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# Effect of Expansive Soil on Foundation and Its Remedies

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**ABSTRACT:** Expansive soils shrink and swell with wetting and drying. The shrink-swell capacity of expansive soils can result in differential movement beneath foundations. The Geotechnical Investigation notes that the soil near the surface of the site is expansive in nature and provides methods to minimize the expansive soil impact on foundations. This paper will discuss about the problems in foundation due to expansive soil & its remedies.

**KEYWORDS:** Expansive Soil, Black Cotton Soil, Shallow Foundation, Deep Foundation.

## I. INTRODUCTION

Expansive soil, also called shrink-swell soil, is a very common cause of foundation problems. Depending upon the supply of moisture in the ground, shrink-swell soils will experience changes in volume of up to thirty percent or more. Foundation soils which are expansive will “heave” and can cause lifting of a building or other structure during periods of high moisture. Conversely during periods of falling soil moisture, expansive soil will “collapse” and can result in building settlement. Either way, damage can be extensive.

Expansive soil will also exert pressure on the vertical face of a foundation, basement or retaining wall resulting in lateral movement. Shrink-swell soils which have expanded due to high ground moisture experience a loss of soil strength or “capacity” and the resulting instability can result in various forms of foundation problems and slope failure. Expansive soil should always be a suspect when there is evidence of active foundation movement.

In order to expansive soil to cause foundation problems, there must be fluctuations in the amount of moisture contained in the foundation soils. If the moisture content of the foundation soils can be stabilized, foundation problems can often be avoided. I will be following up on this concept a bit later.

## II. CAUSE OF EXPANSION

Soils are composed of a variety of materials, most of which do not expand in the presence of moisture. However, a number of clay minerals are expansive. These include: smectite, bentonite, montmorillonite, beidellite, vermiculite, attapulgite, nontronite, illite and chlorite. There are also some sulfate salts that will expand with changes in temperature. When a soil contains a large amount of expansive minerals it has the potential of significant expansion. When the soil contains very little expansive minerals it has little expansive potential.

When expansive soils are present they will generally not cause a problem if their water content remains constant. The situation where greatest damage occurs is when there are significant or repeated moisture content changes.

## III. GENERAL FOUNDATION DESIGN CRITERIA

For satisfactory performance, the foundation of any structure must satisfy two independent design criteria. First, it must have an acceptable factor of safety against bearing failure in the foundation soils under maximum design load. Second, settlements during the life of the structure must not be of a magnitude that will cause structural damage, endanger piping connections or impair the operational efficiency of the facility. Selection of the foundation type to satisfy these

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criteria depends on the nature and magnitude of dead and live loads, the base area of the structure and the settlement tolerances. Where more than one foundation type satisfies these criteria, then cost, scheduling, material availability and local practice will probably influence or determine the final selection of the type of foundation.
The Geotechnical Investigation indicates that no adverse foundation-related subsurface and groundwater conditions would be encountered that would preclude the construction and operation of the proposed structures. The site can be considered suitable for development of the proposed structures.

*A. SHALLOW FOUNDATIONS*

The Geotechnical Investigation has provided guidance for the detailed design of the foundations of the proposed structures. Shallow foundation construction will utilize this data.

*B. DEEP FOUNDATIONS*

Compressive soils have been determined to constitute a consideration in the design of foundations. The recommendations of the Geotechnical Investigation will be utilized in the detailed design of all foundations.

*C.CORROSION POTENTIAL AND GROUND AGGRESSIVENESS*

Corrosively tests will be conducted to determine whether the site soils are either noncorrosive or corrosive for buried steel based on the chloride content and pH values.

## IV. DAMAGE IN FOUNDATION DUE TO EXPANSIVE SOIL

The most obvious way in which expansive soils can damage foundations is by uplift as they swell with moisture increases. Swelling soils lift up and crack lightly-loaded, continuous strip footings, and frequently cause distress in floor slabs.

