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Study of Variation In Bearing Capacity With Respect To Degree Of Saturation

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Abstract - *The focus of study in this paper is directed towards understanding the rate of reduction in bearing capacity after submergence as it is very much dependent on degree of saturation and respective c-Φ parameters. Also this study proposed the approach for calculating bearing capacity (qu) under fully saturated and zero degree saturated condition using actual values of c-Φ parameters by considering initial degree of saturation. It was observed that the bearing capacity decreases considerably by increase in degree of saturation. The calculated values were verified and an equation was derived which shows the relation between bearing capacity and degree of saturation.*

Key Words: Bearing capacity, Cohesion, Angle of internal friction, Degree of Saturation, Density.

1. INTRODUCTION

The bearing capacity is the most important soil property, which governs the design of 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 variation of moisture content stored in the ground and earth structures under varying environmental conditions is an important aspect closely related to the mechanical behaviour of partially saturated soils. Change in the degree of saturation can cause significant changes in volume, shear strength and hydraulic properties, consequently bearing capacity. Bearing capacity of shallow foundation is often reduced during the spring thaw.

The present paper concerns the effect of degree of saturation on bearing capacity which is a function of the apparent angle of internal friction and of the apparent cohesion as evaluated by direct shear tests. The apparent friction angle decreases rapidly with increasing pore pressure coefficient and the apparent cohesion increases rapidly with increasing degree of saturation and pore coefficient. Eventually the soil may get submerged and bearing capacity will get reduced. The method for calculating ultimate bearing capacity of shallow foundation under submergence of soil is different from each other. An unsaturated soil behaves differently in drying and wetting conditions.

2. MATERIALS AND METHODS

The project work was broadly divided into two phases. The initial phase was the experimental part in which soil samples from 5 selected sites were collected. Tests were conducted to determine the properties of the soil such as moisture content, field density, grain size distribution, specific gravity, cohesion, angle of internal friction etc.

Moisture content of the sample was determined by oven dry method, field density using core cutter method, specific gravity using pyconometer test and grain size distribution by sieve analysis. The results obtained are given in the table below.

Table -1: Test Results

PARAMETERS	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5
MOISTURE CONTENT	31.8%	23.8%	15%	17%	15.1%
FIELD DENSITY	1.71 g/cm3	1.826 g/cm3	1.78 g/cm3	1.97 g/cm3	2.06 g/cm3
SPECIFIC GRAVITY	2.56	2.469	2.353	2.381	2.6
GRAIN SIZE ANALYSIS	Gravel - 18.7% Sand - 60.3%	Gravel -11% Sand -59% S/C -29%	Gravel- 18% Sand -55% S/C -27%	Gravel - 31.4% Sand -53% S/C - 14.2%	Gravel -16 % Sand -55 % S/C - 20%

3. TRIAXIAL TEST

Triaxial compression test was used to determine the shear characteristics of the soil. In this test the cylindrical specimen is stressed under conditions of axial symmetry. Triaxial test for 5 samples were conducted on cell pressure 1kg/cm2, 2kg/cm2 and 3kg/cm2 under dry, saturated and field conditions. Mohr's circle was drawn for each degree of saturation, from which we got the values of cohesion and angle of internal friction.

Mohr's circle for sample 1 under partially saturated condition is given below,

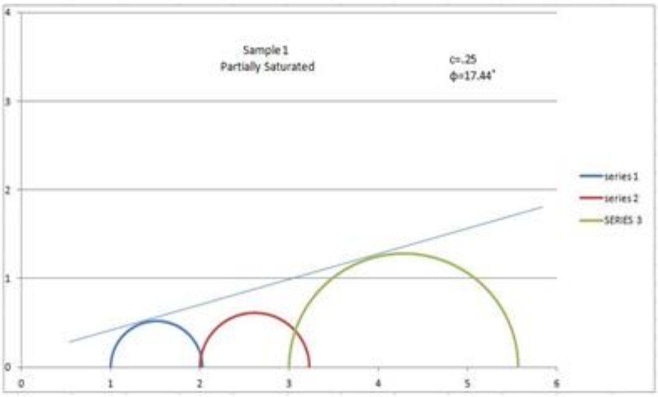

Fig 1. Mohr's circle

For determining the ultimate bearing capacity of shallow foundation under 2x2 square footing Terzaghi's bearing capacity equation is used

qu =1. 3CNc+ɣ Df Nq+0.4BɣNɣ
where, qu - Ultimate bearing capacity C - Cohesion
Df -Depth of footing
B- width of footing ɣ - Density of soil

Nc, Nq and Nγ are the general bearing capacity factors which depend upon the angle of internal friction.

	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5
UNSATURATED	S=67 C=0.3 kg/m2 ϕ=17.1 q_u=250 Kg/m2	S=87.2C =0.4 kg/m2 ϕ=18,3 q_u=554 Kg/m2	S=67.9 C=0.5 kg/m2 ϕ=17.8 q_u=658 Kg/m2	S=79 C=0.5 Kg/m2 ϕ=19.1 q_u=670 Kg/m2	S=87 C=0.5 Kg/m2 ϕ=20. q_u=798 Kg/m2
PARTIALLY SATURATED	C=0.2 Kg/m2 ϕ=29. q_u=816 Kg/m2	C=0.2 Kg/m2 ϕ=2.3 qu=748 Kg/m2	C=0.3 Kg/m2 ϕ=31.3 qu=1004 Kg/m2	C=0.2 Kg/m2 ϕ=30 q=999 Kg/m2	C=0.6 Kg/m2 ϕ=31.4 q_u=1338 Kg/m2
FULLY SATURATED	C=0.6 Kg/m2 ϕ=12.3 q_u=159 Kg/m2	C=0.2 Kg/m2 ϕ=1.3 q_u=214 Kg/m2	C=0.2 Kg/m2 ϕ=20. q_u=361 Kg/m2	C=0.5 Kg/m2 ϕ=1 q_u=285 Kg/m2	C=0.6 Kg/m2 ϕ=21.5 q_u=400 Kg/m2

4. CONCLUSION

Ultimate bearing capacity were calculated for a 2 x 2 footing at a depth of 2 m by considering Terzaghi's bearing capacity equation for square footing. Experiments were also conducted at unsaturated state (sample kept in oven) and fully saturated state to check the extremities.In the light of the results from the experimental works following important conclusion can be drawn

- Unit weight of the soil samples is linearly increases up on saturation.
- Angle of internal friction reduces upon the saturation of the soil as the degree of saturation increases the water content increases in the pores of the soil which will get in to contact with the soil particles helps in reduction of friction between them.
- Degree of saturation increases the cohesion also increases as the pores were occupied by water upon saturation.
- Ultimate bearing capacity is a function of c, φ, and ϒ .The increase in c and ϒ upon saturation is not increasing the Qu value since the φ value was decreasing. So we can conclude that in coarse grain soils the φ has significant role in bearing capacity.
- The aspect of effect of degree of saturation on reduction in bearing capacity of shallow foundation is comparatively the most neglected aspect but from the experiments it is clear that it plays an important role in the ultimate bearing capacity of soil, hence an equation was formulated which incorporates the term degree of saturation also and it is given by,

$$q_u = 700\ C + 40\phi - 6\ S + 600\ \Upsilon - 1300$$

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