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Effect of inclusion of Hexagonal Mesh on Expansive Soil

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Abstract:*Presence of expansive soil creates difficulties in construction activities because of swelling and shrinkage properties. This soil is widely found in India, hence stabilization of this soil is essential. Hexagonal mesh is used in Ferro cement concrete technique to reinforce R.C.C. Structures, hence an attempt is made to use hexagonal mesh to reinforce the expansive soil for stabilization. The objective of the study is to determine the effect of inclusion of hexagonal mesh on expansive soil. In this work unconfined compressive strength test, California Bearing Ratio test were conducted on expansive soil.Hexagonal mesh isused for reinforcing the soil by varying the number of layers of hexagonal mesh from 1 to 5.Maximum strength of unreinforced soil is found 4.86 kPa, whereas after inclusion of 5 layers of hexagonal mesh as a reinforcement it is increased to 20.41 kPa.*

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I. Introduction

Black cotton soil is an example of expansive soil. It has low bearing capacity & shearing strength. Itis highly compressible in nature& characterized by high liquid limit, plasticity index&swelling property. It containsmontmorillonite mineral which leads to swelling and shrinkage of soil, when it comes in contact with moisture it swells and shrinks upondrying. Hence Construction of the Civil Engineering structures on such type of soils is very difficult. For the construction of pavement subgrade must be strong, if the subgrade consists of expansive soil, then to achieve economy in construction, it should be replaced by another soil having sufficient strength or reinforcement should be provided.

The soil mass is mainly reinforced toimprove its stability,bearing capacity, shear strength, density&California bearing ratio value in Civil Engineering Construction work on expansive soil.

Amit kumarsingh, (2016) studied effect of jute fiber reinforcement layers in black cotton soil, conducteduncconfined compressive strength on black cotton soiland observed that at 4 layers of reinforcement maximum strength is attained.A.K.Choudhary, (2012) used single reinforcement layer to improve the CBR of expansive soil subgradeand found that insertion of a single layer of horizontal reinforcement of jute geotextile is better reinforcing material as compared to geogrid, it improves the CBR value significantly but it is less durablethan geogrid.Das tapas and singhbaleshwar, (2014) an attempt is made to study Deformation and strength characteristics of jute geotextile reinforced soils. Jute geotextile & fly ash were used to reinforce the soil, concluded that the strength significantly increases with inclusion of jute geotextiles in layers. The increase in strength is proportional to the number of layers of jute geotextile provided in the soil.D. Baglari, (2013) carried out comparative study on lime treated soil and lime treated soil reinforced with geosynthetic material. Results of this work shows that the geosynthetic reinforcement can further improves the performance of lime treated expansive soils.H.P. Singh, (2013) studied on the Strengthening of Soil by using Jute Geotextile Sheets. Triaxial test was conducted by placing Geotextile layers at equal vertical spacing in four different combinations Concluded that introduction of Jute Geotextile layers into the soil gives significant increase to the shear strength.Harshitabairagi, (2014) studied effect of jute fibers on engineering characteristics of black cotton soil. An attempt is made to increase the CBR &UCS by using jute geotextile. In the present study the soil samples were blended with 0%, 1%, 2% to 5% of jute fiber&Concluded that increase in California bearing ratio and unconfined compressive strength test is remarkable. Increase in The C.B.R. value was found to be 1.8% to 4.1% and for unconfined compressive strength it was found to be 1.09kg/cm^{2}to 1.35 kg/cm^2. Amit kumarsingh, (2016) carried out an experimental study to Improve CBR of Expansive Soil with Jute Fibre Reinforcement and properties of soil are improved by artificial means & they experienced that introduction of Jute Geotextile layer into the soil increases the California bearing ratio & unconfined compressive strength and this increase is maximum at 4 layers of Jute Geotextile.D.Kanakaraju Yadav1, (2017) Conducted experimental study on expansive soil of Vemulawada, Telangana state to improve the CBR value by using Geo synthetics. Two types of reinforcing materials such as Geo-textile and Geo-grids are used and placed at a depth of 20 mm from the top

of CBR mould. From this paper it is concluded that after reinforcing the soil with Geotextile the CBR is raised slightly but CBR value increases to twice when it is reinforced with Geo-grid.

