Foundation and Footing Analysis for Educational Building

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Abstract - It is common for tall buildings in Gorakhpur to have a ground response that is highly sensitive to the behavior of the structure. Therefore, the geology of the ground needs to be carefully assessed and considered in the design process to accurately predict the performance of the foundation system. This paper sets out a systematic design approach and ground investigation methodology for the soil conditions frequently encountered in Gorakhpur. Various foundation design methods are introduced along with several case studies conducted in Gorakhpur.

Keywords:- (G+3) Building, Design procedure, Method of Foundation and Footing.

INTRODUCTION

The foundations of the building transfer the weight of the building to the ground. While 'foundation' is a general word, normally, every building has a number of individual foundations, commonly called footings.

Usually each column of the building will have its own footing.

Since the weight of the building rests on the soil (or rock),engineers have to study the properties of the soil very carefully to ensure that it can carry the loads imposed by the building. it is common for engineers to determine the safe bearing capacity of the soil after such study. As the name suggests, this is the amount of weight per unit area the soil can bear. For example, the safe bearing capacity(SBC) at a location could be 20T/m2, or tonnes per square metre.

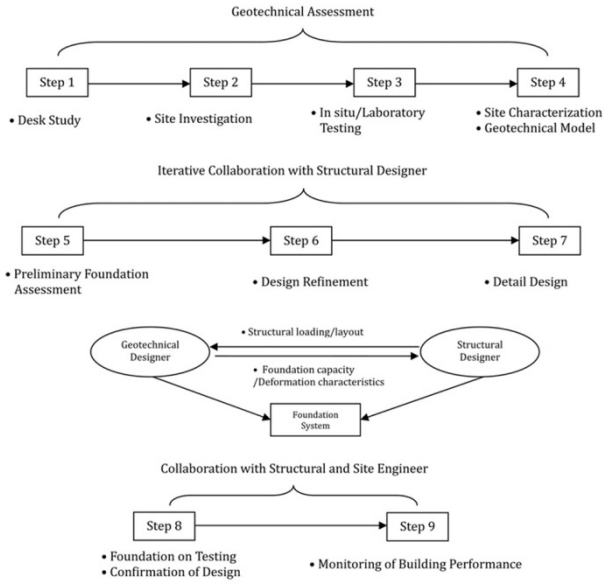
The three major considerations for foundation design are as follows:

- Geotechnical capacity
- Structural capacity
- Vertical and lateral movement (serviceability)

The geotechnical capacity and the structural capacity can be evaluated by either of the following approaches:

- Factor of Safety Design
- Limit State Design

The vertical and lateral movement should be less than the allowable deformation for the structural and adequate building performance.



Ground condition in Gorakhpur:-

Sl.no.	Description	Compressive Strength
1	Extremely Strong Rock	>250MPa
2	Very Strong Rock	100-250
3	Strong Rock	50-100
4	Medium Weak Rock	25-50
5	Weak Rock	5-25
6	Very Weak Rock	1-5
7	Extremely Weak Rock	0.25-1

Raft Foundation:-

Design sequence for raft foundation

In Gorakhpur, the raft foundation system is generally planned for tall buildings when the founding ground comprises WR or other solid ground types. However, such foundation exhibit flexible characteristics to some extent even under stiff ground conditions owing to the relatively low thickness to width ratio unlike in the case of massive footings such as in a bridge foundation. These flexible features become more evident with uneven loading or under softer and varying ground conditions. the combination of such factors along with the differential

settlement of soil becomes a crucial component sufficiently through design and needs to be controlled sufficiently through collaboration between the geotechnical and structure engineers.

DESIGN OF RAFT FOUNDATION

Design Considerations:

If the loads transmitted by the columns in a structure are so heavy or the allowable soil pressure so small that individual footings would cover more than about one-half of the area, it may be better to provide a continuous footing under all columns and walls. Such a footing is called a raft or mat foundation. Raft foundations are also used to reduce the settlement of structures located above highly compressible deposits. Since rafts are usually at some depth in the ground, a large volume of excavation may be required. If weight of the excavated soil is equal to the weight of the structure and that of the raft, and the centre of gravity of excavation and structure coincide, settlement would be negligible. Where complete compensation is not feasible, a shallower raft may be accepted if the net increase in loads in small enough to lead to tolerable settlement. A raft foundation may be rectangular or circular and may be with or without an open.

