has to be suitable. This property is the most significant one as the stability of the structure mostly depends on it.

Due to increase in population and industrialization, there is increase in construction activities in the cities and industrial area. Hence, it has become necessary to carry out construction activities on marshy land, low lying area, expansive soil having swelling and shrinkage characteristics, water logged areas *etc.* Safe bearing capacity values are assumed depending upon type of soil encountered at proposed depth of foundation.

In addition to properties of soil, width of foundation, depth of foundation, water table variation near the base of the footing, eccentricity of loading governs the ultimate and safe bearing capacity of soil. With all these factors into consideration the study was undertaken i.e. 'Effect of different parameters on bearing capacity of soil'. Thus, based on investigations carried out, it will be possible to decide optimum depth of foundation for proposed structure, from economy and practical considerations.

2. LITERATURE REVIEW

Terzaghi was the first to propose a bearing capacity equation on the consideration of general shear failure in the soil below a rough strip footing. Using the principle of superposition, he demonstrated the effects of soil cohesion, its angle of internal friction, surcharge (soil lying above the level of footing base), soil unit weight and footing width on the ultimate bearing pressure. Later on, Brinch Hansen introduced factor that accounted for footing shape and load inclination, in the bearing capacity equation.

K. Manjunath and A.S. Reddy studied the effect of depth and water table on bearing capacity of rectangular footing. They found that as depth of foundation increases, bearing capacity increases. They found that these is increased in dry density and decrease in optimum moisture content. They also studied the effect of depth of footing using geotextile reinforcement.

Javad Hajiani and Nader Hataf carried out experimental and numerical investigation of the bearing capacity of model circular footing on reinforced sand. They investigated the bearing capacity of circular and ring footings on reinforced sand by conducting laboratory model tests along with numerical analysis. The effects of the depth of the first layer of reinforcement, vertical spacing and number of reinforcement layers on bearing capacity of the footings were investigated

3. BEARING CAPACITY BASED ON LABORATORY TESTS

3.1 Laboratory Tests

The soil used in the study is collected from Aurangabad Airport, 10km from Aurangabad City. The soils samples are collected at a depth of 0.9m, 1.2m, 1.5m and 1.8m. The aim of this work is to study the effect of different parameters on bearing capacity of the soil. Experimental work was planned to study the properties of soils collected for determination of ultimate bearing capacity of the soil.

For the soils the basic properties such as specific gravity were determined, sieve analysis was carried out and consistency limit *i.e.* liquid limit and plastic limits were determined for classification of the soil. Standard Proctor test and direct shear tests were conducted to determine maximum dry density, optimum moisture content, cohesion and angle of internal friction(ϕ). The test results of soils tested for these properties are as shown in table 1.

Based on the laboratory test results and as per bureau of Indian standards the soil is classified as CH *i.e.* clayey soil with high compressibility.

Table 1: Geotechnical Properties of Soil

Properties of Soil Samples	Depth in meter			
	0.9	1.2	1.5	1.8
Grain size distribution				
Gravel size (4.75 mm to 80.00 mm) in %	----	----	1.30	2.35
Sand size (0.075mm to 4.75 mm) in %	12.41	13.89	12.60	15.20
Silt and clay size (below 0.075 mm)	87.59	86.11	86.10	82.45
Consistency limits				
Liquid limit %	68.00	64.50	59.80	52.50
Plastic limit %	34.50	31.25	29.50	28.50
Plasticity index %	33.50	33.25	30.30	24.00
Specific gravity	2.64	2.68	2.71	2.77
Compaction characteristics				
Maximum dry density in gm/cm^3	1.62	1.64	1.66	1.68
Optimum moisture content %	26.20	24.90	22.60	21.40
Shear parameters				
Cohesion in kN/m^2	29.43	26.97	24.52	22.62
Angle of internal friction (ϕ)	14.00	16.00	17.50	18.50

4. EXPERIMENTAL ANALYSIS

Based on the laboratory experimentation carried out the values of, c and ϕ are obtained. These parameters are important to determine ultimate and safe bearing capacity of soil. Based on this data, effect of depth of footing, is studied and is discussed in following paragraphs.

4.1 Effect of Depth of Footing on Bearing Capacity

The depth of footing is important parameters, which governs the ultimate bearing capacity of the soil. Ultimate bearing capacity is determined by using equation given by IS 6403 – 1981. The shape of footing taken is rectangular footing with length =1.5 m and width = 1m.

The values of ultimate bearing capacities determined by IS code method are as shown in table 2.

Table 2: Effect of Depth of Rectangular Footing on Ultimate Bearing Capacity

Type of soil	Depth of foundation in metre				Type of failure
	0.9	1.2	1.5	1.8	
Blackish Clayey soil	226.61	246.26 (8.67)	265.08 (16.97)	283.53 (25.11)	Local shear failure

In table 2, the values in parenthesis indicate the percentage increase in ultimate bearing capacity in comparison with 0.9 metre depth of foundation. Thus, for soil, which is clayey soil with high compressibility having good value of cohesion and lesser angle of internal friction the percentage increase in ultimate bearing capacity in comparison with 0.9m depth, for depths of 1.2m, 1.5m and 1.8m are found to be 8.67%, 16.97% and 25.11% respectively. Figure 1 shows the effect of depth of footing on ultimate bearing capacity of soil for local shear failure.

