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Ready Reckoner For Foundation On Different Soil

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ABSTRACT— The civil engineer has many diverse and important encounters with soil. Every building structure has to be constructed on soil foundation soil depending upon site conditions. Therefore, soil is ultimate foundation material which supports the structure. The proper functioning of the structure will therefore depend critically on the success of the foundation element resting on the sub soil. It is therefore, necessary to know the bearing capacity of the soil, the pattern of stress distribution in the soil beneath the loaded area, the probable settlement of the foundation, effect of vibration and water level. The present project work is aimed towards study of selection criteria of foundation types based on soil conditions, acceptance criteria of different parameters of soils. The method used to determine bearing capacity is IS Code Method which is described in detail, while other methods like Terzaghi, Mayeroff and Vesics methods are briefly described. Load calculations are carried out for a G+2 residential building and G+3 commercial building. The results are obtained for various values of specific weight, cohesion and angle of internal friction. The type of foundation like shallow strip footing resting on different soil like cohesion-less soil can be suggest by using the software. The parameter of different types of soil can be input for this and can obtained from the analysis of soil. In conclusion, the need for a proper evaluation methodology for calculation of correlation lengths of soil properties and their influence in foundation design is highlighted. The calculation for foundation on different soil by using this software and without software can be compare and time require for this calculation can also be compare.

KEYWORDS- Bearing Capacity, Ready Reckoner, IS Code Method.

I. INTRODUCTION

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 super structure 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 footing etc. Terzaghi (1943) proposed the first comprehensive bearing capacity analysis for the case of strip footing with rough base for a frictional cohesive soil using limit equilibrium method. The initial contributions in this area were also made by Prandtl, (1920) Resissner (1924). Prandtl (1920) obtained analytical closed form solutions for ultimate bearing pressure for the case of a strip footing on weightless semi-infinite space. This analysis is applicable to frictional cohesive soil and to a purely cohesive soil. Meyerhoff (1951) used limit equilibrium method for the evaluation of ultimate bearing capacity of shallow foundation with rough base for a c-Ø soil. Chen (1975) used limit analysis approach and employed Prandtl and Hill mechanism for the evaluation of bearing capacity factors for rough and smooth footings respectively.

II. METHODOLOGY

Bearing capacity is the power of foundation soil to hold the forces from the superstructure without undergoing shear failure or excessive settlement. Foundation soil is that portion of ground, which is subjected to additional stresses when foundation and superstructure are constructed on the ground. Various terminology in bearing capacity are:

Ultimate Bearing Capacity (qf): It is the maximum pressure that foundation soil can withstand without undergoing shear failure.

Net ultimate Bearing Capacity (qn): It is the maximum extra pressure (in addition to initial overburden pressure) that a foundation soil can withstand without undergoing shear failure. γ is the unit weight of soil & D is the depth to foundation bottom from Ground Level.

Safe Bearing Capacity (qs): It is the safe extra load; the foundation soil is subjected to in addition to initial overburden pressure. F – Factor of Safety

$$q_n = q_f - \gamma D$$

$$q_s = \frac{q_f}{F} + q_o$$

Terzaghi (1943) was the first to propose a comprehensive theory for valuating safe bearing capacity of shallow foundation with rough base. The theory is based on assumptions of soil being homogeneous and isotropic. The form of equation used by Meyerhof (1951) for determining ultimate bearing capacity of symmetrically loaded strip footings is the same as that of Terzaghi but his approach to solve the problem is different. He assumed that the logarithmic failure surface ends at the ground surface, and as such took into account the resistance offered by the soil and surface of the footing above the base level of the foundation. Vesic(1973) confirmed that the basic nature of failure surfaces in soil as suggested by Terzaghi as incorrect. However, the angle which the inclined surfaces AC and BC make with the horizontal was found to be closer to 45+ϕ/2 instead of ϕ. IS: 6403-1981 recommends a bearing capacity equation, which is similar in nature to those given by Mayerhof and Brinch Hansen. The code recognises, depending upon the deformations associated with the load and the extent of development of three types of failure surfaces, namely General Shear Failure, Local Shear Failure, Punching Shear Failure. The IS Code method of calculation of bearing capacity is based on following equation.

$$q_{nu} = CN_c s_c d_c i_c + \sigma(N_q - 1)s_q d_q i_q + \frac{1}{2}B\gamma N_\gamma s_\gamma d_\gamma i_\gamma W'$$

III. IS CODE SPECIFICATIONS

Table.1 Acceptance Criteria for Soil as a Construction Material

Sr. No	Item	Acceptance Criteria	Remark
A	Clay Content	Maximum 10 %.	If soil is not under the acceptance criteria shall be treated by soil nailing, replacing, improving properties by substitution with lime, etc.
B	Deleterious Content Test	Material should be free from swamp, marshes and bogs.	
C	Particle Size Distribution & Classification of Soil	Soil should not be classified as OL, OI, OH or Pt	
D	OMC & Maximum Dry Density	As per Loading conditions	
E	Density	Shall not be less than 1.52gm/cc	
F	Wet Sieve Analysis & Grading	As per Loading conditions	
G	Moisture Content	As per Loading conditions	
H	Dry Density	As per Loading conditions	

Various soil parameters are listed in above table which will make the soil suitable for construction purposes.

