EFFECT OF CEMENT ON THE HEAVE OF AN EXPANSIVE SOIL

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ABSTRACT

Expansive soil, called shrink-swell soil, also is very common cause of foundation problem. Depending upon the supply of moisture in the ground, shrink- swell soil will experience changes in volume of up to thirty percent or more. Foundation soils which arc expansive will "heave" and can cause lifting of a building or other structure like pavements, embankments during period of high moisture. An attempt has been made in this study to check the heave behavior of expansive soil with the addition of cement. The soil collected from Vrindavan garden is use for project. The properties of soil sample have determined. The results of MDD and heave are compared between original soil samples and modified with cement. The heave of expansive soil is reducing to great extent with the use of cement. The use of cement in soil to reduce heave is an effective method.

Keywords: *Expansive soil, cement, Optimum moisture, Maximum Dry Density, Heave*.

INTRODUCTION

Expansive clays, which are rich in mineral montmorillonite, absorb water during monsoon and undergo swelling as a consequence. Expansive soils are those which show volumetric changes in response to changes in their moisture content. During summer, the water evaporates and

cause shrinkage of the soil. This alternate swelling and shrinkage with moisture fluctuations causes strains in the structures built in them and, as a result, the structures are distressed. Single storey and two-storey buildings, pavements,
canal beds and linings, retaining walls are some of the structures which undergo distress.

The expansive soil hazards are often caused by water swelling and dehydration shrinkage, the swelling deformation of expansive soil contains two categories which are internal layer expansion and lattice expansion. The latter is the expansion of expansible minerals, the lattice expansion mince the obvious expansions of mineral volume cause by water entering which is one part of the mineral compositions or lattice.

Heave arises during freezing owing to cryostatic suction effects that can increase the upward water penetration to facilitate ice-lens growth and increased heave. The main aim of project is to study the effect of cement on the swelling of soil. The effect of cement on the heave of expansive soil was determined experimentally.

This paper describes the experimental set up used for the project, and also the material and procedures adopted for laboratory testing.

A. Swelling & Shrinkage in Expansive Soil

As clay particles are formed, there are usually several points in the particle arrangement where there is an electrical imbalance is increased whenever a 'string' of clay particles is broken apart. Thus, the result is that a clay particle typically has a negative net electrical charge on its surface. Whenever a water molecule drifts close enough to the surface of clay particle, the negatively charged surface of the clay particle causes the positive end of the water molecule to turn toward the particle and close enough to the particle, the water molecule is attracted to the clay particle surface sufficiently strong that the water molecules becomes trapped.

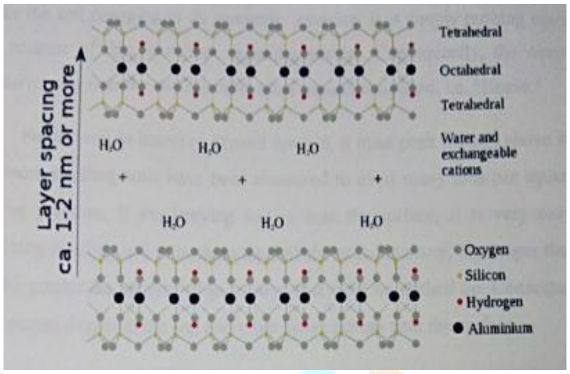

Figure 1. Structure of Montmorillonite

Also, unattached or free positively charged particle, called cations tend to acquire a spherical shaped arrangement of water molecules which have their negative ends directed towards the positively charged cation. When the free cations and its captured water molecules approach a clay particle, the attraction between the negatively charged surface and the positively charged outside of the cation sphere of water molecule causes the cation to be captured by the clay particle, thus increasing the amount of water associated with the clay particle.

Montmorillonite is a very soft phylloslicate group of minerals that typically form in microscopic crystals, forming clay. Montmorillonite, a member of smectite family, is 2:1 clay, meaning that it has 2 tetrahedral sheets sandwiching a central octahedral sheet as shown in figure 1. The particle is plate shaped with an average diameter of approximately one micrometer. It is the main constituent of the volcanic ash weathering product bentonite.