The current study is focused on the effect of the inclusion of hexagonal mesh layers on California bearing ratio (CBR) and unconfined compressive strength (UCS) testfor expansive soil.

II. Material And Methods

Expansive soil collection: The soil selected for the study is black cotton soil, collected from Aurangabad district. Properties of the soil are determined by standard procedures.

Table no 1: Shows Properties of the soil.

Property	Value
Specific gravity	2.74
Liquid limit	71
Plastic limit	42.59
Plasticity index	28.41
Optimum moisture content	12 %
Unconfined compressive strength	4.86 kPa
C.B.R. Value	3.7 %

Ferro cement concretetechnique:

Ferro cement is a thin construction, consisting of steel rods, wire meshes & Portland cement mortar is used instead of concrete. First the Skelton frame is made using the steel rods of diameter 3 to 8 mm bent to the required shape. The steel rods are used for holding the wire mesh of diameter 0.5 to 1.5 mm in position and shape of the structure. The required numbers of wired mesh layers are fixed on both sides of the skeleton frame. The wire mesh may be square woven wire mesh or hexagonal wire mesh. The meshes are filled with rich cement mortar by any method.

After going through the concept of Ferro cement concrete, it is decided to use the similar kind of hexagonal mesh as reinforcement to strengthen the expansive soil which causes damages to the civil engineering construction activities.

Hexagonal shaped mesh:

It is a wired mesh, made of thin flexible steel wire having openings of hexagonal shape. This material have less thickness, easily available in the local market at low cost, hence this material is decided to use as a reinforcement in this experimental work. It is available in several gaps of 1/2 inch (about 1.3 cm), 1 inch (about 2.5 cm) diameter and 2 inch (about 5 cm). Chicken mesh is commonly used for fencing purpose & occasionally used to protect plants and property from animals, though the thinness.

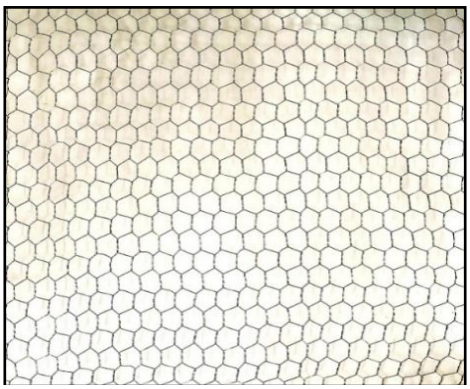


Figure 1 Hexagonal shaped mesh

Testing methods:

The black cotton soil is used in the present study which is widely found in India,thesesoils are improvedby providing thereinforcement.Soil improvement enhances engineering properties, increases shear strength & ultimate strength of soil.Reinforced soil is a composite material consisting of alternating layers of compacted backfill and man-made reinforcing material, soil is treated with natural or synthesized additivesto improve its properties.There are several methods to improve the expansive soil to make it suitable for the construction by addition of combination of different fibers, by inclusion of reinforcing material or by using

combination of both fiber & reinforcing material. Soil can be improved by the mechanical stabilization, chemical stabilization, stabilization with additives etc. One such previous method which use Jute geotextile as a reinforcing material. Even though it is biodegradable material many researchers have worked with this material as it is environment-friendly. Another method of mechanical stabilization uses different geosynthetics materials of non-woven geotextile & geomesh as reinforcement. From the literature it is found that no work is done by using the hexagonal mesh, hence this study includes stabilization of expansive soil by using hexagonal mesh.In spite of available methods for the treatment of expansive soil, it still has been felt the importance to study the effect of treatment of such materials so as to obtain a more improved technique to deal with this problematic soil. The use of Hexagonal mesh is a new and innovative material, which is used in expansive soil to stabilize it. Aseries of C.B.R.& U.C.S. tests have been conducted on black cotton soil by varying number of layers of hexagonal mesh from 1 to 5, the layers of reinforcement are placed uniformly along the length of soil specimen. The effect of varying number of layers on CBR & UCS test is studied and results are compared with that of unreinforced soil specimen. This paper presents the beneficial effects of placing the horizontal reinforcement from the top surface of the subgrade of soil.