The values of bearing capacities of typical soil and rock types play an important role in selection of type of footing. Table 2 lists down numerous types of soils along with their bearing capacity.

Table.2 Bearing Capacity for Different Soil Types

Sr. No.	Type of Soil or Rock	SBC (kPa)
ROCKS		
1	Rocks (hard) without lamination and defects, for example granite, trap and diorite	3300
2	Laminated rocks, for example sand stone and lime stone in sound condition	1650
3	Residual deposits of shattered and broken bed rock and hard shale, cemented material	900
4	Soft rock	450
NON-COHESIVE SOILS		
5	Gravel, sand and gravel mixture, compact and offering high resistance to penetration when excavated by tools.	450
6	Coarse sand, compact and dry (with ground water level at a depth greater than width of foundation below the base of footing)	450
7	Medium sand, compact and dry	250
8	Fine sand, silt (dry lumps easily pulverized by fingers)	150
9	Loose gravel or sand gravel mixture; loose coarse to medium sand, dry	250
10	Fine sand, loose and dry	100
COHESIVE SOILS		
11	Soft shale, hard or stiff clay in deep bed, dry	450
12	Medium clay, readily indented with thumb nail	250
13	Moist clay and sand clay mixture which can be indented with strong thumb pressure	150
14	Soft clay indented with moderate thumb pressure	100
15	Very soft clay which can be penetrated several centimetres with the thumb	50
16	Black cotton soil or other shrinkable or expansive clay in dry condition (50 percent saturation)	50

IV. RESULTS & DISCUSSION

Foundation Selection is a critical concept being the base of the structure various aspects need to be kept in consideration selecting suitable foundation which we can be made convenient by forming a reckoner. A strip footing, combined and mat footing can also be provided for a row of columns, which are closely spaced as their spread footings overlap each other. For the cohesive soil for getting allowable bearing capacity more than actual bearing capacity deep foundation can be used.

The input values of Unit weight, Angle of internal friction are provided based on some typical values of soil conditions available. The size of footing in each case is kept same so that the net pressure at base of footing remain same and the footing can be directly compared based on their net safe bearing capacity. The value of safety against net pressure is obtained by dividing net pressure by net safe bearing capacity.

Basic aspects of reckoner in spreadsheet of general criteria are categorized as soil acceptance criteria giving as per the Indian standards.

Table.3 Results for Bearing Capacity Calculations (Readings are taken from Reckoner)

Parameters	1	2	3	4	5	6	7	8
Unit Weight (kN/m^3)	18	18	18	18	18	18	18	18
Cohesion (kN/m^2)	0	0	0	0	25	25	25	25
Angle of Friction	37	37	37	37	36	36	36	36
Shape of Footing	Square	Rectangular	Circular	Strip	Square	Rectangular	Circular	Strip
Width (m)	1	0.8	1.125	1	1	0.8	1.125	1
Length (m)		1.25				1.25		
Depth (m)	2	2	2	2	2	2	2	2
Factor of Safety	3	3	3	3	3	3	3	3
Working Load (kN)	750	750	750	750	1600	1600	1600	1600
Net Pressure at base (kPa)	750.000	750.000	754.512	750.000	1600.000	1600.000	1609.626	1600.000
Overburden Pressure (kPa)	36	36	36	36	36	36	36	36
Net Ultimate B.C. (kPa)	3205.135	3088.218	3002.160	2949.179	5710.160	5500.718	5394.376	4805.589
Net Safe B.C. (kPa)	1068.378	1029.406	1000.720	983.060	1903.387	1833.573	1798.125	1601.863
Actual FoS	1.425	1.373	1.326	1.311	1.190	1.146	1.117	1.001
Comment	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe

V. CONCLUSION

- Various type of soil has different bearing capacity as non-cohesive and cohesive soils have different range but spreadsheet of 'Soil type' helps to guess the bearing capacity range as per the soil type.
- For cohesion less soil (C=0), all the shapes of footing were safe in between 30-50 degrees in pilot readings and limiting value of internal friction angle ϕ is 370 for all shapes of footing. With their area and other parameters being same, square footing has yielded a maximum safety ratio against net pressure as compared to strip, rectangular and circular footing.

- For cohesive soil, the safety limits of ϕ are again between 30-500 in pilot readings. However, the limiting values for all the types are dropped to 360 for strip footing and 350 for square, rectangular and circular footing. Though the area is same, the safety ratio for square footing is again highest among all the shapes.

- Determination of bearing capacity and selection of foundation is time consuming and many calculations is required in which reckoner suggest the appropriate foundation type with various soil testing making it user friendly**.**

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