Bearing Capacity:-

The bearing capacity of soil is defined as the capacity of the soil to bear the loads coming from the foundation. The pressure which the soil can easily withstand against load is called allowable bearing pressure.

Following are some types of bearing capacity of soil:

Ultimate bearing capacity of soil (qu)

The gross pressure at the base of the foundation at which soil fails is called ultimate bearing capacity.

Net ultimate bearing capacity (qnu)

By neglecting the overburden pressure from ultimate bearing capacity we will get net ultimate bearing capacity.

$$q_{nu} = q_u - \gamma D_f$$

Where γ = unit weight of soil, D_f = depth of foundation

Net safe bearing capacity of soil (qns)

By considering only shear failure, net ultimate bearing capacity is divided by certain factor of safety will give the net safe bearing capacity.

$$q_{ns} = q_{nu}/ F$$

Where F = factor of safety = 3 (usual value)

Gross safe bearing capacity (qs)

When ultimate bearing capacity is divided by factor of safety it will give gross safe bearing capacity.

$$q_s = q_u/F$$

Net safe settlement pressure (qnp)

The pressure with which the soil can carry without exceeding the allowable settlement is called net safe settlement pressure.

Net allowable bearing pressure (qna)

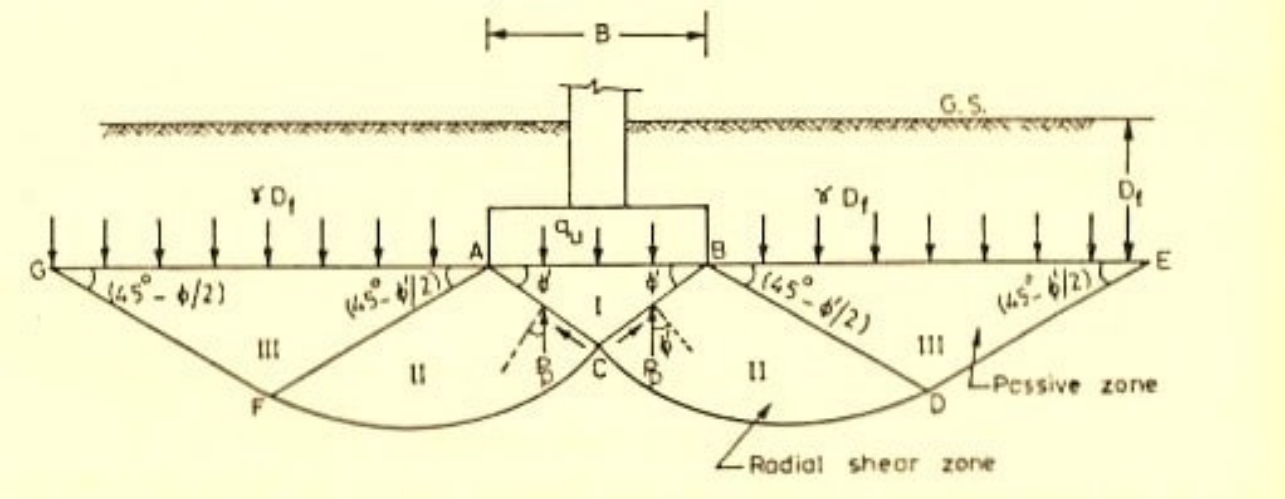
This is the pressure we can used for the design of foundations. This is equal to net safe bearing pressure if $q_{np} > q_{ns}$. In the reverse case it is equal to net safe settlement pressure.

