International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.10, October 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

A Review on the Effect of Jute Fibre on the Lime Treated Expansive Soil

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ABSTRACT

Construction of light structures such as highways, railroads, runways, and other lifeline structures, may get severely damaged due to very high swelling and shrinkage behaviour of black cotton soil. Because of its swell-shrinkage behaviour it is also called expansive soil. In India, black cotton soil cover as high as 20% of the total land area. Expansive soil isthat soil, which have high swelling and shrinkage characteristics and CBR value and shear strength. Hence, there is need for improvement of these properties. At present construction is managed by using granular or lime stabilized soils. The use of Jute geo-textile is a new and innovative solution, in which a geo-textile material is used in expansive soil as a reinforcement to stabilize it. The use of natural and artificial fibres is a suitable method for homogeneous soil reinforcing. The present study attempts to understand the effectiveness of Jute fibres in controlling swelling behaviour of black cotton soil measured in the laboratory with and without use of random reinforced jute fibres in the black cotton soil. The properties of stabilized soil such as shrinkage limit, unconfined compressive strength and California bearing ratio were evaluated and their variations with content of jute fibres are evaluated. Soil samples containing 0%, 1%, 2% to 5% of jute fibre were prepared and index properties were evaluated as per relevant IS code of practise. The test results showed significant decrease in the expansive behaviour of the black cotton soil. The shrinkage limit increases from 13.75% to 28.68% if black cotton soil is mixed with 5% lime and jute fibres from 0% to 5% by weight of black cotton soil. There is significant increase in California bearing ratio and unconfined compressive strength.

Keywords: *Black cotton soil; index properties; jute fibres; stabilization; swelling behaviour*.

1. INTRODUCTION

Soil improvement is of major concern in the construction activities due to rapid growth of urbanization and industrialisation. The term soil improvement is used for the techniques which improve the index properties and other engineering characteristic of expansive soils. Expansive soils are clay of high plasticity. They content essentially the clay mineral montmorillonite. The soils have high shrinkage and swelling characteristics. The shearing strength of the soils is extremely low. The soils are highly compressible and have very low bearing capacity. It is extremely difficult to work with such soils. These soils are residual deposits formed from basalt or trap rocks. The tendency of expansive soil to increase in volume due to infiltration of water is resisted by the structure resting on the soil and as a consequence, vertical swelling pressure is exerted on the structure. Swelling pressure develop if the soil is not allow to swell freely. The magnitude of swelling pressure depends on the degree of expansion permitted. If the swelling pressure exerted by soil is not controlled, it may cause uplift and distress in structure. Structures constructed on expansive clays induce heave from various sources. Shrinkage, from the reduction of moisture caused by evaporation or thetranspiration of vegetation, and the subsequent increase in soil moisture content has caused heave in expansive soils. Environmental conditions of a particular area in which expansive soils are located play an important role in the behaviour of such soils. The alternate swelling and shrinkage causes differential movement in the structure build over such soils and result in following damages: (Gromko 1974).

- Damage to pavements: The roads that pass through expansive subgrades and subjected to heave and settlement of these soils. This result in irregularities, cracking and rutting of pavement surface, requires high maintenance cost.
- Damage to building: Lightly loaded structures resting on expansive clays will undergo substantial damage due to severe cracking.
- Damage to canals: The lined and unlined canals are also damaged due to expansive soils. The side slopes of canal embankment were found to be eroded and become soft when constructed using expansive soils. (Coduto 1999)
- Damage to conduits: Conduits such as water supply lines and drainage pipes have been subjected to both lateral and vertical movements, because of swelling of expansive clays.
- Structural damage to buildings, canals, underground structures etc. has been caused mainly by differential heave of the foundation sub-soils.

Differential heave is a function of a number of variables such as lateral thickness of the clay strata, variations in water content beneath the structure, non-uniformity of the soil, and other causes related to the use and occupation of the particular structure.

2. EXPANSIVE SOILS: INVESTIGATION AND STABLIZATION

Stabilization of expansive soils by chemical additives such as lime and cement has been tried for many years with varying degrees of success. Organic chemicals, fly ash, and some other compounds show some promise as agents that will reduce heave in soils. Lime

Lime stabilization develops from Base Exchange, cementation, and carbonation processes between the clay particles and the lime. The Base Exchange capacity of clay, i.e. the ability of clay to absorb exchangeable cation, arises from the negative charge of the clay particles. Stabilization with lime apparently occurs because (a) the ca++ ion becomes hydrated, restricting water adsorption on the particle, (b) its large size (1.02 A) does not allow it to fit into the water net, reducing water adsorption, and (c) its +2 valence limits the negative field penetration of the clay particles. For example, orientation of water around Ca montmorillonite exists out to only about 15 A, while water orientation of Na-montmorillonite exists out to about 100 A. Consequently, adsorbed

IJARSE
ISSN: 2319-8354

ca++ ions cause the clay particles to flocculate to a more dense condition compared with Na montmorillonite. Cementation is a long-time chemical or pozzolanic reaction in which lime reacts with clay mineral constituents to form compounds such as calcium silicate hydrates and calcium aluminium hydrates that probably interlock with the clay particles to form a permanent bond. Carbonation takes place upon exposure of lime to the atmosphere. Reaction of lime with air forms carbonates that seem to produce weak cement that could reduce the overall effectiveness of lime additions.