The water content of montmorillonite is variable and it increases greatly in volume when it absorbs water. Similar to many other clays, montmorillonite swells with addition of water. However some montmorillonites expand considerably more than other clays due to the water penetrating the interlayer molecular spaces and continuous adsorption. The amount of expansion is largely due to the type of exchangeable cation contained in the sample. The presence of sodium as the predominant exchangeable cation can result in the clay swelling to several times its original volume.

B. Heave characteristic of Expansive Soil

The term “Heave” is used with respect to expansive soils, it usually means that the soil surface is movinf upward, however , if given the opportunity to do so, an expansive soil that is getting wetter will increase in volume, or heave in every direction. But, because the expansive soil particle adjacent to the particle that is attempting to expand laterally, the result is sort of like the soil engaging in an isometric exercise. It is simply pushing against itself and because of that, it cannot expand sideways. Consequently, the direction that expansive soils near the surface most often expand is upward i.e. “*Heave*”.

For soils to heave or expand upward too, some swelling soils have been measured to exert many tons per square foot of swelling pressure. If the heaving soil is near the surface, it is very for the underlying swelling soil to push up the soil above it. However, the deeper the swelling soil, the greater the amount of soil above that must be pushed up. Consequently, less heave occurs deeper in the soil and more occurs near the surface.

Conversely, if the soil is drying out, the soil will also change in volume in every direction but in a direction opposite to that which occurs when it is getting wet (i.e. the soil shrinks in volume). When the soil shrinks, one soil particle does not resist shrinkage byan adjacent soil like it resisted swelling by the same particle. Instead, every soil particle is free to reduce in size by giving up water. Besides causing the ground surface to recede or go down, the shrinking process results in cracks in the soil.

C. Damage caused by 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 lightl loaded, continuous strip footings and frequently cause distress in floor slabs. Because of the different building loads on different portions of a structures foundation, the resultant uplift will vary in different areas.

However, experience also shows that uncontrolled shrinking and swelling of expansive soil can lead to increased stresses in a concrete pavement due to non uniform support, which accelerates pavement degradation and negatively impacts pavement smoothness. Although changes in soil moisture content are inevitable over the life of a pavement, expansive soils can be effectively addressed through proper compaction, selective grading, and or chemical modification.

Drilled pier foundations have been used to reduce expansive soil damage. However these types of foundations can also be adversely affected by expansive soil behavior if the piers are not sufficiently deep. Frequently if the corners piers of a pier supported structure are lifted up during swelling in the wet season, and then break their skin friction bond with the ground when the soil shrinks away from the pier in the following dry season. Loss of "skin friction" decreases the pier's ability to support building loads. This straining to the soil can become great enough that the pier falls. To prevent this style of damage, the piers must be drilled well below the zone of seasonal moisture fluctuation, and they must be designed with the assumption that the upper portions of the pier will lose contact with the adjacent soil.

D. Remedial measures

There are two conditions that must be satisfied before expansive soil becomes a problem: expansive soils must be present and the soil moisture conditions must change. Obviously, if expansive soil is not present, the extreme soil shrinks and heave normally associated with expansive soils will not occur.

If the soil water content can be kept from changing, or at least the change kept to a minimum, lesser shrink or heave will occur and the problem created by expansive soil will be minimized. However, it must be recognized that constructing a house or a building interrupts an established energy gradient (principally due to surface evaporation and plant transpiration) that is causing soil water to move from depth to the surface or vice versa. This induced water flow will ultimately result in some shrink or heave, even in the volume of soil beneath the interior of the house or building that is not being influenced by outside factors such as climate. However, once the interrupted energy gradient has reached equilibrium, no further shrink or heave likely will occur unless something external happens to upset the soil moisture equilibrium. Three things that often cause the soil water content to change are climate, site vegetation, and irrigation.