Sample preparation of unconfined compressive strengthtest:

Unconfined compressive strength test is the shear strength of cohesive soil. These test gives the approximate strength of cohesive soil. In this study soil is reinforced by varying number of reinforcing layers. It is the maximum stress carrying capacity of cylindrical shape soil specimen, test is carried out on samples which can stand without any lateral support, when its sides are not provided with any confinement. Specimen of height to diameter ratio 2:1 that is metallic split mould of height 76 mm and diameter 38 mm is used for determination of unconfined compression test. Sample fails either by shear on inclined plane or it may fail by bulging. The stress is obtained at any stage by the vertical load divided by cross sectional area. The cross sectional area of sample increases in compression. It is assumed that the total volume the sample remains same. The soil sample is prepared at the desired dry density and optimum moisture content. Quantity of water equal to the optimum moisture content is used in the testing. The layers of reinforcement are placed uniformly along the length of soil specimen by maintaining equal parts through the length of the sample. The number of parts of reinforced soil will be (n+1), where n is number of reinforcing layers. Then specimen is placed at the bottom of the loading device. Proving ring and dial gauge are set to zero. Load is applied at constant rate. Sample is compressed until the cracks are induced on soil specimen & the peak value of compressive stress is recorded as the unconfined compressive strength. The testing is carried out both unreinforced and reinforced soil samples.

Figure 2 Soil sample during unconfined compressive strength test

Figure 3 Soil sample afterunconfined compressive strength test

Sample preparation of California bearing ratio:

California bearing ratio is used for evaluating suitability of subgrade and the materials used in sub base and base courses. The results CBR test are used to correlate the thickness of materials required for pavement construction. Test is conducted on prepared specimen in mould of diameter 150 mm and height of 175 mm. The optimum moisture content is obtained first and used in the sample preparation. The reinforcement is provided uniformly along the length of mould. The plunger is penetrated at the rate of 1.25 mm/minute. The loads required for the penetration of 2.5 mm & 5 mm penetration are recorded by proving ring & deformation are measured with dial gauge. The test load is expressed as a percentage of the standard load at the respective deformation level, is known as CBR value. The testing is carried out both unreinforced and reinforced soil samples.

