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Effective study of Geocell, Geogrid and Geo textile as Geo -Reinforcement on CBR and Resilient modulus value of subgrade

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Abstract: This paper presents the results of the California Bearing Ratio (CBR) values of Specimens of conventional and Specimens with Geosynthetics at various Heights of CBR mould. Along with the CBR, Cyclic load test is performed to evaluate the resilient modulus values of Optimum CBR specimens on expansive soils. In highway construction, if soil is of Black cotton which is having conventional CBR value of 0.9% is not suitable for pavement sub grade as per IRC: 37-2012. Black cotton soils are not effective in increasing the CBR and resilient modulus value. In this research we emphasis on geocell, geogrid and geotextile as Soil reinforcement. Coir geotextile and geogrid of uniaxial, biaxial, triaxial are installed at 1/3H, 1/2H and 2/3H from top of CBR mould. From this we suggest Triaxial Geogrid and Coir Geotextile with 1/3H are most effective in increasing the CBR value. Vehicle tyre tube are cut into hollow cylinder are used as geocell with different aspect ratio (0.75, 1 and 1.5) at different heights with chevron pattern are investigated and suggested that Geocell with aspect ratio 1.5 and 1/3H is effective in increasing the CBR value. CBR test is performed by data acquisition method which directly gives the load at deformation 2.5mm and 5mm. Furthur the optimum CBR specimens of geocell, geo grid and geotextile are subjected to cyclic load test to find out the resilient modulus.

Keywords: CBR, Geocells, Geogrid, Geotextiles, Cyclic load test, Black cotton soil

Introduction: In construction of various structures, there are various kinds of soils used; however, some soil deposits in natural form are effective for construction, whereas other soils are not effective in using in construction without treatment such as problematic soils. These soils need to be excavated and then replaced, or their properties should be modified before they are subjected to applied loads by the upper structures. Typical of problematic soils are the expansive soils. This type of soils are very easily subjected to damages due to its high susceptibility to volume change, sensitive to moisture content. Due to increase in the cost of construction, Engineers often prefer modifying the properties of fine grained soils in situ via by reinforcing the soil by geosynthetics or stabilization of expansive soils. Generally, the typical expansive soils can be easily identified from their high plasticity, heave and the high swell- shrink potential which are made of clay, shale or marl. A well-known Expansive soil with very high volume change is Black Cotton Soil (BCS) Nature of BCS is due to the presence of Montmorillite group, which dominates its clay fraction.

Because all these problems, load bearing and load spreading property of expansive soil reduces. In order to overcome these issues, Geotechnical engineers are persistently searching for various option to mitigate its objectionable characteristics.

Data and Methods:

Soil Analysis:

Visual condition survey of site from where soil was brought was conducted. Site consists of expansive soil especially Black cotton soil. Laboratory tests including the Hydrometer test, standard Proctor test, sieve Test and atterbergs Limits performed for soil samples brought from the soil. Soil was classified as per the IS classification of soil depending upon the Liquid Limit(LL), Plastic Limit(PL). Hydrometer Analysis is used to determine particles distribution size ranging from 0.075mm to 0.01 mm. It depends upon the Stokes Law. It consists of Long Neck Marked from Top to Bottom. . According to IS: 2720(Part 4) -1985, the soil passing through 75μ is taken and kept in an oven for 24 hours. Take about 50gms of soil in a conical jar and about 200 ml of water. Dispersing agents are prepared by mixing 4g of sodium hexameta-phosphate and 2g of sodium carbonate in 100ml of water and stir it thoroughly. After this transfer this dispersing agent and soil solution in one conical jar and made it to stir for 1 minute under mechanical stirrer. The total soil sample is then transferred to graduated cylinder and distilled water is added up to 1000 ml and again stir it for 1 min. Start the stop watch and the readings are recorded at 0.5, 1, 2, 4, 9, 30, 60, 120 and 1440 minutes. For each reading the hydrometer is inserted about 20 seconds before the reading and then taken out and kept in a cylinder. The values are computed using the Stokes law. A graph is plotted against percentage of finer and the particle size using the graph the amount of clay and silt are obtained.

California Bearing Ratio Test:

The California Bearing Ratio value was determined according to IS 2720-Part16 (2002).The mould containing the specimen is placed on the testing machine and the penetration plunger is brought in contact with the soil. The dial gauge and proving ring readings are set to zero. The load is applied such that penetration rate is 1.25mm/min.

The CBR values are determined corresponding to both 2.5 mm and 5.0 mm penetration, and the greater values is used for the design. Generally, the CBR for 2.5 mm penetration is high. However, if the CBR for 5.0 mm penetration is greater than that for 2.5 mm penetration, the test is repeated. The procedure followed here is according to IS code.

Resilient Modulus through Cyclic Test:

Resilient Modulus (MR) is an essential material property used to describe unbound asphalt materials. It is a proportion of material solidness and gives an intend to investigate firmness of materials under various conditions, for example, dampness, thickness and feeling of anxiety. It is additionally a required info parameter to robotic exact asphalt outline strategy. MR is commonly decided through research facility tests by estimating solidness of a barrel example subject to a cyclic pivot stack. Strong modulus is characterized as a proportion of connected pivot deviator stress and hub recoverable strain. By and large for unbound total base materials Resilient modulus fluctuate somewhere in the range of 15000 and 60000 psi.

