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Study of Different Types of Foundations for Different Types of Soils

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***Abstract*: Soil plays an important role in the consideration of the type of foundation to be designed for a particular structure. This paper gives an overview of the types of foundations to be considered on the basis of the soil type and its properties and soil improvement techniques used to make the soil conditions better.**

***Keywords*: Soil, Types of soils, Types of foundation, Improving techniques.**

1. Introduction

Soil is an unconsolidated material formed of solid particles, generated by the disintegration of rocks. Soil plays a major role in determining the type and depth of the foundation, therefore, various tests are carried out on the in situ soil to determine the suitability. If the soil on the site is not suitable for the supporting structure, then soil improvement techniques are used rather than preferring deep foundation.

2. Related work

A. Literature review

1) Soil stabilization using plastic granules. (Glories Thomas Paul, Arshad A. Hakkeem, Joju Lawrence Y, Roshan M. Dileep)

This study is based on improving the properties of black cotton soil using recycled glass and plastic. Black cotton soil tends to absorb water, gets soft, swells and the capacity for bearing water tends to reduce in monsoon season and in summer and other drier seasons the soils shrinks and becomes hard.

The soil is considered unsuitable for construction due it's characteristics like high plasticity, shrinkage and low strength when wet and swelling. Adding plastic and glass to the soil in the presence of water fills up the voids contributing to dry density and adding them in soil increases strength, overall optimum moisture content and ultimate bearing strength and decreases overall maximum dry density of the soil.

2) Soil improvement techniques, by Gaafer, Manar, Bassioni, Hesham, Mostafa, Tareq.

This study is based on soil improvement techniques that are used to improve the performance of saturated clayey soil and the study also focuses on the applicable soil types and the cost of those soil improvement techniques. Improvement techniques such as soil replacement, pre-loading, stone columns, stabilization with additives and thermal methods are used to increase bearing capacity, improving shear strength and decreasing consolidation settlement of saturated medium clay. Cost of the foundation works is one of the factor contributing in the selection between different improvement techniques.

3. Scope of study

The objective of the study is the determination of the designs and the type of foundations, earthworks, and/or pavement subgrades required for the intended man-made structures to be built and to understand the utilization of soil stabilisation on roadways, parking areas, site development projects, airports and many other situations where sub-soils are not suitable for construction.

A. Foundations on expansive and collapsible soils.

1) Expansive soils

When increase in moisture content in soil leads to expansion hen those soils are known as expansive soils. The expansive characteristics of soil is mainly due to montmorillonite clay mineral. These expansive soils are also known as swelling soils or black cotton soils. Structures built on such kind of soils may experience cracking and damage due to severe movements of the soil mass mainly due to it's shrinking and swelling characteristics.

Swelling and cracking causes several damages such as damages to floor slabs and external walls of the building. Due to swelling, the floor slab is pushed up and it takes a dome shape and further cracks are developed in the floor, the footing wall is pushed outwards leading to cracks on the end wall of the building.

Due to restrictions in movement cracks also occur at the junction between the wall and the floor slab and also between the wall and the roof slab. Diagonal cracking of walls can lead to cracks at the corners of the window and door openings. Cracking can also damage the utilities buried in the soil such as sewage lines, water pipes, gas lines, telephone lines etc. Damages occur very slowly and are usually visible after many years of construction.

Due to high swelling properties some preventive measures are required such as replacement of expansive soil, modification and foundations design to withstand swelling.

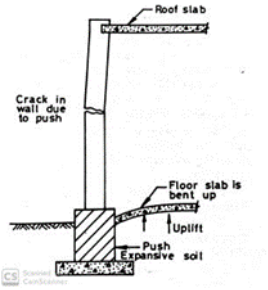

Fig. 1.

2) Design of foundations on swelling soils

Strong, rigid and flexible structures are constructed to withstand swelling. To isolate the foundation from the swelling effect deep foundations like drilled piers and under-reamed piles are constructed.

3) Drilled pier

This type of foundation is designed to avoid bearing capacity failure and to keep the settlements not beyond the safe limits. In addition to criteria of bearing capacity and settlements, safety must be checked against the uplift force. The soil sticks to shaft of the pier and grips the shaft. During expansion, the soil tries to lift the pier along it. Due to which an uplift force acts upon the pier. Inadequate resistance against the uplift force can uplift the pier.

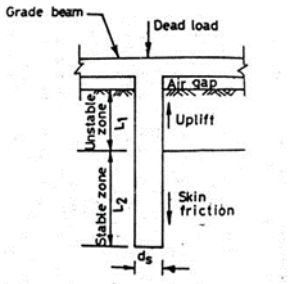

Fig. 2. Straight shaft-pier foundation

4) Belled drilled pier

This type of drilled pier is used when the uplift force acting upon the straight shaft pier is large. So to prevent the uplifting of the pier this type of drilled pier is considered.

