

# **Efficacy of Geosynthetics in Subgrade Stabilization-A Comparative Study in Laterite Soil**

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**ABSTRACT:** The increase in urbanization has led to scarcity of lands. As a result roads and buildings have to be constructed over soils with low bearing capacity. The performance of a road depends on the property of subgrade. This paper thus focuses on the effect of stabilizing locally available soil with various types of geosynthetics. The geosynthetics used here are Geotextiles and Geogrid. CBR tests were conducted on soil compacted to optimum moisture content and maximum dry density. The variations of CBR value on the same soil reinforced with each type of geosynthetics were analyzed. Thus the most efficient geosynthetic for the subgrade stabilization considering both performance and economy could be suggested through this project

**KEYWORDS:** California Bearing Ratio (CBR); Optimum Moisture Content (OMC); Maximum Dry Density(MDD); Geotextile; Geogrid

## **I. INTRODUCTION**

Roads are the vital lifelines of the economy making possible trade and commerce. They are the most preferred modes of transportation and considered as one of the cost effective modes. An efficient and well-established network of roads is desired for promoting trade and commerce in any country and also fulfills the needs of a sound transportation system for sustained economic development. To provide mobility and accessibility, all weather roads should connect every nook and corner of the country. To sustain both static and dynamic load, the pavement should be designed and constructed with utmost care. The performance of the pavement depends on the quality of materials used in road construction.

Subgrade is the in situ material upon which the pavement structure is placed. Although there is a tendency to look at pavement performance in terms of pavement structures and mix design alone, the subgrade soils can often be the overriding factor in pavement performance. The construction cost of the pavements will be considerably decreased if locally available low cost materials are used for construction of lower layer of pavements such as subgrade, sub base etc. If the stability of local soils is not adequate for supporting the loads, suitable methods to enhance the properties of soil need to be adopted. Soil stabilization is one such method. Soil stabilization can be done with many materials out of which geosynthetics are of great significance in terms of performance as well as economy.

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## II. LITERATURE REVIEW

Zornberg et al (2010) found that geosynthetics can provide a reinforcement function in paved and unpaved roads to improve the subgrade bearing capacity or reduce the base/sub-base thickness of the new pavement. To improve the subgrade bearing capacity, the geosynthetic reinforcement is placed at the interface between the sub-base and subgrade layer of the paved road and at the base/subgrade interface for unpaved roads. The stresses imposed on the subgrade are higher in unreinforced pavements than in geosynthetic-reinforced pavement.

Imad et al (2012) showed that geogrid to be effective in reducing granular material shear deformation, especially in the traffic direction and in thin pavements. They also concluded that for thick-base layers, a single geogrid layer installed in the upper one-third of the layer would improve the pavement performance.

Nithin et al (2012) found the critical behavioral changes acquired by using the coir geotextile as reinforcing agent and their potential to provide an excellent and economical medium for stabilizing subgrade for rural roads. They found that coir geotextile – reinforced soils perform better than unreinforced ones. It also helps to reduce the permanent deformation of the subgrade compared to unreinforced one. The soil samples with a geotextile of higher tensile strength exhibits higher load carrying capacity and there is less deformation compared to those with lower tensile strength values. Of the six varieties of reinforcement used, CSB-400450 (Coir Stitched Blanket) is found to be the best choice of reinforcement.

Singh et al (2013) showed that the CBR value of soil increases with the inclusion of Jute fibre. When the Jute fibre content is increases, the CBR value of soil was increased. They also found that preparation of identical soil samples for CBR test beyond 1 % of fibre content is not possible and optimum fibre content was found to be 1 % by dry weight of soil. The CBR value of soil increases with the increase in length and diameter of fibre. The maximum increase in CBR value was found to be more increased by 24% over that of plain soil at fibre content of 1 % for fibre having diameter 2 mm and length 90 mm.

R. H. Jadvani, K. S. Gandhi(2013) found that use of geotextiles have been found very effective solution in various geotechnical problem like foundation on soft soils, land slide control, pavement sub grade stabilization in road and railway construction, reinforced embankments over soft soils, erosion control etc.

Charles et al. (2014) showed that interfacing soil with a geogrid material increases the penetration resistance and hence the CBR strength is increased by 73% in unsoaked conditions. Thus the performance of a subgrade material in a pavement system is better with the inclusion of a geogrid. The addition of a single layer of Triaxial 130s and Triaxial 170 geogrid at the top of the third layer in a sandy silt soil increases the CBR value of the sample for soaked and unsoaked Placing one layer of geogrid at top of layer 3 has more effective performance in penetration resistance in unsoaked condition than soaked conditions for both geogrids.