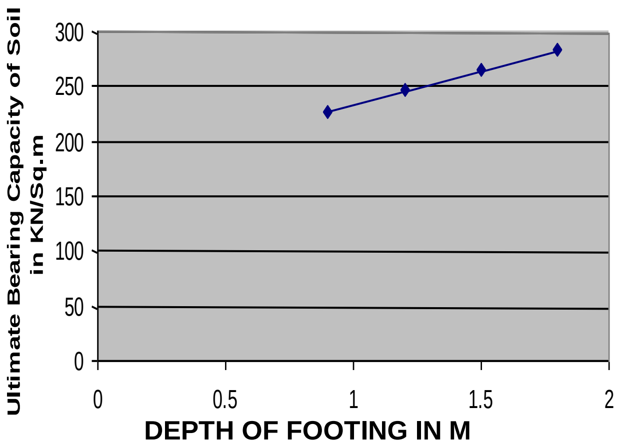

Figure 1: Effect of Depth of Footing on Ultimate Bearing Capacity of Soil

Table 3: Effect of Depth of Rectangular Footing on Safe Bearing Capacity

Type of soil	Depth of foundation in metre				Type of failure
	0.9	1.2	1.5	1.8	
Blackish Clayey soil	85.25	95.28 (11.76)	105.01 (23.17)	114.67 (34.51)	Local shear failure

In table 3, the values in parenthesis indicate the percentage increase in safe bearing capacity in comparison with 0.9 metre depth of foundation. Thus, for soil, which is clayey soil with high compressibility having good value of cohesion and lesser angle of internal friction the percentage increase in safe bearing capacity in comparison with 0.9m depth, for depths of 1.2m, 1.5m and 1.8m are found to be 11.76%, 23.17% and 34.51% respectively. Figure 2 shows the effect of depth of footing on safe bearing capacity of soil for local shear failure.

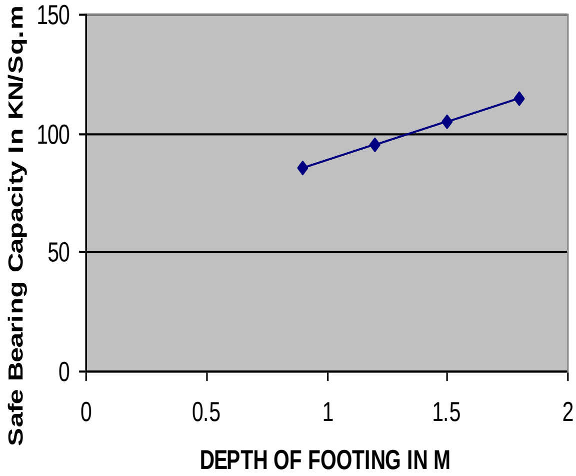

Figure 2: Effect of Depth of Footing on Safe Bearing Capacity of Soil

4.2 Effect of water table on bearing capacity

The change in moisture content of the soil affects the properties of the soil. Similarly, if soil gets submerged its ability to support the load coming over its unit area is reduced when the water table is above the base of the footing, the submerged weight is used for the soil below the water table for computing the surcharge. The water table corrections are applied to determine the ultimate bearing capacity of the soil. The values of safe bearing capacities determined by using factor of safety of 3 by IS code method and Terzaghi's method for rectangular footing.

Table 4 Effect of water table on safe bearing capacity of soil for rectangular footing by Terzaghi's method

Type of soil	**Safe bearing capacity in Kn/m^2**			**Type of failure**
	Without water table correction	Water table may reach upto the base of the footing	Water table may reach upto the ground level	
Blackish clayey soil	144.16	131.97 (8.45)	105.83 (26.58)	Local shear failure

From table 4 it is found that the percentage decrease in safe bearing capacity of soil due to water table corrections is found to be 8.45% and 26.58% safe bearing capacity of soil is reduced to about 26.58% when the watertable may reach upto ground level.

Table 5: Effect of water table on safe bearing capacity of soil for rectangular footing by IS Code method

Type of soil	**Safe bearing capacity in Kn/m^2**			**Type of failure**
	Without water table correction	Water table may reach upto the base of the footing	Water table may reach upto the ground level	
Blackish clayey soil	141.28	129.1 (12.18)	99.70 (29.43)	Local shear failure

From table 5 it is found that the percentage decrease in safe bearing capacity of soil due to water table corrections is found to be 12.18% and 29.43% safe bearing capacity of soil is reduced to about 29.43% when the watertable may reach upto ground level.

5. CONCLUSIONS

Based on the studies carried out following conclusions are drawn:

1. The important parameters, which govern the bearing capacities of soil are : cohesion, unit weight of soil, depth of proposed foundation and angle of internal friction.
2. As depth of foundation increases ultimate bearing capacity of soil increases. The effect of increase in depth on safe bearing capacity is predominant due to increase in surcharge weight.
3. The percentage increase in ultimate bearing capacity in comparison with 0.9m depth, for depths of 1.2m, 1.5m and 1.8m are found to be 8.67%, 16.97% and 25.11% respectively.
4. The percentage decrease in safe bearing capacity of soil due to water table correction is found to be 8.45% and 26.58% by Terzaghi's method.
5. The percentage decrease in safe bearing capacity of soil due to water table correction is found to be 12.18% and 29.43% by IS Code method.

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