The physical effect of small lime additions (from 2 to 8 percentages) is to significantly decrease the liquid limit, plasticity index, optimum dry density, and swell, and to increase the optimum water content and shear strength of expansive type clays. The decrease in liquid limit and plasticity index observed from lime stabilization apparently occurs mostly from cementation and possibly carbonation processes rather than· from ion exchange phenomena. Esrig, for example, found that electro osmotic hardening of illitic clay using calcium chloride solutions and a voltage gradient of 1 v/cm occurs from ion exchange and a decrease in the water content. These changes are associated with large increases in the liquid limit and a slight increase in the plasticity index. Adding lime in an amount exceeding that required for ion exchange (about 1 to 3 percentage) increases the cementation processes.

Various procedures exist that improve the effectiveness of lime. Grinding the lime to very fine particle size, adding it in more than one application, and maintaining the lime at high purity are helpful. Intimate mixing of lime and subsequent compaction~ should begin immediately after adding water to the soils. Proper mixing is easier to achieve in practice with fully hydrated lime rather than with partially hydrated lime (quicklime). Dolomitic limes appear better than calcitic limes for cementation reactions for most clay except kaolinite types, while calcitic limes are more effective in reducing swelling tendencies in clay through ion exchange phenomena than are dolomitic limes. Lime added to illite seems to be less effective than lime added to montmorillonite clays.117

3. LITERATURE REVIEW

Woodward, et al., 124 found that attempts to distribute lime with water in drill holes through natural soils were not very successful. It was necessary to excavate the soil, mix it directly with lime, and replace the mixture, which is a process costing several times that of simple removal and replacement of expansive soils. Usually, only the top foot can he economically stabilized. A fairly new limes slurry pressure-injection process has been claimed to be effective, but this has not been adequately established.126 the soils are treated in an undisturbed condition to any desired depth. Lime slurry is forced laterally and vertically downward into the soil under extreme pressure. The slurry follows old fracture planes in the soil or creates new planes, depositing numerous seams and sheets of lime. There is a contact chemical reaction along these seams between the lime and soil with the result that the seams function as moisture barriers and prevent a change in water content.

Wyoming's highway department found that lime treatment worked in some cases, but not with soils containing clay with fine silts and sands. Kansas's highway department found that a 2 percentage lime treatment reduced swell by SO percentage, while 4 to 6 percentage treatment practically eliminated swell in soils. Oklahoma's highway department found swell substantially reduced by lime treatment. The Mississippi Highway Department mixes small amounts of cement or lime with expansive base course material of its county roads, which seems to stabilize the soil sufficiently for the comparatively low needs of these little-trafficked roads.

Phanikumar and Sharma, 2007), Two mechanisms are likely to occur when fly as is blended with expansive soil, 2001;. They are (i) physico-chemical interactions and (ii) mechanical changes. Expansive clay particles are replaced by the non plastic fines of fly ash. Fly ash, which is composed of silica, alumina and iron oxides, promotes flocculation of clay particles by cation exchange. The surface area of the flocculated particles and their affinity for water ell index, swell potential and swelling pressure.

Phanikumar (2009) compared the effect of lime and fly ash on free swell index, swell potential, swelling pressure, co-efficient of consolidation, compression index, secondary consolidation characteristics and shear strength. Lime content was varied as 2%, 4% and 6% whereas fly ash content was varied as 0%, 10% and 20%. It was noted that at 20% fly ash there was a significant reduction in swell potential, swelling pressure, compression index and secondary consolidation.

Bairagi, (2014) studied the Effect of jute fibres on engineering characteristics of black cotton soil and gave result that CBR and UCS values of soil were increased significantly when mixed with jute fibre from 0% to 5%.

Choudhary et al, (2012) studied the improvement in CBR of expansive soil with a single Jute reinforcement layer and gave results that reinforcement in layer controls swelling and enhances CBR value. Singh, (2013) conducted work on strength and stiffness of soil reinforced with jute geotextile sheets and concluded that there is increase in shear strength of soil with inclusion of jute in soil.

Pandit et al, (2016) conducted experimental work on Effects of Jute Fibre on Compaction Test and concluded that OMC of soil increases up to 1.25% of jute fibres and then decreases for 1.50%. MDD decreases up to 1.25 % of jute fibre and then increases for 1.50%.

Das and Singh, (2014) studied on Deformation and strength Characteristics of jute geotextile in reinforced soil concluded that jute layer reinforcement is very effective in stabilizing and protecting of weak soil.

Gill and Singh, (2012) studied CBR improvement of clayey soil and concluded that CBR was improved by 9.4% with different positions of layer. Jagan, (2016) conducted a case study on a critical review on applications of natural jute fibres and concluded that the CBR value of soil was increased after mixing the jute fibre in soil.

4. CONCLUSION

Differential heave from moisture absorption of expansive clay foundation subsoil has been the source of considerable damage to numerous manmade structures around the world. The amount of heave actually observed is dependent on many factors, particularly climatic conditions, moisture content of the soil immediately prior to placement of the structure, and amount and type of the foundation clay. The most expansive types of soil are those that contain calcium and, especially, sodium montmorillonite minerals. The primary force contributing to heave in montmorillonite clays can be expressed in terms of suction pressures identified as osmotic and matrix potentials. The absorption of moisture by osmosis is not completely understood, but its mechanism arises from ionic charges inherent in the clay particles. This mechanism is responsible for a considerable portion of the swelling. Matrix suction pressure arises from capillary or surface tension forces and occurs only in partially saturated soils. The procedure for construction on expansive foundation subsoil begins. Once these are known, the soil can be stabilized to minimize foundation heave or, if this proves impractical, the structure can be designed to withstand the expected heave.

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