Olaniyan et al (2014) showed an increase in the strength of subgrade by introducing geogrids reinforcement in the soil. They concluded that geogrids placed at 3/5 the distance from the base showed higher CBR value(increased by 103%) than when placed at 2/5 and 4/5 distances from the base. Subaida et al (2014) conducted an experimental study to investigate the beneficial use of woven coir geotextiles as reinforcing material in the pavement section. They found that the inclusion of coir geotextiles enhanced the bearing capacity of thin sections. Placement of geotextile at the interface of the subgrade and base course increased the load carrying capacity. The plastic surface deformation under repeated loading was also reduced within the base course irrespective of base course thickness. The optimum placement position of coir geotextile was found to be within the base course at a depth of one- third of the plate diameter below the surface. The increase in ultimate bearing capacity and bearing capacity at any settlement were

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obtained when coir geotextile was placed at mid depth of the subgrade. Coir geotextile placed at the base/ subgrade interface enhanced subgrade confinement and reduced heaving.

Neetu B. Ramteke, AnilkumarSaxena, T. R.Arora (2014) observed that geogrids provide improved aggregate interlock in stabilizing road infrastructure through sub-grade restraint and base reinforcement applications. When single layer of geogrids was placed at the depth of (25, 50, 100mm) from the top of the mould, the maximum California Bearing Ratio (CBR) obtained was at 25mm and when the geogrids was placed in two layers at { (25 &75 mm),(50 &75 mm), (50 &100 mm)} CBR was increased and it was maximum at 25 & 75mm geogrid layer by 38.21% when compared with that of unreinforced soil. Aginam, C.H. et.al. (2014) carried out several investigations to determine the geotechnical properties of lateritic soils used for road construction. It is observed that samples having CBR values greater than 30% is found to be suitable as sub-base material. But the laterite soil sample cannot be used as base course material since the CBR value is not greater than 80%.

Chetanet.al. (2015) found the strength aspects of woven coir geotextiles on weak subgrade. Under static plate load tests the inclusion of H2M5 (Handloom Mattings) coir geotextile gives higher strength at lower deformation compared to unreinforced section. They showed that there is significant reduction in the settlement and the compressive strains in the pavement, as the soil is reinforced with the coir geotextile since the coir acts like a membrane, tension member which provides the necessary reaction to the applied load. H2M5 coir geotextile is more effective in reducing settlement and strains than H2M6 coir geotextile, because of more stiffness. Reinforced pavement section with coir geotextile reduces the tensile strain in pavement. Coir geotextile has good frictional capabilities and provide tensile resistance to lateral soil movement.

Abhijith (2015) showed that the CBR strength using coir fibre was improved and optimum fibre length obtained was 1.5cm and optimum fiber content was 5% of total weight of soil. He also concluded that placing geotextiles (CCM-400) (Coir Stitched Blanket) at two third depth from bottom position was seems to be more effective.

Dr. Anil Kumar Choudhary, (2015) found that the CBR characteristics of geogrid reinforced red mud depends on the embedment depth of reinforcement. Insertion of geogrid increases the stiffness of red mud. At optimum embedment depth of geogrid total pavement thickness obtained is minimum so it is more economical.

R. Vijay Kumar, P. LavanyaRekha (2016) found that the performance of the subgrade soil can be improved using geogrid reinforcement. The highest CBR achieved for optimum placement and amount of geogrid reinforcement provided for the subgrade soil improved by about 2.4 times the unreinforced. The strength of soil increased and the CBR values of the reinforced increased by 2.4 times when compared to unreinforced and reinforced.

Charles A. Adams, et.al (2016) found the CBR of the reinforced soil increased for all geogrid placement locations. Two-layer geogrid reinforcement only marginally improved strength over single layer reinforcement placed close to mid-depth (from the top) of the compacted sample. This seems to suggest that single-layer geogrid reinforcement may suffice in some situations provided the placement depth is appropriate.

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### III. MATERIALS COLLECTED

#### A. Laterite Soil

The laterite soil is collected from borrow pits at a depth of 2m from Puthencruz, Ernakulam. Various tests were conducted to determine the properties of the soil. The results are as follows:

TABLE I. PROPERTIES OF LATERITE SOIL

Sl. No	Property	Test	Value	Remarks
1	Specific gravity	Pyconometer	2.65	Range:2.6-2.8
2	Compaction	Modified proctor test	OMC-25% Max. dry density:1.56x10 <sup>3</sup> kg/m <sup>3</sup>	-
3	Permeability	Constant head permeability test	K=0.105mm/s	Coarse & medium sand
4	CBR	CBR Test	CBR <sub>2.5</sub> =7.13 CBR <sub>5</sub> =7.09	Medium
5	Particle size distribution	Sieve Analysis	D <sub>10</sub> :520microns; C <sub>u</sub> =8.26 C <sub>c</sub> =1.003; gravel=38.4% Coarse=22%; Medium sand=31% Fine sand=7%; Silt and clay=0.7%	Well graded

#### B. Geotextiles

Geotextiles for the project is collected from Charankattu Coir Manufacturers, Cherthala, Ernakulam.

