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Bearing Capacity Of Foundation-Review Paper

Abhishek Arya[1], Dr. N.K. Ameta[2]
[1](PhD Scholar, Dept. of Civil Engineering, M.B.M. Engg. College, J.N.V. University, Jodhpur, Rajasthan, India)
[2](Professor, Dept. of Civil Engineering, M.B.M. Engg. College, J.N.V. University, Jodhpur, Rajasthan, India)

ABSTRACT: *Foundation is the most important part of any structure. It gets the load of the whole building and therefore it is important to properly design foundation of the building. Bearing capacity of the soil underneath and the settlement of footing are the two major concerns in the design. A lot of work from a long time is going on for finding the bearing capacity of soil and the settlement of the footing. This paper reviews the work done so far on these.*
Keywords: *Bearing capacity, settlement*

I. INTRODUCTION

Foundation design consists of two distinct parts: the ultimate bearing capacity of the soil under the foundation, and the tolerable settlement that the footing can undergo without affecting the superstructure. The ultimate bearing capacity aims at determining the load that the soil under the foundation can handle before shear failure; while, the calculation of the settlement caused by the superstructure should not exceed the limits of the allowed deformation for stability, function and aspects of construction. Research on the ultimate bearing capacity problems can be carried out using either analytical solutions or experimental investigations. The former could be studied through theory of plasticity or finite element analysis, while the latter is achieved through conducting prototype, model and full-scale tests. A satisfactory solution is found only when theoretical results agree with those obtained experimentally. A literature survey on the subject shows that the majority of the bearing capacity theories involve homogeneous soils under the foundations. Soil properties were assumed to remain constant for the bearing capacity analysis, and therefore analytical solutions, like Terzaghi's bearing capacity theory, matched with the experimental results. However, in cases where the soil properties vary with depth, most of these theories cannot be implemented, and the analytical solutions that take into consideration the non-homogeneity of the soils are approximations, and hence the results are inaccurate.

II. REVIEW OF PREVIOUS WORK

Determination of bearing capacity of soil has undergone through a long process from old times through analytical and experimental studies by a number of research works. A brief review of significant bearing capacity investigations and contribution of different investigators have been presented briefly here.

(1) Shilpa Prakash (An orissan treatise on architecture)

According to Shilpa Prakash (An orissan treatise on architecture) depth of foundation of a temple or an important building should be equal to one third of its height above ground level.

(2) Rankine (1985)

Bearing capacity of shallow foundation on loose, dry granular sandy soil

$$qf = \gamma z \left[\frac{1+\sin\varphi}{1-\sin\varphi}\right]^2$$

(3) Prandtl (1920)

Developed the equations for bearing capacity of c-φ soils by assuming that the soil is weightless and considering the equilibrium of plastic sectors

(4) Terzaghi and Hogentogler (1928)

Assumed triaxial type shear failure under uniform strip footing

(5) Newmark (1935)

Developed chart to determine vertical stress at a point under uniformly loaded area

(6) Westergaurd (1938)

Developed expression for pressure distribution in soil under point load, assuming the soil to be an elastic medium of semi- infinite extent

(7) Terzaghi (1943)

Developed the bearing capacity expression for strip footing

$q_{ult} = c N_c + q N_q + 0.5 \gamma B N_\gamma$

(8) Terzaghi and Peck (1948)

Gave empirical formula to compare the settlement of model square footing (30 cm x 30 cm)

(9) Skempton (1951)

Proposed the following expression for bearing capacity for cohesive soils

(10) Meyerhof (1951, 1953, 1955 and 1963)

Derived the expression for bearing capacity by taking into account for shear resistance of soil mass above the foundation level for both shallow and deep foundations

(11) Button (1953)

He analyzed the bearing capacity of a strip footing resting on two layers of clay. He assumed that the cohesive soils in both layers are consolidated approximately to the same degree. In order to determine the ultimate bearing capacity of the foundation, he assumed that the failure surface at the ultimate load is cylindrical, where the curve lies at the edge of the footing. The bearing capacity factor used depends on the upper soil layer and on the ratio of the cohesions of the lower/upper clay layers.

(12) Reddy and Srinivasan (1967)

They extended the work of Button to include the effect of the non-homogeneity and anisotropy of soil with respect to the shear strength. The basic assumptions involved in determining the ultimate bearing capacity are: the failure surface is cylindrical, the coefficient of anisotropy is the same at all points in the foundation medium, the soil in each layer is either homogeneous with respect to the shear strength or the shear strength in each layer varies linearly with depth.