The best way to avoid damage from expansive soil is to extend building foundation beneath the zone of water content fluctuation. The reason is twofold: first, to provide for sufficient skin friction adhesion below the zone of drying; and second, to resist upward movement when the surface soil become wet and begin to swell.

OBJECTIVE

[1] To determine the effect of cement on the upward swelling (heave) of soil.

[2] To determine the percentage heave increase or decrease pertaining to the addition of cement in the soil.

MATERIALS & METHODOLOGY

The entire test is divided into two phases. In the first phase, initially the OMC & MDD of the expansive soil are determined. After compacting to the required MDD, a base plate of standard dimensions is centrally placed on the top layer of soil and a dial gauge is fixed on it. As the water content is allowed to increase, the soil swells and base plate suffers upward pressure. The dial gauge shows reading which corresponds to observed heave in millimeters.

In the second phase, the procedure is repeated with addition of cement at OMC and MDD of expansive soil at respective percentage cement content. The dial gauge shows corresponding readings in due intervals of time are noted carefully. The test results are compared and concluded.

Set-up details

Outer Tank = 70cm x 70cm x 20cm.

Inner Tank = 50cm x50cm x 20cm.

Weight of soil = 68.50 kg.

Drop hammer = 11.6 kg.

Dial gauge = least count 25 mm.

Footing plate = 5 mm thick.

Figure 2. Outer Tank.

Figure 3. Inner Perforated Tank.

The soil taken for the test was sieved through 4.75 mm sieve then allowed to dry for 24 hours in oven. From Standard Proctor Test, the MDD of the basic soil was found to be 1.37 gm/ml at an OMC of 10%. From the MDD of the soil, the quantity of soil obtained as 68.5 kg. This mass of soil was then mixed with water at its OMC i.e. 6.85 liters of water. This wetted soil was kept for curing for 4 hours in air tight bag. The setup consist of an inner tank, outer tank, dial gauge, foundation plate. Fine grained soil was used to provide a fixed and plain base to the inner tank. Soil mass was divided in 5 parts so as to fill in 5 layers. First part of soil mass was poured in tank and was given 131 strokes by drop hammer as mentioned. Similar procedure was adopted for remaining layers. After compacting all layers, the foundation plate was kept at the centre of the tank and a dial gauge was attached to the centre of base plate with the help of magnetic base. The outer tank was filled with water up to compacted soil layer and corresponding readings were taken on dial gauge. Dial gauge readings indicate the swelling occurred in soil. Readings were noted at an interval of 5 minutes for first 30 minutes and then interval was varied as shown in tables. The test was performed on soil with and without using cement as a reinforced material.

Calculations

[1] Number of blows:

As per IS:2720(PART VII) 1987

$$\text{Energy} = \frac{\text{height of drop x blows x no.of layers x weight of hammer}}{\text{Volume of mould}}$$

Energy = 6.065 kg/cm/1cc

$$6.065 = \frac{40 \times N \times 5 \times 11.6}{20 \times 50 \times 50}$$

N = 131 blows.

[2] Mass of soil

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

$$1.37 \times 10^{-3} = \frac{\text{mass}}{50 \times 50 \times 20}$$

Mass = 68.5 kg without cement.

Now with cement the density from standard proctor test comes out to be 1057 g/ml.

$$1.57 \times 10^{-3} = \frac{\text{mass}}{50 \times 50 \times 20}$$

Mass = 75.5 kg.

RESULTS

Table No 01. Summary of Properties of Soil.

Sr No.	Parameter	Value
1	Free Swell Index	23.02
2	Water Content	6.79 %
3	Specific Gravity	2.46
4	Grain Size Analysis	Coarse grained well graded
5	Liquid Limit	68.98 %
6	Plastic Limit	36.43 %
7	Maximum Dry Density	1.37 g/ml
9	Optimum Moisture Content	12 %

The OMC & MDD of test soil with various percentage of cement (i.e. 0 %, 0.5 %, 1.0 %, 1.5 %, 2.0 %, 2.5 %) was determined by performing the Standard Proctor Test as per IS: 2720 (part II) 1973.