Geotextile specification-H2M5

Weight (kg/m<sup>2</sup>) =0.740

Mesh opening size (mm) = 9 x 9

Tensile strength (kN/m) = 10.4

#### C. Geogrid

The geogrids for the project work was collected from Grogrid Ltd., Chennai.

Geogrid specification- Biaxial geogrid.

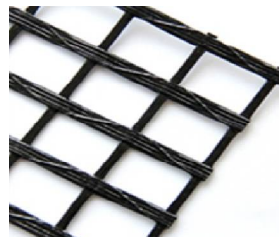
Raw Material - Polyester. Strength - 35 kN

Colour- Black

Mesh aperture – 25mm X 3 mm.



a.



(b)

Fig. 1. Geosynthetics (a) Woven Geotextile (b) Geogrid

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## IV. RESULTS AND DISCUSSIONS

### A. CBR Test on laterite soil reinforced with geotextiles

CBR Tests were conducted in laterite soil where the geotextiles were placed at three different heights of the specimen. The heights at which the test was conducted are H/2, H/3 and H/4 from the top of the mould (where H is the height of the specimen).

When geotextile was placed at H/2:

- CBR value for 2.5 mm penetration = 19.31%
- CBR value for 5 mm penetration = 18.91%.

When geotextile was placed at H/3:

- CBR value for 2.5 mm penetration = 19.7%.
- CBR value for 5 mm penetration = 19.18%.

When geotextile was placed at H/4:

- CBR value for 2.5 mm penetration=20.49%.
- CBR value for 5 mm penetration =19.97%.

TABLE II. LOAD-PENETRATION VALUES

Penetration (mm)	Load		
	H/2	H/3	H/4
0.5	48.6	59.4	86.4
1	102.6	118.8	156.6
2	205.2	221.4	313.2
2.5	263.4	270	380.8
3	306	302.4	384.2
4	351	348.6	427.2
5	388.8	394.2	470.4
7.5	466.2	475.2	550.2
10	520.8	550.8	616.6
12.5	571.5	615.6	699.4

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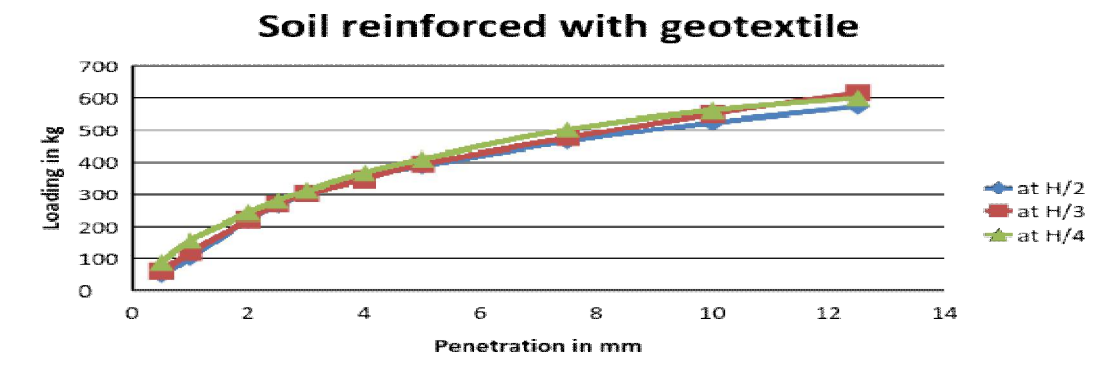


Fig. 2 Load-Penetration graph with geotextile at three depths

It is observed that when the geotextile was placed at H/2 depth from the top of the specimen, the CBR value for 2.5 mm penetration was found to be 19.31 % and the CBR value for 5 mm penetration was 18.91 %.this shows that there is an increase in the CBR value of the subgrade as compared to the CBR value of the unreinforced soil. Again when geotextile was placed at H/3 depth from the top of the specimen, the CBR value for 2.5 mm penetration was found to be 19.70% and the CBR value for 5 mm penetration was 19.18 %.this shows that the CBR value of the soil enhanced with change in depth.When geotextile was placed at H/4 depth from the top of the specimen, the CBR value for 2.5 mm penetration was found to be 20.49 % and the CBR value for 5 mm penetration was 19.97 %. So the maximum value of CBR is obtained when the woven geotextile was placed at a depth of H/4 from top of the specimen. Hence it is considered to be the optimum height in this case.

**Result:**

The load-penetration curve was plotted for all the 3 heights. It is observed that the maximum CBR value is observed when the geotextile was placed at one- fourth of the height of the specimen.