(13) Brown and Meyerhof (1953)

They investigated foundations resting on a stiff clay layer overlying a soft clay layer deposit, and the case of a soft layer overlying a stiff layer. They assumed that the footing fails by punching through the top layer for the first case, and with full development of the bearing capacity of the lower layer in the second case. Equations and charts giving the appropriate modified bearing capacity factors were given, derived from the empirical relationships obtained based on the experimental results. The results of the investigation are summarized in charts, which may be used in evaluating the bearing capacity of layered clay foundations, but these results are essentially experimental, and therefore are strongly affected by the characteristics of the clay tested. The purpose of this paper is to present the results of a series of model footing tests carried out on two-layered clay soils, and the models have many limitations. First, they are limited to one type of clay, although the strength of the clay was varied, the deformation properties remained constant. Second, studies were limited to surface loading only, using rigid strip and circular footings with rough bases. Third, all studies were made in terms of the undrained shear strength of the clay, using the $\phi = 0$ analyses. They also conducted a series of tests on footings in homogeneous clay. They observed that the pattern of failure beneath a footing is a function of the physical mode of rupture of the clay, which is strongly dependent on the structure of the clay. The failure mechanism of the structure of the clay is not adequately defined by conventional Mohr-coulomb concepts of cohesion and friction.

(14) Ohri (1971)

Studied the effect of interference of two adjacent smooth and rough square footings subjected to vertical load on cohesionless soil.

(15) Binquet and Lee (1975)

Reported study on reinforced soil beds. Proposed hypothesis on failure mechanism on reinforced earth. Evolved various dimensionless parameters which influence the bearing capacity of reinforced soil beds.

(16) IS 6403 (1981)

IS: 6403- 1981 recommends that for the computation of ultimate bearing capacity of a shallow foundation in general shear failure, following Equation may be used:

$q_{nf} = c N_c s_c d_c i_c + q (N_q – 1) s_q d_q i_q + 0.5 B \gamma N_\gamma s_\gamma d_\gamma i_\gamma W'$ ………………… (1)

where q_{nf} is the ultimate bearing capacity. Nc, Nq and Ny are bearing capacity factors

$N_c = (N_q – 1) \cot \varphi$ ………………… (2)

$N_q = e^{\pi \tan\varphi} \tan^2 (45° + \varphi/2)$ ………………… (3)

$N_\gamma = 2 (N_q + 1) \tan \varphi$ ………………… (4)

where s, d and i are shape, depth and inclination factors given by IS code.

For local shear failure the shear strength parameters C_m and φ_m should be used in bearing capacity equations instead of C and φ.

$C_m = 2/3 C$ ………………… (5)

tan φm = 2/3 tan φ ………………… (6)

(17) Akinmsuru and Akinbolade (1981)

Reported that bearing capacity ratio is highest at depth ratio(i.e. the ratio of depth of first layer of reinforcing strip to width of footing) of about 0.5.

(18) Guido et. Al. (1986, 1987)

For geogrid reinforced soil, the bearing capacity ratio is decreased with increase of depth rati.o

(19) Sinaidi and Hassan Ali (2006)

Reinforced soil is better than natural soil by 7 times and better than stone column by 1.75.

(20) Sawwaf and Nazir (2010)

In cases where structures are very sensitive to settlement, soil reinforcement can be used to obtain the same allowable bearing capacity at a much lower settlement with the same sand density.

(21) M. Mosallanezhad, Hataf and Ghahramani (2010)

The use of innovative Grid-Anchor as reinforcement element to improve bearing capacity of soils compared to using ordinary geogrid was investigated and it is shown that a significant increase in bearing capacity is obtained.

(22) Farsakh, Chen and Sharma (2013)

When the foundation is built on very weak soil (e.g., compressible, high plasticity clay soils), the reinforced soil mass, as a load transfer platform, creates a composite structure to distribute loads more uniformly over soft founda- tion soils, thus reducing the stress concentration, which will reduce the consolidation settlement of the underlying weak soil.

(23) Verma, Jain and Kumar (2013)

In case of layered soils, for the same thickness and type of soils in top layer (fine gravel) and bottom layer (sand), the ultimate bearing capacity increases with the increase of size of square test plates and settlement decreases with increases the size of the square test plate.

(24) Marto and Oghabi (2013)

The presence of geogrid in the soil makes the relationship between the settlement and applied pressure of the reinforced soil almost linear until the reaching to the failure stage.

(25) Abdrabbo (2015)

Studied behaviour of strip footing on reinforced and unreinforced sand slope.

III. CONCLUSION

Calculations of bearing capacity of soil and settlement of footing is most important work in footing design so it is very important to properly determine their exact values. The results must be established parallel to their theoretical solutions. More and more research work is required in this field for various types of soils available.

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