Results:

Laboratory analysis of soil samples indicated that the Properties of Black cotton soils and CBR values of various Geosynthetics at different height are evaluated. Among that CBR value of Soil specimen with Geocell are effective compared with the Geogrid of Uniaxial, Biaxial and Triaxial and Geotextile. By observing the Values of CBR of various Geosynthetics at different Heights of 1/3H, 1/2H, 2/3H, and the effective Height among all the heights are 1/3H. Apart from the Geocell, all the types of geogrids are effective in increasing the CBR values from conventional CBR Value. Among the Uni, bi, tri axial geogrid, triaxial geogrid is very effective in increasing the CBR value.

Table 1 Physical Properties of Black Cotton soil

S.No	Soil Property	Limit
1	Specific Gravity	2.51
2	Sand Size (%)	28.39
3	Silt Size (%)	57.40
4	Clay Size (%)	14.37
5	Liquid Limit (%)	54
6	Plastic Limit (%)	44.40
7	Plasticity Index (%)	8.71
8	Soil Classification	MH or OH
9	Optimum Moisture Content (%)	12
10	Maximum Dry Density (kN/m^3)	19.21
11	California Bearing Ratio (%)	0.90
12	Gravel content (%)	0
13	Modulus of resilient(Mr)	67Mpa

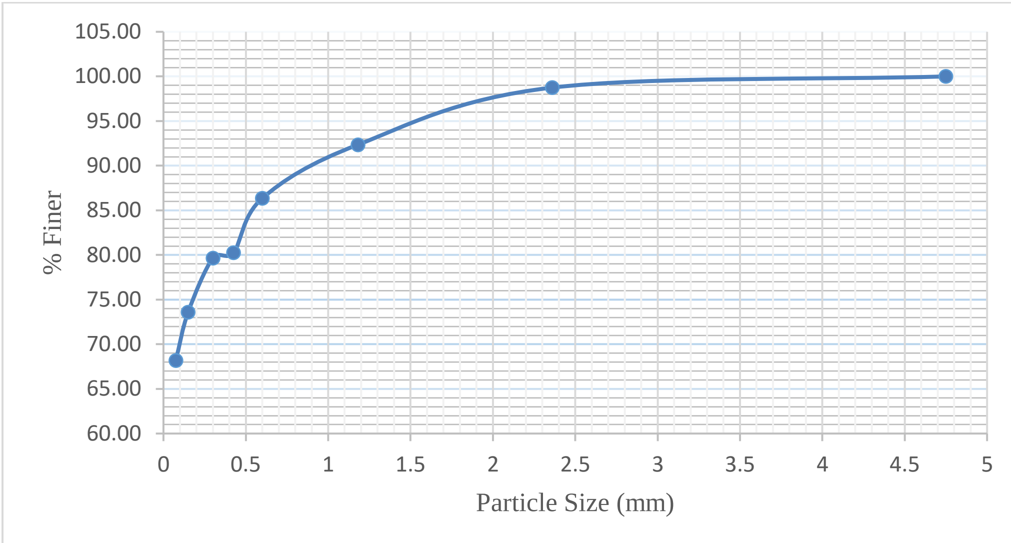

Fig 1 Grain size distribution curve

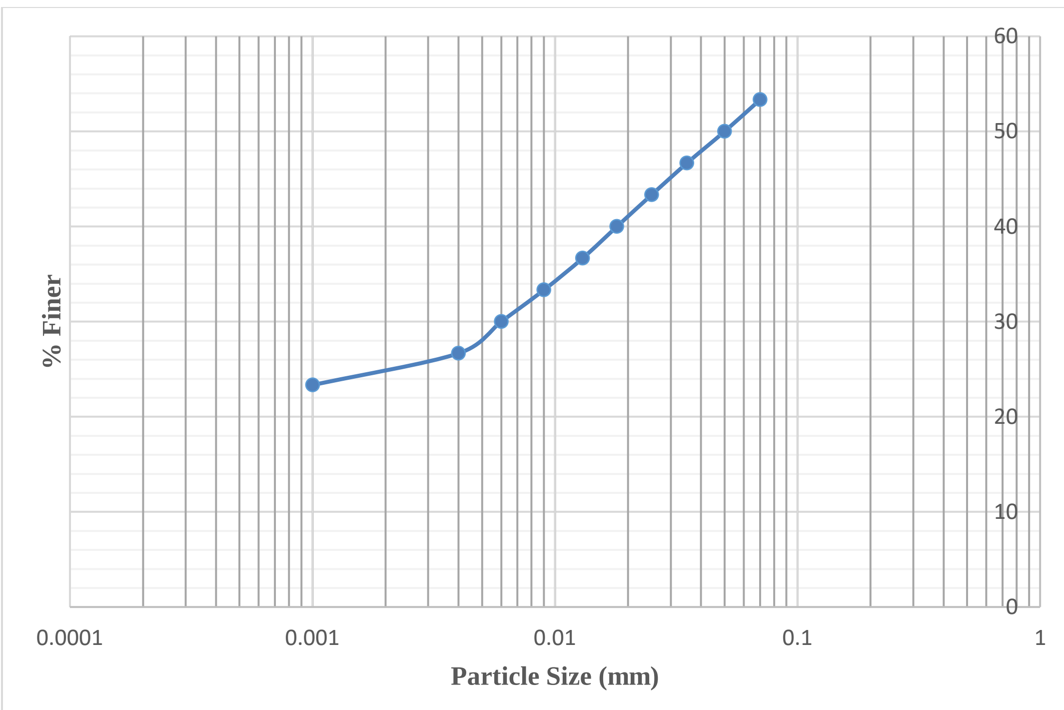

Fig 2 Hydrometer Analysis of soils

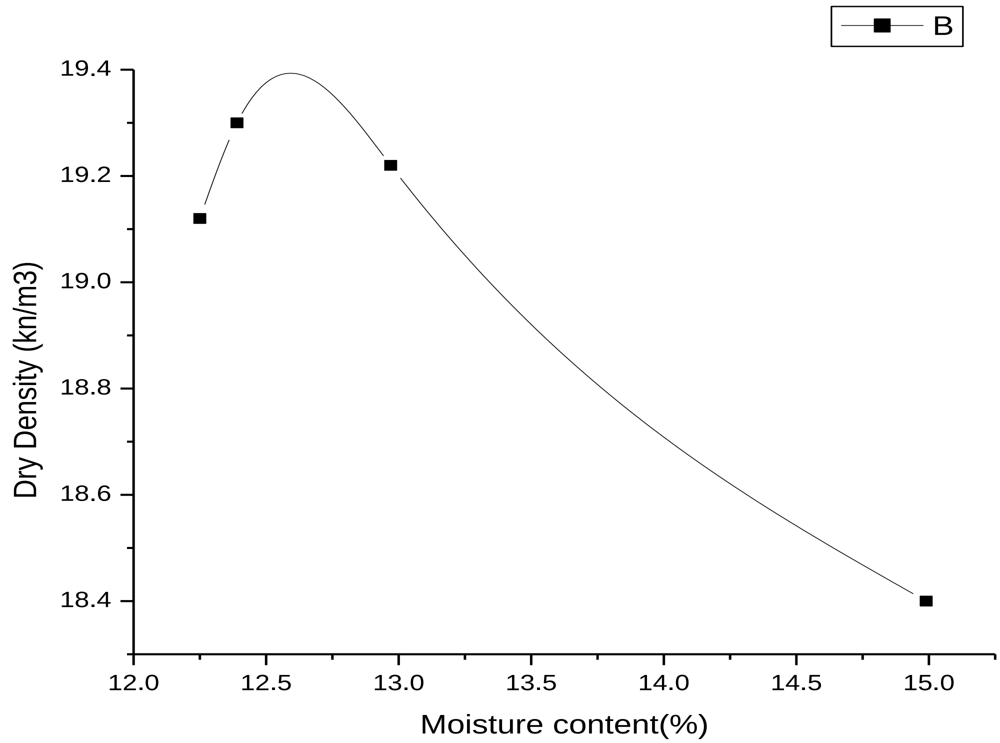

Fig 3 Compaction Curve of Black Cotton Soil

Fig 4 Geocell at 1/3H in Chevron pattern Fig 5 Vehicle tyre tube as Geocell

Table 2 CBR values of soil when Geocell is at different heights

Geocell Height / Aspect Ratio	1/3H	1/2H	2/3H
0.75	2.5	1.99	1.67
1	3.4	3.1	1.8
1.5	3.941	2.846	2.33

The strength properties performed in the study along with the geocell of aspect ratios (0.75, 1, and 1.5) at different height heights (1/3H, 2/3H, 1/2H) are performed. By observing the Values, CBR is highest at the 1/3H from the top of the mould. Higher the aspect ratio, higher will be the CBR value. Load v/s Penetration graph for different height at various aspect ratio are shown below:

