International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 06 | June - 2022 Impact Factor: 7.185 ISSN: 2582-3930

COMPARATIVE STUDY BETWEEN ANALYTICAL AND SOFTWARE METHOD OF CALCULATING BEARING CAPACITY OF SOIL

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ABSTRACT

Any civil engineering structure is as strong as its foundation, a foundation is as strong as its soil. Soil considered as strong as it has higher bearing capacity. Soil is considered as a complex material produced by weathering of solid rock; it is the most important material which is used for construction of any civil engineering structure. As it is a complex material it has numerous properties or say characteristics but bearing capacity of soil is quite evident.

Main objective of this paper is to consider maximum parameter and analyze their effect on soil bearing capacity. There are various methods for calculation of bearing capacity of soil but in this project bearing capacity of black cotton soil at different four location in Amravati i.e., Parvati Nagar, Sai Nagar, Navsari and Dastur Nagar has been calculated by the IS code method, Terzaghi's analysis and by Geo5 software.

KEYWORDS: - Bearing capacity, Soil parameters, Depth of footing, Geotechnical software.

INTRODUCTION

All civil engineering structures whether they are buildings, dams, bridges etc. are built on soils. A foundation is required to transmit the load of the structure on a large area of soil. The foundation of the structure should be so designed that the soil below does not fail in shear nor there is the excessive settlement of the structure. The conventional method of foundation design is based on the concept of bearing capacity.

Soil when stressed due to loading, tend to deform. The resistance to deformation of the soil depends upon factors like water content, bulk density, angle of internal friction and the manner in which load is applied on the soil. The maximum load per unit area which the soil or rock can carry without yielding or displacement is termed as the bearing capacity of soils.

Soil properties like shear strength, density, permeability etc., affect the bearing capacity of soil. Dense sand will have more bearing capacity than loose sand as unit weight of dense sand is more than loose sand.

Stresses transmitted by a foundation to underlying soils must not cause bearing-capacity failure or excessive foundation settlement. The design bearing pressure equals the ultimate bearing capacity divided by a suitable factor of safety. The ultimate bearing capacity is the loading intensity that causes failure and lateral displacement of foundation materials and rapid settlement. The ultimate bearing capacity depends on the size and shape of the loaded area, the depth of the loaded area below the ground surface, groundwater conditions, the type and strength of foundation materials, and the manner in which the load is applied.

METHODOLOGY

ENGINEERING TESTS

In order to find out safe bearing capacity of soil necessary soil properties has been evaluated with help of following tests

Specific Gravity

Sieve Analysis

Compaction Test

Triaxial Test

Fig.1. Compaction Test

Fig. 2. Triaxial Test

We found the following properties of soil at location Parvati Nagar Amravati, from the tests mentioned above.

Specific Gravity	2.30
Soil Classification	SW
Unit Weight of soil	17.77 kN/m^3
Moisture content	20.4%
Dry Density	1.61 gm/cc
Cohesion	47.07 kN/m^2
Angle of internal friction	5.85^o

Table 1. Soil properties

TERZAGHI'S BEARING CAPACITY THEORY

Based on Terzaghi's bearing capacity theory, column load is resisted by shear stresses at edges of three zones under the footing and the overburden pressure above the footing. The first term in the equation is related to cohesion of the soil. The second term is related to the depth of the footing and overburden pressure. The third term is related to the width of the footing and the length of shear stress area. The bearing capacity factors, Nc, Nq, N_γ, are function of internal friction angle, ϕ

Terzaghi's Bearing capacity equations:

Strip footings:

$q_u = c\,Nc + \gamma\,D\,Nq + 0.5\,\gamma\,B\,N_\gamma$

Square footings:

$q_u = 1.3\,c\,Nc + \gamma\,D\,Nq + 0.4\,\gamma\,B\,N_\gamma$

Circular footings:

$q_u = 1.3\,c\,Nc + \gamma\,D\,Nq + 0.3\,\gamma\,B\,N_\gamma$

GEO5 (GEOTECHNICAL SOFTWARE)

