ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume3, Special Issue 6, February 2014

National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)

On 15th to 16th February, Organized by

Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.

The Effect of Water Table on Bearing Capacity

Arindam Das [1], Shreyoshi Biswas [2]

Assistant Professor, Department of civil Engineering, Modern Institute of Engineering and Technology, West Bengal, India[1]

B.Tech student, Department of civil Engineering, Modern Institute of Engineering and Technology, West Bengal, India[2]

ABSTRACT: Soil is a universally occurring natural element formed due to continuous denudation of different sorts of rocks and minerals. Each type of soil inherits a lot of similar characteristics from its parent rock like chemical composition, physical appearance, colour, texture etc. In spite of these, there are yet a lot of other important characteristics that significantly comes into play in the construction sector and civil engineering. One such important factor is the bearing capacity of soil. Bearing capacity is affected by various other factors like depth of water table, dimensions of footing, type of loading etc.

KEY WORDS: Bearing Capacity, Ground Water Table, Shallow Foundation, Constructional Precautions and Remedies on soil of low bearing capacity

I. INTRODUCTION

Details are critical when constructing a sound building foundation that will withstand water and control dampness. Foundation repairs are often difficult and expensive, so it's important to build a foundation correctly the first time. Building a sound foundation depends particularly a lot upon the depth of ground water table at the site. Lesser the depth, harder it is to build a strong foundation as the soil will have low bearing capacity. As speaking of bearing capacity, it is the maximum stress which a particular soil can withstand without failing. This paper emphasizes on the particular topic of the various effects of the water table on the bearing capacity of soil and subsequently on the ease of general foundation construction.

II. PROJECT INFORMATION

A. TYPES OF FAILURE IN FOUNDATIONS

There are only three specific modes of soil failure associated with soil type, foundation size and depth. These include general shear failure, local shear failure and punching shear failure.

i) General shear failure

It is a mode of failure in which ultimate strength of soil is associated with the entire surface of sliding before the entire structure underlying soil is affected by excessive movement. This mode of failure depending on soil type, foundation size and depth is commonly encountered in stiff clays and sand soil that is in dense underlying shallow foundation. When the load of the structure is increased, the foundation pressure on the shallow foundation increases.

ii) Local shear failure

This mode of failure is encountered in sand soil that is medium dense and medium stiff clay type of soils. Local shear failure is characterized by absence of distinct peak in pressure against foundation settlement. . Local shear failure is associated with progressive failure surface that extends to ground surface once bearing capacity has been reached. In addition, it is a failure with ultimate shearing strength of soil that is usually mobilized locally along with the potential surface of sliding. This happens at a time when the structure supported by soil is affected by rapid movement.

iii) Punching shear failure

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, *Volume3, Special Issue 6, February 2014*

National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)

On 15th to 16th February, Organized by

Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.

This mode of failure usually occurs in loose sands and soft clays types of soil. It is accompanied by a surface that is triangular in shape and is directly under shallow foundation. One major characteristic of punching shear failure is the lack of distinctive ultimate bearing capacity. Ultimate bearing capacity in punching shear failure is considered to be the pressure that corresponds with excess foundation settlement. It involves failure of reinforced concrete slab that have been subjected to high local forces especially in flat slab structures and usually happens at column support points.