Figure 4 Soil sample of C.B.R. after test

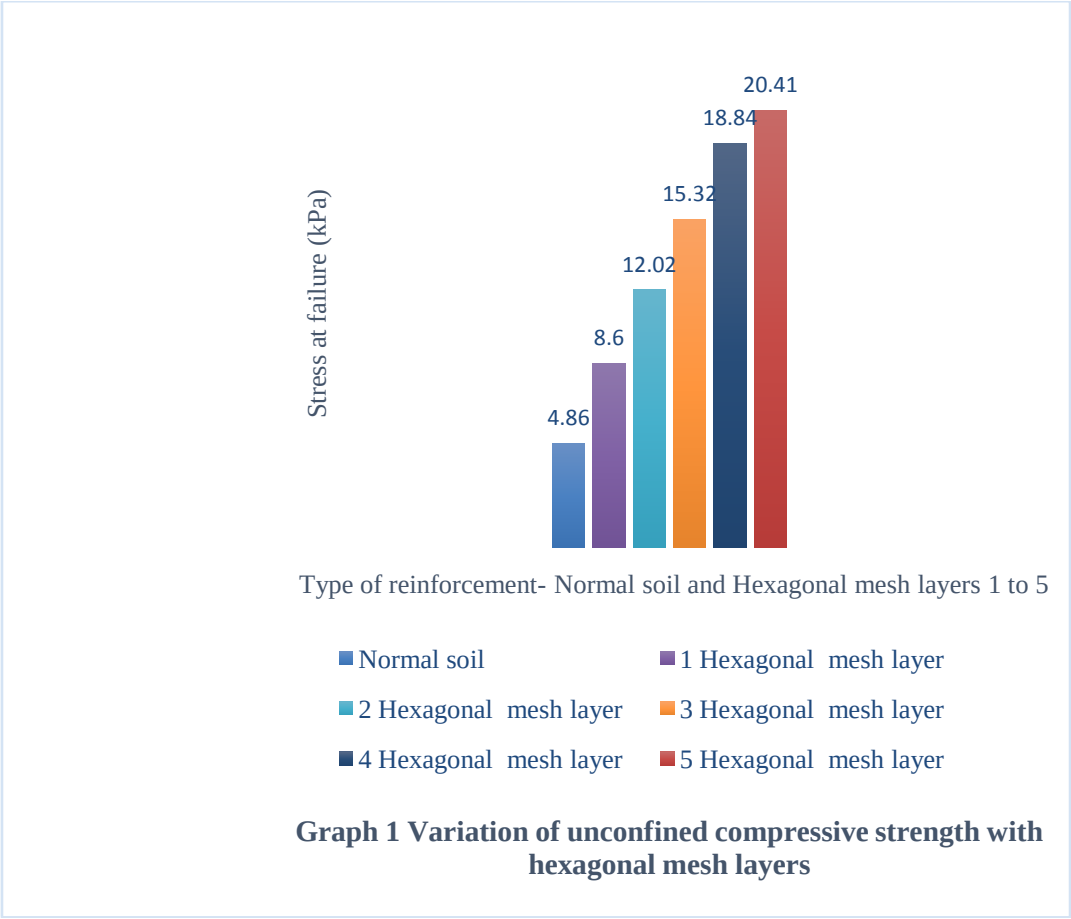
III. Result and Discussion

Unconfined compressive strength test:

- The unconfined compressive strength test is conducted by applying axial load on expansive soil specimen under reinforced and unreinforced conditions.
- The unconfined compressive strength of soil is increased from 4 kPa to 20 kPa at 5 layers of hexagonal mesh, indicates that ductility of soil sample increases after inclusion of reinforcing material.
- The unconfined compressive strength of soil sample increases as the number of reinforcing layers increases.
- Percentage increase obtained in theunconfined compressive strength of soil is320% in case of 5 layershexagonal mesh.
- Graph shows number of hexagonal mesh layers and stress at failure of soil sample.

Table no 2: comparison between unconfined compressive strength, %increase in unconfined compressive strength &number of hexagonal mesh layers used as reinforcement.

Number of hexagonal mesh layers used as reinforcement	Unconfined compressive strength (kPa)	%Increase in unconfined compressive strength
Unreinforced soil	4.86	0
1 Hexagonal mesh layer	8.60	76.95
2 Hexagonal mesh layer	12.02	147.33
3 Hexagonal mesh layer	15.32	215.23
4 Hexagonal mesh layer	18.84	287.65
5 Hexagonal mesh layer	20.41	319.96