GEO5 stands for "The Global Environment Outlook: Environment for the future we want (GEO5)". GEO5 is best and powerful software suite for solving geotechnical related problems. It is based on traditional analytical methods Fine develop the full package of geotechnical software – GEO5 and it is designed to solve various geotechnical problems such as excavation, slope stability, earthen dam, structure's foundation and more. Whereas geotechnical engineering related problems (slope stability, foundations, retaining walls), the GEO5 suite also includes highly sophisticated applications for the analysis of tunnels, building could be damage due to tunnelling, or stability of rock slopes.

In this project we calculate the bearing capacity of strip footing by using this geotechnical software and other shape of footing like Square, Rectangular, Circular etc. are not calculated because this footing is not available in the software.

INDIAN STANDARD CODE METHOD

This is the advanced analytical method for determining the safe bearing capacity of soil. It indicates the bearing capacity of soil for different water levels considering various shapes of footing as well as different loading conditions (inclined or vertical).

$$q_{nf} = C\, N_c\, S_c\, d_c\, i_c + \bar{\sigma}\, (N_q - 1)\, S_q\, d_q\, i_q + \frac{1}{2} \times \gamma\, B\, N_\gamma\, S_\gamma\, d_\gamma\, i_\gamma\, w'$$

$$q_s = \frac{q_{nf}}{FOS} + \bar{\sigma}$$

C = Cohesion of soil

S_c, S_q, S_γ = Shape factor for footing

i_c, i_q, i_γ = Inclination factor for footings

$\bar{\sigma}$ = Surcharge wt. of soil

N_c, N_q, N_γ = Bearing capacity factor

γ = Unit weight of soil

q_s = Safe bearing capacity

w' = Effect of water table

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RESULTS AND DISCUSSION

The below table indicate safe bearing capacity of soil by Terzaghi's Analytical Method at different depths, at different locations along with the different shapes of footing.

Sample. Location	Shape of footing	Safe bearing capacity(kN/m^2) For depth		
		1.2 m	1.5 m	1.8 m
	Square	126.69	134.67	142.63
	Circular	126.52	134.48	142.45
	Rectangular	122.35	130.32	138.29
	Strip	105.15	113.12	121.09
	Square	107.08	115.32	123.58
	Circular	106.83	115.07	123.33
	Rectangular	103.70	111.95	120.21
	Strip	90.46	98.71	106.97
	Square	143.82	151.56	159.30
	Circular	143.69	151.43	159.18
	Rectangular	138.64	146.38	154.12
	Strip	118.02	125.77	133.50
	Square	111.56	114.21	117.49
	Circular	111.38	113.95	117.22
	Rectangular	107.75	110.41	113.41
	Strip	92.71	95.45	98.18

Table 2. Results by Terzaghi's Method

Following are the graph showing safe bearing capacity of soil by Terzaghi's Method for various depth, various shape of footing.