Because of the different building loads on different portions of a structure's foundation, the resultant uplift will vary in different areas. As shown in Fig. 1, the exterior corners of a uniformly-loaded rectangular slab foundation will only exert about one-fourth of the normal pressure on a swelling soil of that exerted at the central portion of the slab. As a result, the corners tend to be lifted up relative to the central portion. This phenomenon can be exacerbated by moisture differentials within soils at the edge of the slab. Such differential movement of the foundation can also cause distress to the framing of a structure.

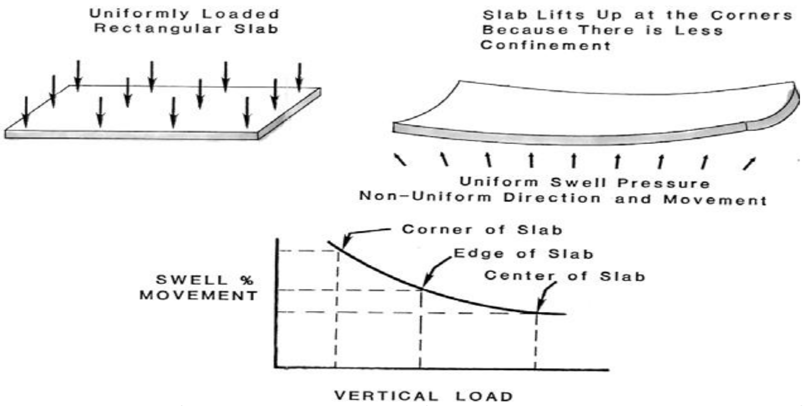


Fig 1: A rectangular slab, uniformly loaded, will tend to lift up in the corners because there is less confinement

## V. EXPANSIVE SOIL COMMON IN INDIA

Black cotton soil is a very common expansive soil in India.

A black cotton soil occurs mostly in the central and western parts and covers approximately 20% of the total area of India. Most of black-cotton soils of India are spread across the Deccan Lava Plateau, the Malwa Plateau, and interior Gujarat, where there is both moderate rainfall and underlying basaltic rock. Because of their high clay content, black

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soil develop wide cracks during the dry season, but their iron-rich granular structure makes them resistant to wind and water erosion. They are also highly moisture-retentive, thus responding well to irrigation.

1.0 Demerits: These soils contain fine clay particles. This property induces a great affinity to water of such type of soil. Alternate swelling and shrinkage in extensive limit during wet and dry process respectively results cracks in soil without any warning. These cracks may sometimes extend to severe limit like 1/2" wide and 12"deep. So building to be founded on this soil may suffer severe damage with the change of atmospheric conditions.
Highway and construction of structures on Black cotton soils has been a challenge to the respective engineers and designers because of its high swelling and shrinkage characteristics. This major group of soil consists of inorganic clays of medium to high compressibility. The Black cotton soil is very hard when dry, but loses its strength completely when on wet condition.
Foundation for buildings and structures founded on black Cotton Soils shall be designed in accordance with section1.2 or 1.3.