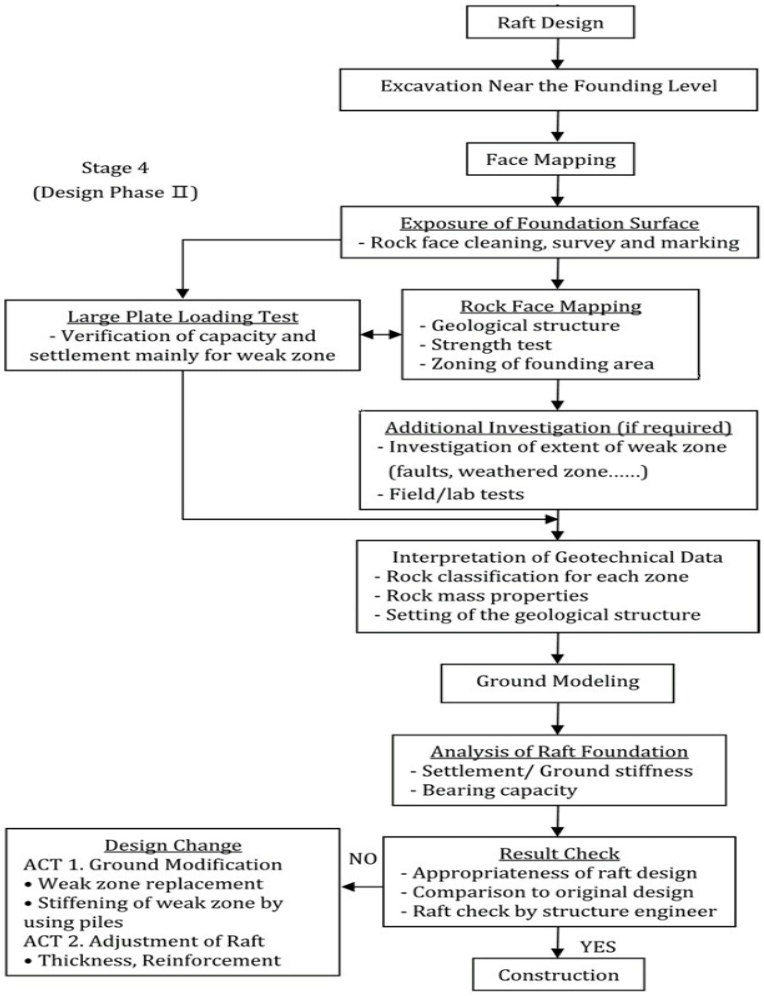
How to Calculate Bearing Capacity of Soil?

Calculation of bearing capacity of soil:

For the calculation of bearing capacity of soil, there are so many theories. But all the theories are superseded by Terzaghi's bearing capacity theory.

Terzaghi's bearing capacity theory





Terzaghi's bearing capacity theory is useful to determine the bearing capacity of soils under a strip footing. This theory is only applicable to shallow foundations. He considered some assumptions which are as follows.

1. The base of the strip footing is rough.
2. The depth of footing is less than or equal to its breadth i.e., shallow footing.
3. He neglected the shear strength of soil above the base of footing and replaced it with uniform surcharge. (γD_f)
4. The load acting on the footing is uniformly distributed and is acting in vertical direction.
5. He assumed that the length of the footing is infinite.
6. He considered Mohr-coulomb equation as a governing factor for the shear strength of soil.

SETTLEMENT

When the settlement of a raft foundation is analyzed, it is important initially to realize the major influencing factors and then properly apply them to the analysis. The theory of elasticity is a useful approach to initially understand the behavior of foundations and to approximate the settlement evaluation based on simplified ground.

CONCLUSIONS AND RECOMMENDATIONS

1. In this paper, the design steps for the foundation system for a (G+3) building are described.

2. In Gorakhpur , the rock formation is mainly considered as the founding strata for both raft and pile foundation. The classification of rock based on the local criteria in Gorakhpur are introduced and compared to the international rock classification to help understand the local terminology.

3. Ground investigation method for various rock types and the interpretation method for the Geotechnical parameters for foundation design are introduced.

4. The design sequences of raft, pile and piled-raft foundation are presented.

5. The simple and rigorous design method for evaluating the bearing capacity and settlement of rocks are introduced.

6. Case studies conducted in Gorakhpur on the design of (G+3) building foundation are included for better understanding of the foundation design approach.

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