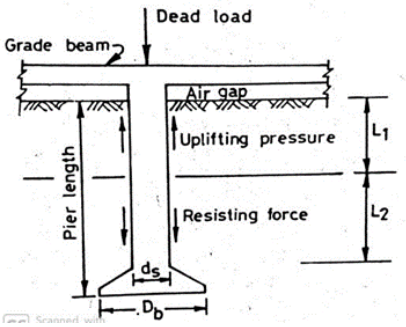

Fig. 3. Bell-pier foundation

5) Under-reamed piles

This type of piles was developed by CBRI, Roorkee. These piles are commonly used for foundations in expansive soils in India. The under-reamed piles are considered most suitable for expansive soils as they tie up structure to a balanced soil mass well below the soil which is movement due to seasonal changes.

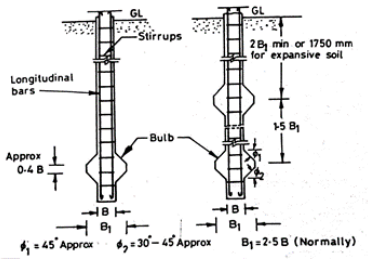

Fig. 4. (a) Single under-reamed pile (b) Double under-reamed pile

B. Collapsible soils

This kind of soil decreases in volume when it attains saturation. These soils are aeolian (wind-deposited) soils having low water content and high void ratio in it's natural state. These soils generally have honeycomb structure in which porous structure is kept by a water soluble inter-particle bond. Increase in water content breaks the inter-particle bond which leads to sudden decrease in volume causing it's collapse. Structures constructed on a collapsible soil have huge settlements causing damages. Utilities like roads, highways, pipelines constructed on such soils are subjected to have maintenance problems.

1) Design of foundations on collapsible soils not vulnerable to wetting

If the soil is not vulnerable to wetting, the methods explained below can be used. Plate load test is conducted before the actual design of foundations on these kind of soils. The figure given below shows a load-settlement curve, this curve is initially linear upto a particular critical pressure pcr and then there is a large settlement shown due to breakdown of the soil structure. These kind of breakdowns in soil is generally observed in collapsible soils having low moisture content and the soils with high moisture content breaks down gradually and there is no large settlements all of a sudden.

Foundations like spread foundations and raft foundations are constructed on collapsible soil which are not susceptible to wetting. Precautions must be taken to prevent the increase of moisture under the foundation. The allowable pressure taken should be less than the critical pressure while designing the foundation.

Continuous footings are considered better than the spread foundations over collapsible soils. Continuous footing consists of footing beams and loading beams. On the tops of continuous strip footings, the footing beams are provided to connect the footings and which also acts as reaction beams. At right angles to the properly reinforced footing beams are the loading beams to carry the loads of the structure.

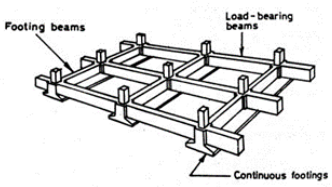

Fig. 5.

In case of heavy structures, spread foundations is not provided because of the large settlements and to reduce the settlements, drilled piers and pile foundation are considerable for transferring the load to a load bearing strata below the soil.

2) Design of foundations on collapsible soils vulnerbale to wetting

The compressible soils which are susceptible to wetting will collapse after some time of the construction. Preventive measures (like re-compaction, filling chemical solutions like sodium silicate and calcium chloride in the foundation, injecting sodium silicate solutions into the soil deposit, vibro flotation for free draining soils, rock columns, drilled piers and piles and drainage control) are taken into consideration and sometimes combination of two or three methods are required depending upon the site conditions.

4. Importance of soil analysis and soil stabilization in the field of architecture

Soil plays an important role in the field of construction as the structures are built on soil and the soil has to bear the load of the structure. Soil analysis is the first and an important practice before any construction. Understanding investigations under Geo-technical engineering of soil helps to take better decisions which leads to a successful construction project.

On the basis of reports of soil testing we can further decide many factors such as the height of the building or the use of construction materials. The information from the soil analysis leads to durable and strong built structures and it can further help in making decisions regarding soil stabilization for better stability of the building.

Hence, for better stability if the structure and to detect hidden dangers and unknown defects of soil, the analysis and soil stabilization is very important in the field of architecture.

5. Conclusion

As we study above data, it is concluded that it is very important to understand soil, soil analysis and its stabilization techniques for a successful construction project and to prevent the structure from any damages due to the soil. The cost of soil analysis is a fraction of the total construction cost so it's important to include in the construction practice.

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