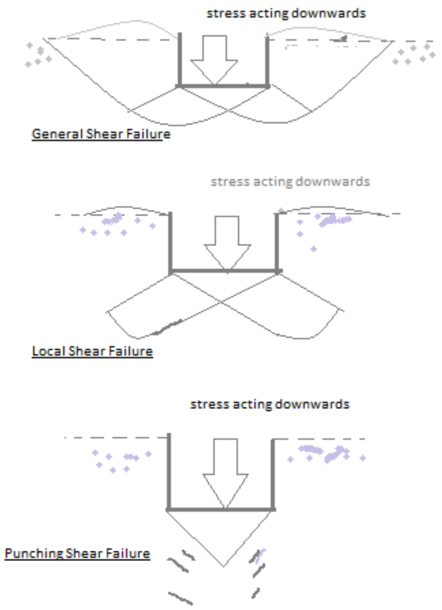

Fig 1: Types of Failures

The depth of a foundation is dependent on the type of the soil under which the foundation stands. A good foundation has the capacity to transmit the load of a structure evenly below the ground surface. However, the ground surface is greatly influenced by the depth of the water table. In construction and design, water table represents the surface that separates between saturated and unsaturated groundwater zones. Depending on the depth of the bed rock, the water table may be high or low. In some areas, the depth of water table keeps on shifting depending on the seasons of rain. When the rainfall is high, say during monsoon, water table rises nearer to the surface while on the other hand descending considerably to lower grounds during the summer.

The depth of water table at any given time affects the modeling design, especially in the case of the shallow foundations. In all cases, the ultimate depth to which one can put utilization of underground space is dependent on the depth of the water table.

1) Terzaghi's Bearing Capacity Equations :

* Terzaghi's Bearing Capacity equation is applicable for general shear failure.
* Terzaghi has suggested following empirical reduction to actual c & ø in case of local shear failure
Mobilised cohesion $C_m = 2/3\ C$
Mobilised angle of $\o_m = \tan^{-1}(\tfrac{2}{3}\tan\o)$
Thus, $N_c{}', N_q{}'$ & $N_\gamma{}'$ are B.C. factors for local shear failure

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume3, Special Issue 6, February 2014

National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)

On 15th to 16th February, Organized by

Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.

$q_u = C_m N_c' + \gamma\, D_f\, N_q' + 0.5\, \gamma\, B\, N_\gamma$

* Ultimate Bearing Capacity for square & Circular footing -Based on the experimental results, Terzaghi's suggested following equations for UBC –

Square footing $q_u = 1.2c'\, Nc + \gamma\, D_f\, N_q + 0.4\, \gamma BN\gamma$

Circular footing $q_u = 1.2c^1 Nc + \gamma\, D_f\, N_q + 0.3\, \gamma BN\gamma$

2) *Hansen's Bearing Capacity Equation* :

Hansen's Bearing capacity equation is :

$q_u = cN_cS_cd_ci_c + qN_qS_qd_qi_q + 0.5\, \gamma\, BN_\gamma S_\gamma d_\gamma i_\gamma$

where,

N_c, N_q & N_γ are Hansen's B.C factors which are somewhat smaller than Terzaghi's B.C. factors.

S_c. S_q & S_γ are shape factors which are independent of angle of shearing resistance;

d_c, d_q & d_γ are depth factors ;

I_c, i_q & i_γ are inclination factors

Table 1:
Factors for shear failures.

φ	General shear Failure			Local Shear Failure		
	N_C	N_q	N_γ	N_c'	N_q'	N_γ'
0	5.7	1.0	0.0	5.7	1.0	0.0
15	12.9	4.4	2.5	9.7	2.7	0.9
45	172.3	173.30.0	297.5	51.2	35.1	37.7

B. 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. The natural pattern of flow of groundwater is altered by human activities, either deliberately, by pumping water from wells or by diverting watercourses, or inadvertently by land use change.

If the rate of abstraction from an aquifer is too high, and exceeds the amount of water recharged from rainfall, the water level in the aquifer will fall. This increases the cost of pumping, and at the same time tends to reduce the yield of individual boreholes, but it also can affect the flow of rivers and streams where they are supported by groundwater.