Table No. 02. OMC & MDD with varying cement content.

Sr.No.	% of cement	OMC %	MDD (g/ml)
1	0.5	15	1.38
2	1.0	15	1.42
3	1.5	10	1.44
4	2.0	12	1.51 *

5	2.5	17	1.40

From the above, the corresponding OMC & MDD of the soil sample with 2 % (max. MDD) cement content was taken into consideration.

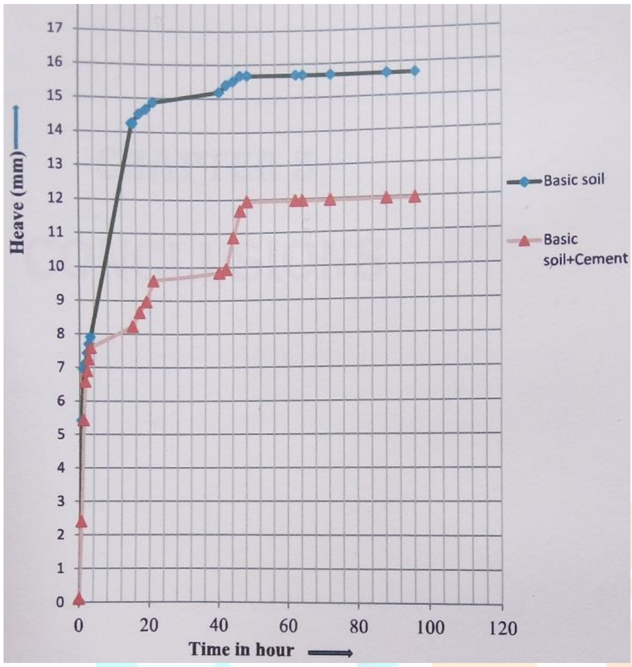

Figure 04. Comparison of Heave Characteristic of Basic Soil and Cement Mixed Soil.

[1] From figure 4 the Heave of expansive soil (Basic indicated by blue dot line) was found to be 15.68 mm.

[2] From figure 4 the Heave of expansive soil (cement mixed soil indicated by red dot line) was found to be 11.95 mm.

CONCLUSIONS

[1] From the Standard Proctor Test results, it was found that the MDD corresponding to 2 % cement content was maximum i.e. 1.51 g/ml.

[2]From figure 4, the heave of the expansive soil was found to decrease up to 24 %.

[3] The maximum dry density of basic soil was found to increase with the corresponding increase in cement content.

[4] The adhesion between the water and soil particles increases with addition of cement.

[5] Initially the rate of heaving is high and slows down after some course of time as shown in figure.

[6] It has been observed that with the addition of cement to black cotton soil with various percentages, the MDD again increases with the corresponding increase in OMC.

[7] From the test, it is concluded that the Heave of an expansive soil can be reduced up to remarkable extent by addition of cement in basic soil.

REFERENCES

[1] B.C. Punmia, “Soil Mechanics & Foundations”, Laxmi Publications, 13th edition, 2008.

[2] Mohammad Shukri Al-Zoubi, “Jordan Journal of Civil Engineering”, Undrained Shear Strength & Swelling Characteristics of Cement Treated Soil”, Volume 2, 2008.

[3] J. David Rogers, Robert Olshansky, & Robert B. Rogers, on “Damage to Foundations to Expansive Soils”, 1993.

Ian Jefferson, “Institution of Civil Engineers Chapter C5 Expansive Soils”, University of Birmingham Manuals Series, 2012.

[4] P.J. Sabatini, “Expansive Soil Geotechnical Engineering”, & “Evaluation of a Soil & Rock Properties”.

[5] Dr. Purushothama Raj et. al., Ground Improvement Techniques, Firewall Media, pages 266, 2005.

[6] Charles H Neuberger, “The Use of Lime- Soil Stabilization as a Construction Expedient”, Defense Technical Information Center, pages 120, 1970.