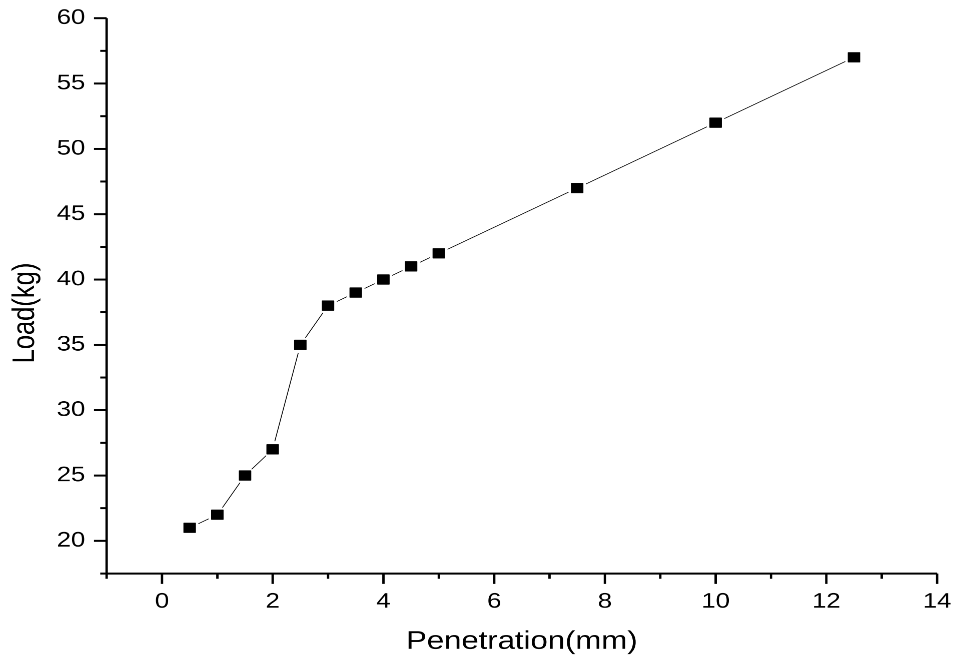

Fig 6 CBR when Geocell of Aspect Ratio 0.75 installed at 2/3H

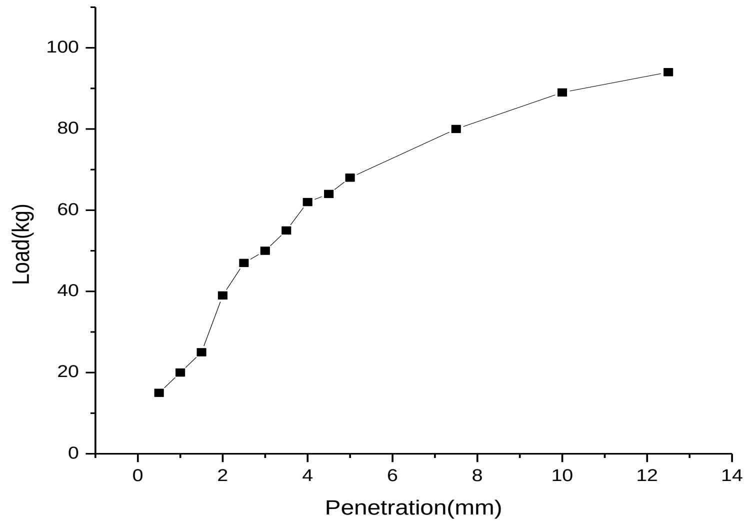

Fig 7 CBR when Geocell of Aspect Ratio 1 installed at 1/3H

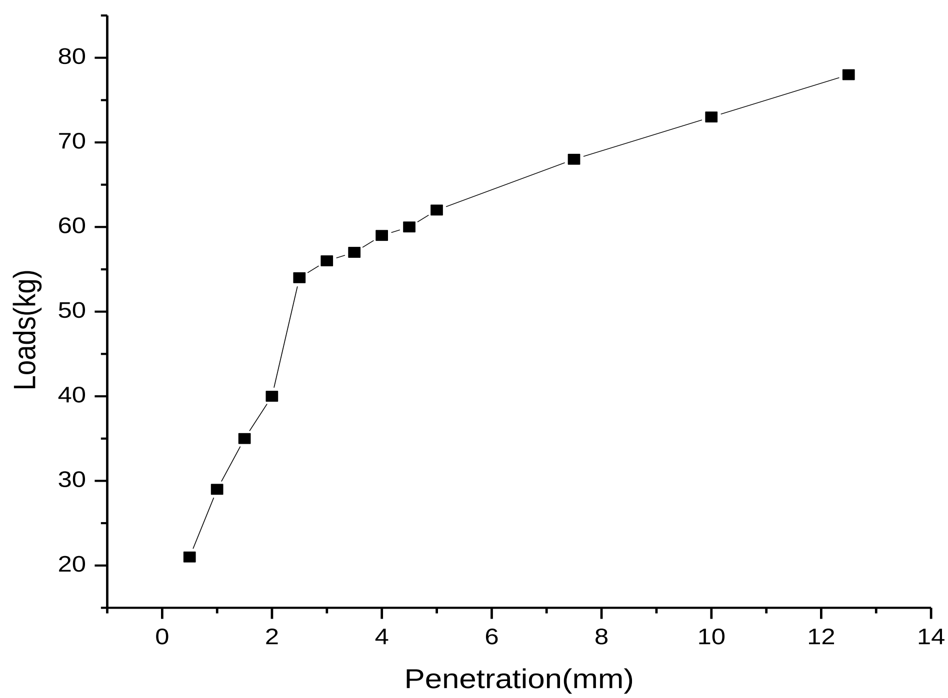

Fig 8 CBR when Geocell of aspect Ratio 1.5 installed at1/3H

The strength properties of Black cotton soil depends upon the aspect ratio in installation of Geocell. Following Graph showing the variation of CBR at 1/3H of different aspect ratio.

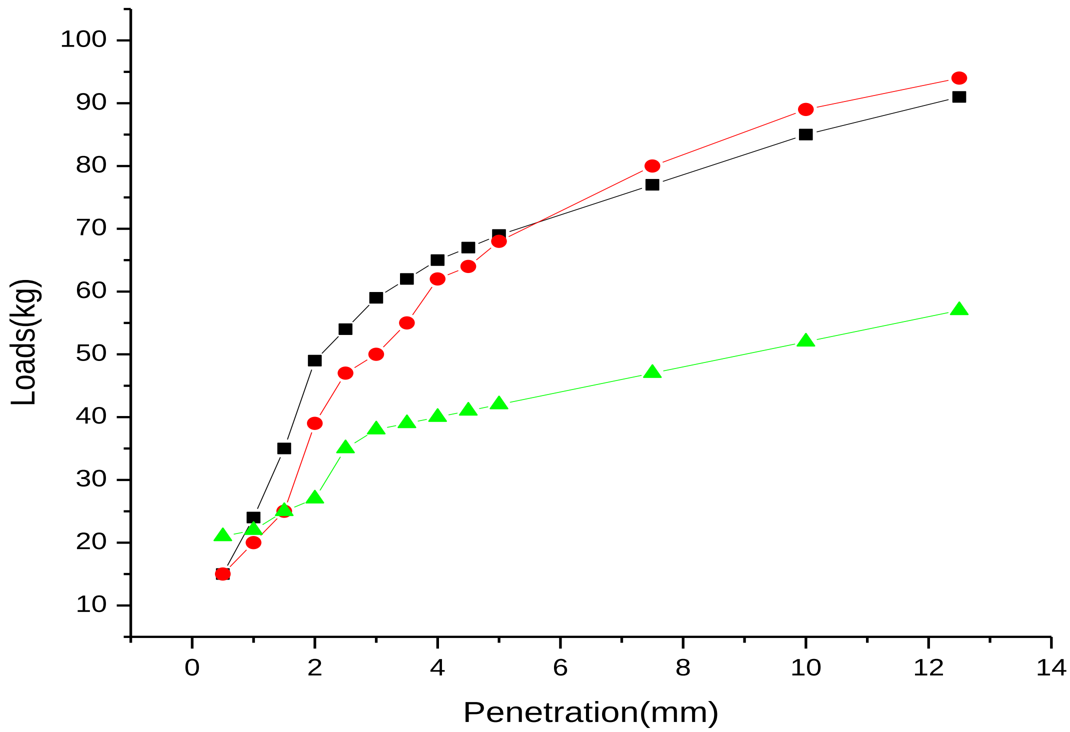

Fig 9 Variation in CBR corresponding to different aspect ratio (0.75, 1, 1.5)