1.1 Exception : Foundation design need not comply with Section 1.2 or 1.3 where one of the following condition is satisfied:-
a) Removal of Black Cotton soils: Where black Cotton Soil is removed-the soil shall be removed to a depth sufficient to ensure constant moisture content in the remaining soil. Fill material shall not contain black cotton soils.
Exception:
Black Cotton Soils need not be removed to the depth of constant moisture, provided the confining pressure in the black cotton soils created by the fill and supported structure exceeds the swell pressure.
b) Stabilization approved building official where the active zone of black cotton soils is stabilized, the soil shall be stabilized by chemical, dewatering, pre-saturation or equivalent techniques.
1.2 Foundations: foundations placed on or within the active zone of black cotton soils shall be designed to resist differential volume changes and to prevent structural damage to the supported structure. Deflection and racking of the supported structure shall be limited to that which will not interfere with the usability and serviceability of the structure.
Foundation placed below where volume change occurs or below black cotton soils shall comply with the following provisions
1. Foundations extending into or penetrating black cotton soils shall be designed to prevent uplift of the supported structure.
2. Foundation penetrating black cotton soils shall be designed to resist forces exerted on the foundation due to soil volume changes or shall be isolated from the black cotton soils.
1.3 Slab-on-ground foundation: Moments, shears and deflections for use in designing slab-on-ground, mat or raft foundations on black cotton soils shall be determined in accordance with WRI/CRSI Design slab-on-Ground Foundations or PIT Standard Requirements for Analysis of Shallow Concrete Foundations on black cotton soils. Using the moments, shears and deflections determined above, non-prestressed slabs-on-ground, mat or raft foundations on black cotton soils shall be designed in accordance with WRI/CRSI design of Slab-on-Ground Foundations and post-tensioned slab-on-ground, mat or raft foundation on black cotton soils shall be designed in accordance with PTI standard Requirements for Design of Shallow Post-Tensioned Concrete Foundations on black cotton soils. It shall be permitted to analyses and design such slabs by other methods that account for soil-structure interaction, the deformed shape of the soil support, the plate or stiffened plate action of the slab as well as both center lift and edge lift conditions. Such alternative methods shall be rational and the basis for all aspects and parameters of the method shall be available for peer review.

## VI. RECOGNITION OF EXPANSIVE SOIL AND REMEDIES

*Recognition of Expansive Soil:* Expansive soils owe their characteristics to the presence of swelling clay minerals. As they get wet, the clay minerals absorb water molecules and expand; conversely, as they dry they shrink, leaving large voids in the soil. Swelling clays can control the behavior of virtually any type of soil if the percentage of clay is more than about 5 percent by weight. Soils with smectite clay minerals, such as montmorillonite, exhibit the most profound swelling properties.

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Potentially expansive soils can typically be recognized in the lab by their plastic properties. Inorganic clays of high plasticity, generally those with liquid limits exceeding 50 percent and plasticity index over 30; usually have high inherent swelling capacity. Expansion of soils can also be measured in the lab directly, by immersing a remolded soil sample and measuring its volume change.

*Way Out:*It is possible to build successfully and safely on expansive soils if stable moisture content can be maintained or if the building can be insulated from any soil volume change that occurs. The procedure for success is as follows:

- Testing to identify any problems
- Design to minimize moisture content changes and insulate from soil volume changes
- Build in a way that will not change the conditions of the soil
- Maintain a constant moisture environment after construction

Expert assistance is needed to do these things successfully.

*Remedies:*(i) The use of lime for stabilizing plastic montmorillonitic clays has been increasing in favor during the last few decades because it lowers volume change characteristics. Generally the amount of lime required to stabilize expansive soils ranges from 2 to 8% by weight.

The addition of lime to clay soil provides an abundance of calcium ions ($Ca^{2+}$) and magnesium ions (Mg2+). These ions tend to displace other common cations such as sodium ($Na^{+}$) and potassium($K^{+}$), in a process known as cation exchange. Replacement of sodium and potassium ions with calcium significantly reduces the plasticity index of the clay. A reduction in plasticity is usually accompanied by reduced potential for swelling. The addition of lime increases the soil pH, which also increases the cation exchange capacity. A change of soil texture takes place when lime is mixed with clays. With the increase in lime content, there is an apparent reduction in clay content and a corresponding increase in percentage of coarse particles.

(ii) Fly ash & fiber reinforcement in foundation also takes a vital role for stabilization of expansive soils.

## VII. CONCLUSION

On the basis of the present study, the following conclusions aremade:

1. Foundation on expansive soil with proper studyof the expansive soil and measures can be safe.
2. Fly ash or lime can reduce the expansion of the soil.
3. Fiber reinforcement also can be a good alternative in case of foundation in expansive soil.

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