Too much groundwater can also be a problem. In wet winters rising groundwater levels can flood into cellars and onto low-lying land. Because groundwater tends to react slowly, this type of flooding problem can be long lasting. Unfortunately damage from groundwater flooding problems are often our own fault – land that is naturally prone to flooding is built on, and flood cellars are converted into living space with furnishings and fittings. Foundations of any construction require to be made on solid sub terrain. Water can erode man-made materials without providing any advanced warning of such erosion. High water content in ground causes the main foundation materials to become wet, then they will become impregnated. Concrete for instance can absorb some water, it that water is constant and the

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume3, Special Issue 6, February 2014

National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)

On 15th to 16th February, Organized by

Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.

concrete basic without some form of water repellant the mix breaks down, even if there are steel rods added to improve the strength, these will erode through rust and finally fail.Water levels (the water table) in and around a building are measured BEFORE construction starts. The higher the table (water level) the hard it is to dig down to a dry, first substrate,. Therefore a house near a river might have foundations 10 feet down, contain high levels of water repellant and have higher grade water membrane - This adds to the initial cost of the build compared to a location high up, away from the levels of water.

C. PRECAUTIONS TO AVOID FAILURE DUE TO LOW BEARING CAPACITY

The bearing capacity of un-reinforced sand is as the bearing capacity of shallow foundation laid on reinforced sand. The soil particles also affect the bearing capacity. The soil participles influence distribution of pore pressures. The width of the foundation is used in determining the bearing capacity ratio. This means that the bearing capacity is affected by the width of the foundation. Layers of geogrid can be reinforced with sand in order to acquire maximum bearing capacity. Other options are as follows:

1. Layers of geotextiles may be used
2. Use 4” minimum diameter perforated drainpipe over the gravel.
3. Cover the perforated drainpipe by gravels and again the gravels by geotextiles
4. Place ½ ” of compactible sand on the geotextile fabric and compact well.
5. Place a layer of reinforced polyethelyne for greater puncture resistance.
6. At extreme scenarios, built crawl space foundation, slab-on-grade foundation and carry out through wall sealing.

D. REMEDIES FOR STRUCTURES ALREADY AFFECTED DUE TO LOW BEARING CAPACITY

1. Use a sump pump to pump the water table below the concrete floor
2. Installation of perimeter drains.
3. Use French drain and footer drain in and around the basement or footing.
4. Consider using the bentonite panels applied to new construction but prefer to use a bitumen (or modified bitumen) or modified rubber elastomeric coating and a dimpled membrane on both block and poured concrete walls. These products will bridge any cracks that will eventually appear , continuing the water proofing along with the dimpled membrane you have a failsafe water proofed foundation.

III. 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. At sites where construction on soils of low bearing capacity is inevitable, then excess ground water should be pumped out as required to get the desired bearing capacity
4. Higher the water table, lesser is the bearing capacity and strength of the soil.
5. Softer the soil, lesser the bearing capacity, lesser is the stability of the foundation.

ACKNOWLEDGEMENTS

I would like to thank my parents for being extremely supportive at every time. I thank Prof. P.K. Roy for guiding and lighting the path of knowledge. I present my heartfelt gratitude to Mr. S. Karati my academic advisor and Mr. A. Das, my mentor without whose help this paper could not have been successfully completed. Last but not the least, thanks to our lord almighty for believing in me and gifting me such a utopia.

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume3, Special Issue 6, February 2014

National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)

On 15th to 16th February, Organized by

Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.

REFERENCES

1. Geotechnical Engineering-Principles and Practice: Coduto; pearson Publication
2. Soil Mechanics: Lambe and Whitman; WIE
3. Text Book on Soil Mechanics and Foundation Engineering: V.N.S. Moorthy; CBS Publication and Distributors
4. Foundation Analysis and Design: J.E. Bowels; McGrawhill
5. IS 8009, IS 1904, IS 6403, IS 2911: Bureau of Indian Standards
6. International Journal of Engineering Research and Application(IJERA)
7. Apa-the engineer wood association
8. Bearing Capacity of Soil: Dr. S. K. Prasad
9. Cal trans(2003)
10. India’s Groundwater Crisis by Paul Wyrwoll ; Global Water Forum(July 30,2012)
11. Shallow groundwater and Related Hazards: Suzanne Hecker, Kim H. Harty, and Gary E. Christenson
12. Case Histories in Geotechnical Engineering by K.A. Patil and G.E. Smith.