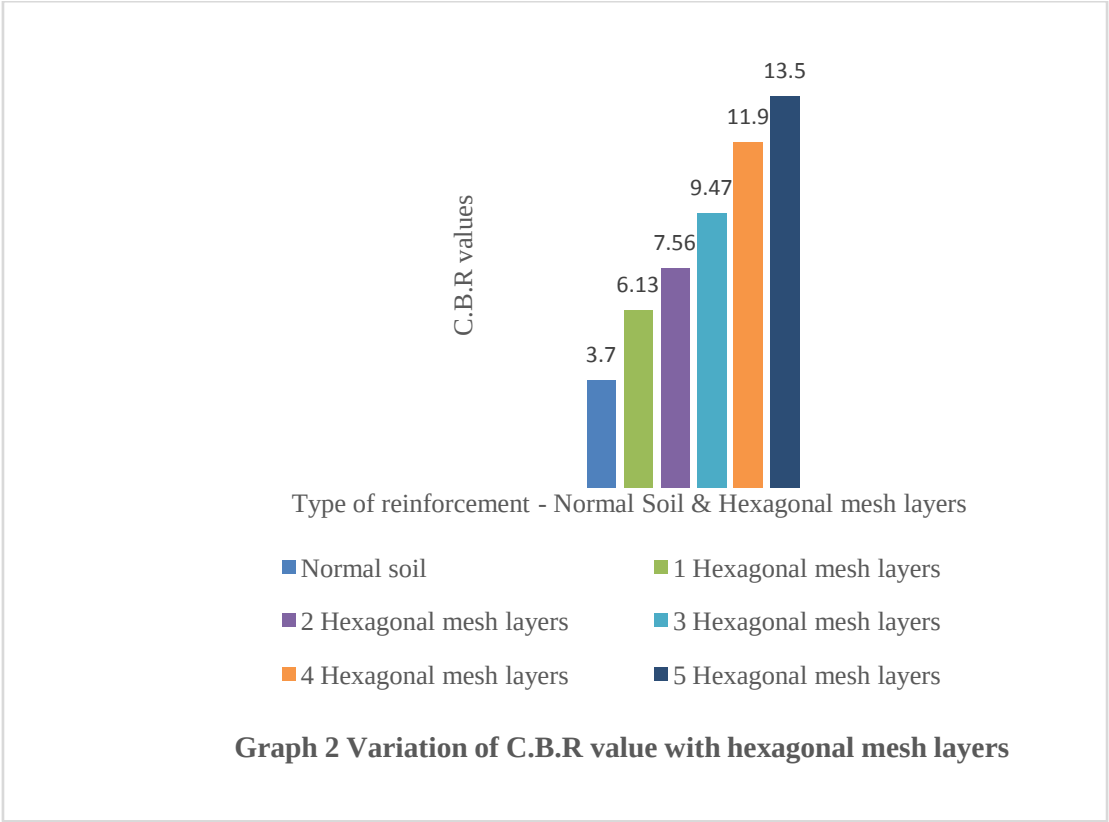
Graph 1 Variation of unconfined compressive strength with hexagonal mesh layers

California bearing ratio (CBR):
The CBR test is conducted by applying penetration load on expansive soil specimen under reinforced and unreinforced conditions and results are given in the following table,

Table no 3: comparison between CBR values, %increase in CBR value, cost of construction & % saving in cost with number of hexagonal mesh layers used as reinforcement.

Number of hexagonal mesh layers used as reinforcement	CBR value	% increase in CBR value	Cost of construction of 1 km road	% Saving in cost
Unreinforced soil	3.7	0	29992410	-
1 Hexagonal mesh layer	6.13	65.68	17653720	69.89
2 Hexagonal mesh layer	7.56	104.32	17786090	68.63
3 Hexagonal mesh layer	9.47	155.95	17940650	67.18
4 Hexagonal mesh layer	11.9	221.62	18117400	65.54
5 Hexagonal mesh layer	13.5	264.86	18338530	63.55

- CBR value of soil with 1 layer Hexagonal mesh is6.13 &5 layer Hexagonal mesh which is 13.5 but the1 layer Hexagonal mesh gives significantpercentage saving of 69.89 % in cost of construction of road.
- Maximum percentage increase obtained in California bearing ratio is 264 % with addition of 5 layers of hexagonal mesh.
- C.B.R value of soil is increased from 3.7 to 13.5 on inclusion of 5 layers of hexagonal mesh into the soil, it indicates that as number of reinforcing layers increases, CBR value of subgrade increases.
- Graph 2 shows the variations in CBR values for reinforced soil & unreinforced soil specimen.



Graph 2 Variation of C.B.R value with hexagonal mesh layers

IV. Conclusion

1. Unconfined compressive strength of soil treated with hexagonal mesh layers is higher than the strength of unreinforced soil.
2. Load and deformation behavior of expansive soil is improved because of reinforcing elements which enhances the CBR value.
3. Increase in UCS & CBR are directly proportional to number of layers of reinforcement provided to the problematic soil, as number layers increases strength increases.
4. From this experimental work it can be concluded that addition of hexagonal mesh layers provides resistance to deformation of soil & strength of soil subgrade increases.
5. After addition of 5 layers of hexagonal mesh to normal soil CBR value increases 4 times &unconfined compressive strength increases 5 times.
6. When soil is treated with5 layers of hexagonal mesh, percentage increase in CBR value & unconfined compressive strength is obtained as260 % &320%respectively.

Hence from this results, it can be concluded that CBR of problematic soil can be improved significantly when hexagonal mesh is used as reinforcement.

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