Effect of Geogrid (Uni, Bi, Tri axial geogrid) on Black cotton soil strength properties

Geogrid mainly functions in transferring the loads to wider area especially in pavement construction. The strength properties performed in this study along with Geogrid of uniaxial, Biaxial, Triaxial geogrid at different height (1/3H, 1/2H, and 2/3H). The variation of strength properties using California Bearing Ratio (CBR) of original soil by installing different types of geogrid at different heights and cured for 4 days i.e., 96 hours.

Fig 10 Triaxial geogrid at 1/3H after CBR test

Table 3 CBR values of original soil when Geotextile at different heights

Height / Type of geogrid	1/3H	1/2H	2/3H
Uniaxial	1.95%	1.753%	1.319%
Biaxial	2.75%	2.485%	2.3%
Triaxial	3.654%	3.369%	2.69%

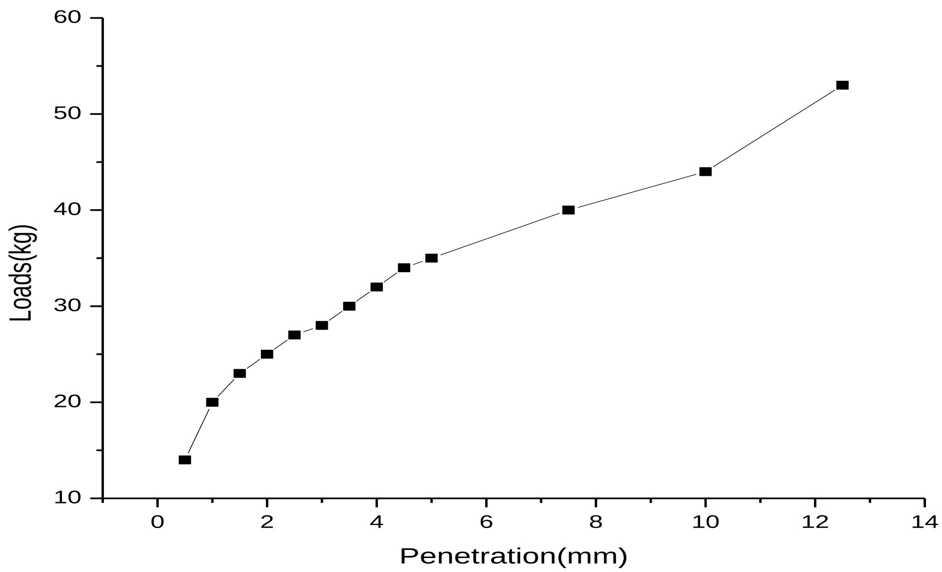

Fig 11 CBR when Uniaxial Geogrid installed at 1/3H