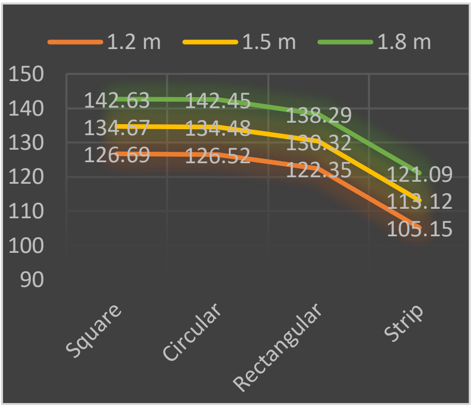

Fig.3. Parvati Nagar Sample

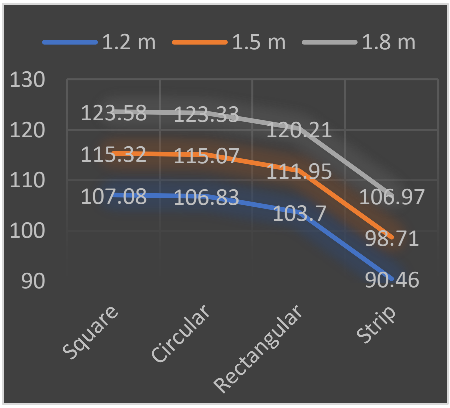

Fig. 4. Sai Nagar Sample

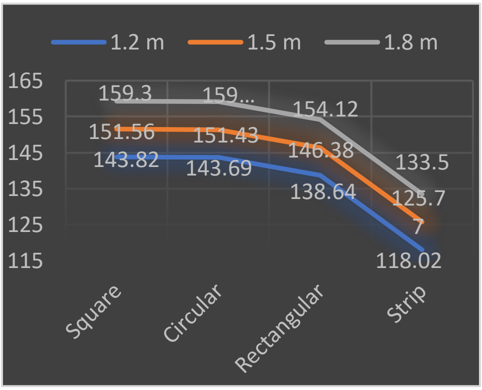

Fig.5. Navsari Sample

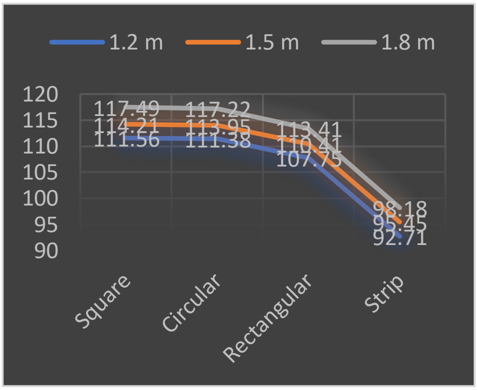

Fig. 6. Dastur Nagar Sample

Following table indicating that safe bearing capacity is evaluated for strip footing for various depth with help of Geo5 Software

Sample. Location.	Shape of footing	Safe bearing capacity(kN/m^2) For depth		
		1.2 m	1.5 m	1.8 m
Parvati Nagar	Strip	167.44	170.52	175.23
Sai Nagar	Strip	148.32	150.57	152.06
Navsari	Strip	186.74	191.37	195.86
Dastur Nagar	Strip	149.79	154.47	159.05

Table 3. Results by Software Method

Following table indicates the safe bearing capacity is evaluated for different water table condition with respect to different shape of footing by IS code method.

Sample. Location	Shape of Footing	q_s kN/m^2	
		Without Water Table	With Water table
		D = 1.2	D = 1.2
	Square	141.91	141
	Circular	141.50	140.88
	Rectangular	121.06	120.36
	Strip	115.27	114.24
	Square	122.96	121.70
	Circular	122.33	121.39
	Rectangular	112.60	111.53
	Strip	101.31	99.73
	Square	157.88	157.32
	Circular	157.60	157.17
	Rectangular	143.46	142.03
	Strip	127.25	126.54
	Square	115.07	114.50
	Circular	114.79	114.36
	Rectangular	110.09	109.61
	Strip	93.46	92.74

Table 4. Results by IS code Method

CONCLUSION

1. GEO5 Software shows 55 to 65% higher values than the Terzaghi method which shows lowest values among all these methods i.e., IS code method, Terzaghi method and software method.
2. The strip footing having the least values of safe bearing capacity and square footing having highest values of bearing for each location, by IS code and Terzaghi method. In IS code method the bearing capacity value for square footing is 20 to 25% greater than strip footing and in Terzaghi method the bearing capacity value for square footing is 15 to 20% higher than strip footing.
3. As the depth of footing increases from 1.2 to 1.5 m and 1.5 to 1.8 m then the bearing capacity values increases in the range of 2 to 3% from previous depth and this effect is predominant due to increasing surcharge weight due to higher depth.
4. The angle of internal friction, cohesion, unit weight of soil and depth of foundation are some of the important parameters governing the bearing capacity of soil for IS code and Terzaghi method.

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