**B. CBR test on Laterite Soil Reinforced with Geogrid**

CBR Tests were conducted in laterite soil where the geogrids were placed at three different heights of the specimen. The heights at which the test was conducted are 2H/5, 3H/5 and 4H/5 from the bottom of the mould (where H is the height of the specimen).

TABLE III. LOAD PENETRATION VALUES

Penetration (mm)	Loading (kg)		
	3H/ 5	2H/5	4 H/5
0.5	54	118.8	43.2
1	135.06	189	86.4
2	286.2	297	183.6
2.5	351	345.6	220.8
3	388.8	388.8	259.2

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4	469.8	459	307.8
5	523.8	513	345.6
7.5	642.6	653.4	448.2
10	745.2	739.8	523.8
12.5	837	820.8	599.4

When geogrid was placed at 3H/5:

- CBR value for 2.5 mm penetration = 25.22%
- CBR value for 5 mm penetration = 24.96%.

When geogrid was placed at 2H/5:

- CBR value for 2.5 mm penetration = 25.62%.
- CBR value for 5 mm penetration = 24.88%.

When geogrid was placed at 4H/5:

- CBR value for 2.5 mm penetration=16.55%.
- CBR value for 5 mm penetration =16.81%.

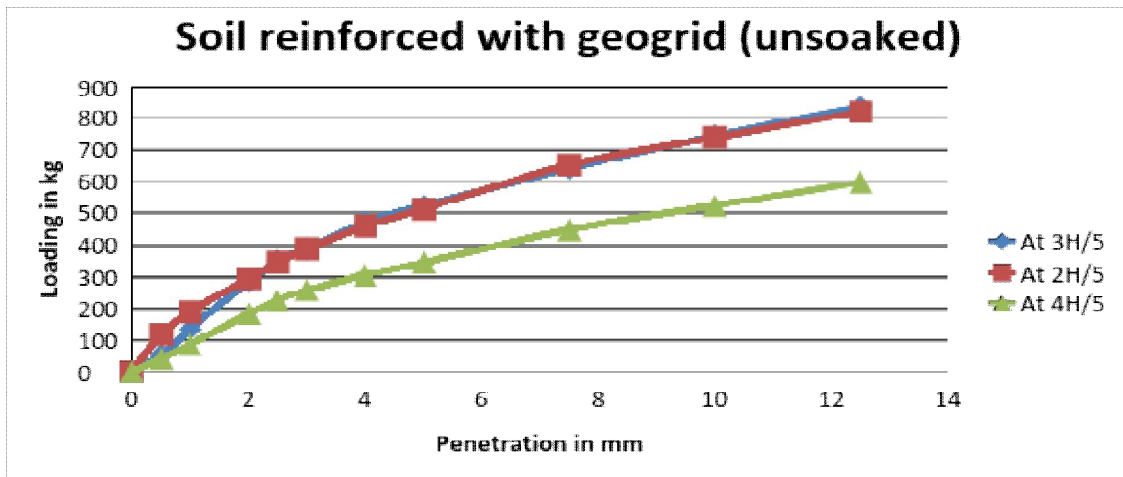


Fig. 3 Load-penetration curve of soil with geogrid

It is observed that when the geogrid was placed at 2H/5 depth from the top of the specimen, the CBR value for 2.5 mm penetration was found to be 25.22 % and the CBR value for 5 mm penetration was 24.96 %.this shows that there is an increase in the CBR value of the subgrade as compared to the CBR value of the unreinforced soil. Again when the geogrid was placed at 3H/5 depth from the top of the specimen, the CBR value for 2.5 mm penetration was found to be 25.62% and the CBR value for 5 mm penetration was 25.48 %.this shows that the CBR value of the soil enhanced with change in depth.

When the geogrid was placed at 4H/5 depth from the top of the specimen, the CBR value for 2.5 mm penetration was found to be 16.55 % and the CBR value for 5 mm penetration was 16.81 %. So the maximum value of CBR is obtained when the geogrid was placed at a depth of 2H/5 from top of the specimen. Hence it is considered to be the optimum height in this case.

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## Result:

The load-penetration curve was plotted for all the 3 heights.

It is observed that the maximum CBR value is observed when the geogrid was placed at one-fourth of the height of the specimen.

## V. CONCLUSIONS

It is seen that both the reinforcements have effectively led to the increase in strength of the soil. The CBR value of the unreinforced laterite soil was obtained as 7.3% after reinforcing it with geotextile it was obtained as 20.49% and reinforcing it with geogrid it was obtained as 25.62%. The CBR tests were conducted by placing the geosynthetics at different heights of the specimen and it was found that in case of geotextile, the optimum height of placement was found to be at H/4 from top of the specimen and in case of geogrids the optimum height of placement was found to be at 3H/5 from bottom of the specimen. Hence it is concluded that the maximum strength of the soil was obtained when the geogrid was placed at a height of 3H/5 from the bottom of the specimen

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