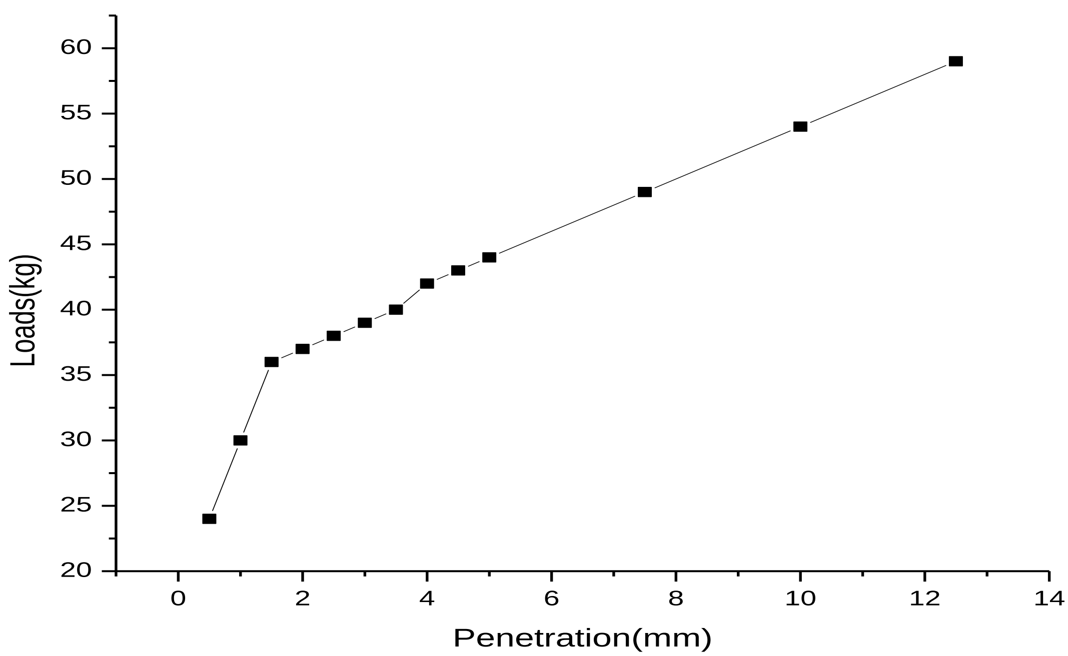

Fig 12 CBR when biaxial geogrid installed at 1/3H

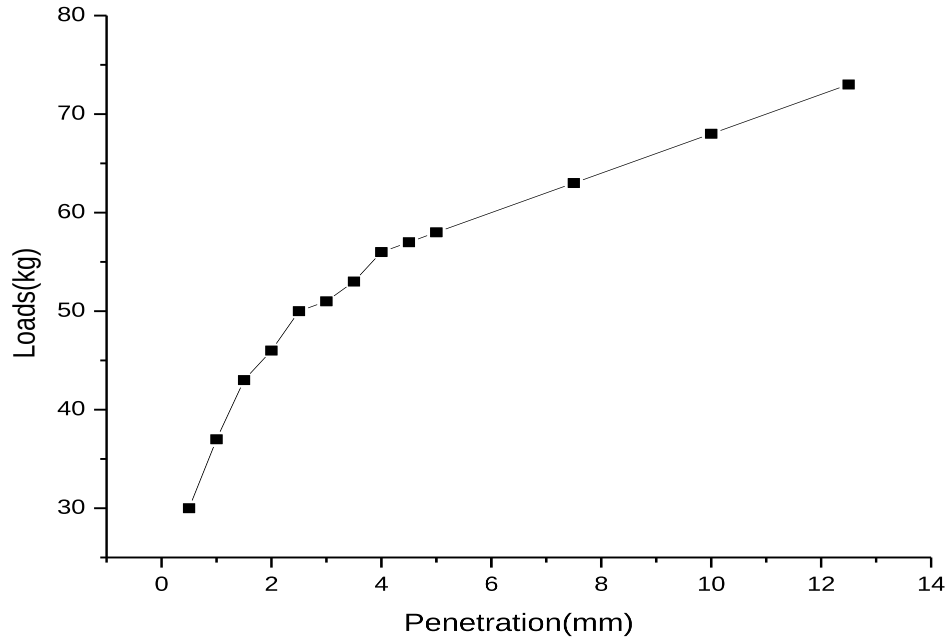

Fig 13 CBR when Triaxial Geogrid installed at 1/3H

The strength properties of Black cotton soil depend upon the type of geogrid installing at 1/3H height. Following Graph showing the variation of CBR at 1/3H of different Geogrid.

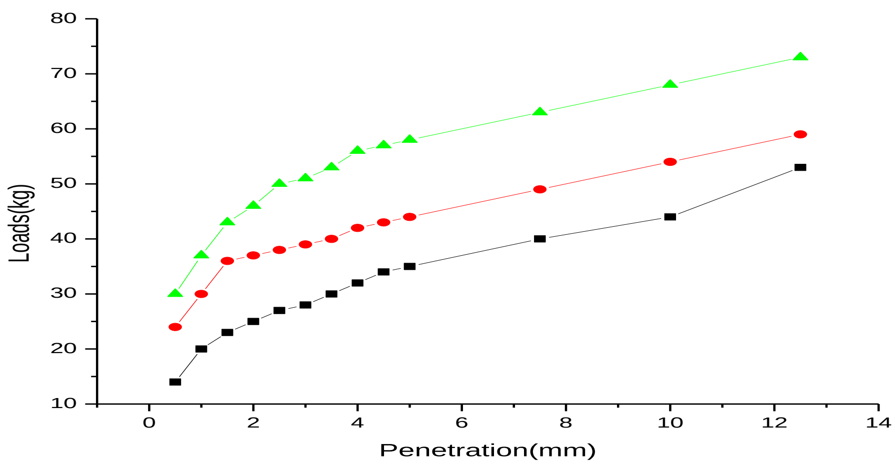

Fig 14 variation of CBR corresponding to Uniaxial, Biaxial and Triaxial Geogrid at Effective height 1/3H

Effect of Geotextile on Black cotton soil strength properties

The strength properties performed in this along with the geotextile at different heights (1/3H, 1/2H, 2/3H). The variation of strength properties using the California Bearing Ratio (CBR) of original soil by installing the Geotextile at different heights and cured for 4 days i.e., 96hours

Table 4 CBR value of original soil when geotextile at different heights

Geotextile	1/3H	1/2H	2/3H
	2.99%	1.45%	2.11%

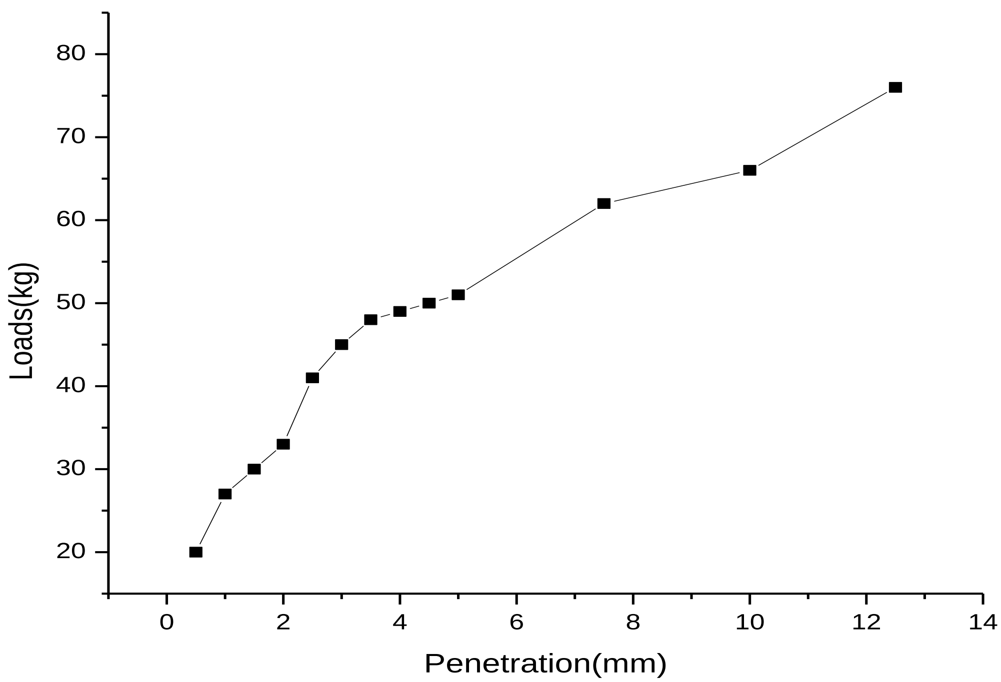

Fig 15 CBR when geotextile installed at 1/3H

Cyclic load Test:

Cyclic Load test is conducted on soil to evaluate the Resilient modulus value of subgrade. It is an important mechanical property which is widely applied in the analysis and design of pavements. Moreover the calculation of the resilient modulus of pavement material is of vital importance for any mechanistically based design/analysis procedure for pavements. In this study cyclic Load test is conducted on the soils installed with geocell of aspect ratio 1.5, triaxial geogrid, Geotextile at 1/3H. These soil samples are subjected to cyclic load test to determine the Resilient modulus of soil**.**

Table 5 Resilient Modulus Values of Geocell, Geogrid and Geotextile

Geosynthetics	Resilient Modulus Value
Geocell of aspect ratio 1.5	26.91
Triaxial geogrid	32.841
Geotextile	35.469

Effect of Resilient Modulus of Black cotton soil when Geocell of aspect ratio 1.5 at height 1/3H

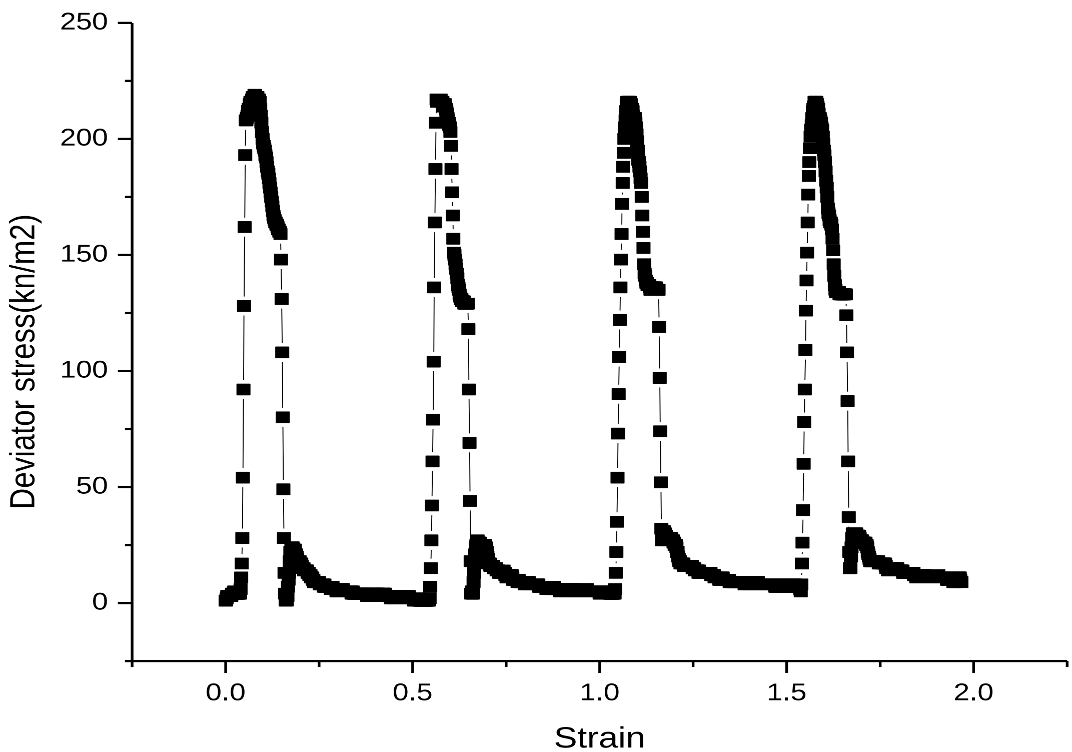

Fig 16 Resilient Modulus when geocell of 1.5 A.R installed at 1/3H

Effect of Resilient Modulus of Black cotton soil when Triaxial Geogrid at height 1/3H

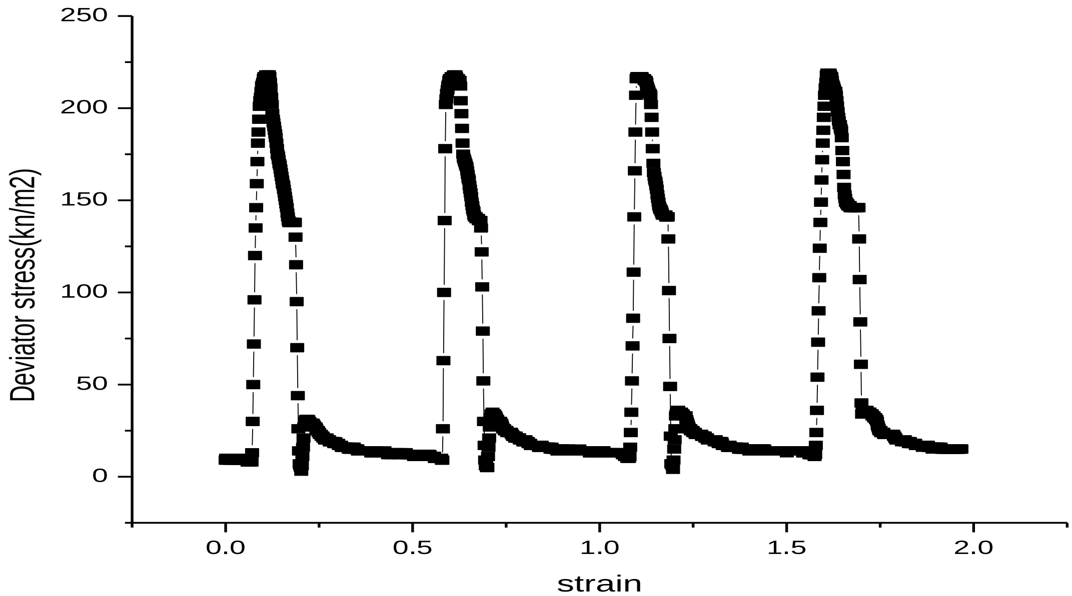

Fig 17 Resilient Modulus when Triaxial Geogrid installed at 1/3H

Effect of Resilient Modulus of Black cotton soil when Geotextile at height 1/3H

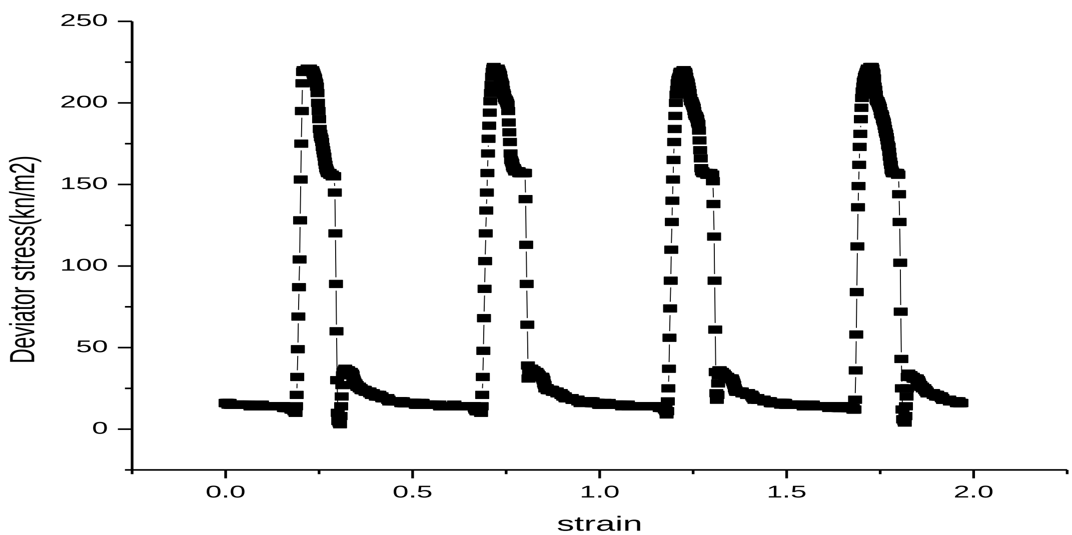

Fig 18 Resilient Modulus when geotextile installed at 1/3H

Discussion and conclusion:

An attempt is made to investigate the index and engineering properties such as Consistency limits, compaction curve, Hydrometer analysis, California Bearing Ratio test of conventional soil and soil reinforced with the Geosynthetics (Geocells, Geogrids, Geotextiles). It has been concluded that there is an increase of all engineering properties of Geosynthetics treated soil.

- Increase in the CBR value by installing the geosynthetics at different heights (1/3H, 1/2H, 2/3H) compared with conventional CBR value of soil.
- The California Bearing Ratio of Geosynthetics Reinforced soil is more effective at the 1/3H from the Top compared with the remaining Heights (1/2H, 2/3H).
- Instaling the Geocell manufactured from vehicle Tyre tube in Chevron pattern compared with the square and other has an effective results.
- California Bearing Ratio values increase with increase in the height of installation of Geosynthetics from bottom to top of CBR mould (2/3H, 1/2H, and 1/3H).
- Effective height in achieving the highest CBR value is 1/3H.
- Soils reinforced with Geocells, Geogrids,Geotextile, the CBR value is more for soiul reinforced with Geocell of aspect ratio 1.5 at 1/3H compared with the Geogrid and Geotextile.
- Among the Various Aspect Ratio of Geocell (0.75, 1, 1.5), Geocell of Aspect 1.5 at 1/3H is very much effective in increasing the CBR values compared with the remaining. By this we can concluded that higher the aspect ratio higher will be the CBR value.
- Various Geogrids (Uniaxial, Biaxial, Triaxial), Triaxial Geogrid is very effective in increasing the CBR values compared with the others.
- Geotextile at 1/3H is very effective in increasing the CBR value.
- Based on the above results, it has been concluded that 1/3H is very effective height to increase the strength values due to presence of pressure bulb at that height.
- Cyclic Load Test are conducted highest CBR values of Geocell of Aspect ratio 1.5, Triaxial Geogrid, Geotextile at 1/3H

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