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INVESTIGATION AND EVALUATION OF BEHAVIOUR OF GEOGRID REINFORCED SOIL USING EXPERIMENTAL ANALYSIS

[1]Adnan Zafar, [2]Shivam Singh Patel
M.Tech Student (Highway Engineering), Assistant Professor Department of Civil Engineering
Maharishi University, Lucknow, India

Abstracts: Geogrids are commonly used to reinforce retaining walls, as well as subbases or subsoils below roads or structures. Soils pull apart under tension. Compared to soil, geogrids are strong in tension. Geosynthetic-reinforced soil technique has been increasingly used in civil engineering practice over the last two decades. This paper presents the results of a series of experimental investigation supported by numerical analysis to examine the behavior of geogrid reinforcing element under different conditions. The test results demonstrated the potential benefit of using geosynthetic- reinforced soil in pavements. The purpose of the study is to numerically simulate the response of geosynthetic reinforcement to CBR results.

Keywords: **Geogrid, subbase, CBR results, Geosythetic**

I. Introduction

One of the major problems faced by the engineers in highway construction in plains and coastal areas of India is the presence of soft/ loose soil at ground level. Roads constructed over this loose soil demands higher thickness of granular materials resulting in the high cost of construction. Alternately, attempts of reducing the thickness of pavement layer to make an economic construction will lead to early damage to the pavement, which in turn will make the road unserviceable within a short period after construction.Thisconditionmaybefurtherworseifsupplementedwithpoordrainage or lack of it. Some states of India is situated in a region of high rainfall area suffers from poor drainage as well as weak subgrade condition. This is one of the major causes of deplorable road condition in thosestates.

Looking at the poor road condition of some states of India use of geogridis thought for road construction to improve the performance of roads. Geogrid a geosynthetic manufactured from polymers are selected for this purpose.

Geogrids used within a pavement system perform two of the primary functions of Geosynthetics: separation and reinforcements. Due to the large aperture size associated with most commercial geogrid products, geogridsare typically not used for achieving separation of dissimilar material. The ability of a geogrid to separate two materials is a function of the gradations of the two materials and is generally outside the specifications for typical pavement materials. However, geogrids can theoretically provide some measure of separation, albeit limited. For this reason, separation is a secondary function of geogrids used in pavements. The primary function of geogrids used pavements in reinforcement, in which the geogrid mechanically improves the engineering properties of the pavement system.

II. General Applications of Geosynthetics

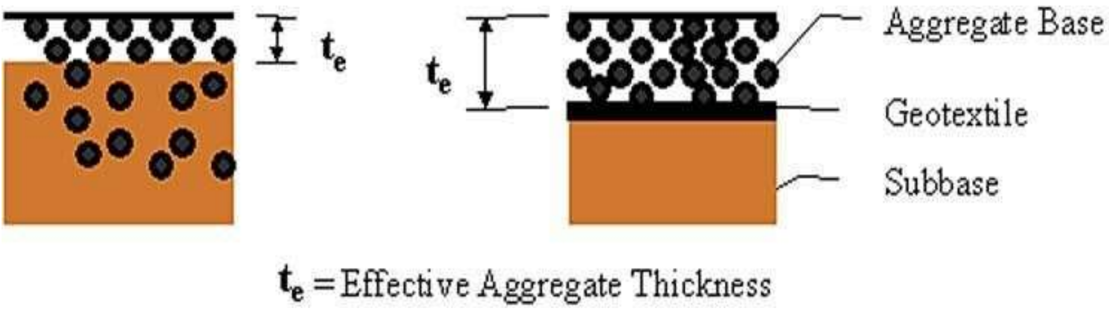
Four of the most common general uses of geosynthetics for local agencies are:

A. Separation

One of the most common uses of geosynthetics is to use a geotextile to provide separation of two layers with different soil properties. Separation is the placement of a flexible geosynthetic material, like a porous geotextile, between dissimilar materials so that the integrity and functioning of both the materials can remain undisturbed or even improved. Using a road as an example, the separator will prevent the aggregate base course from sinking into weaker subgrade material (aggregate loss) and preventing fine material in the subgrade from pumping up into the aggregate base course (pumping). If aggregate loss or pumping occurs, the strength of the pavement can be drastically reduced as shown in Plate 1 below which shows the reduced “effective” thickness of the aggregate base course.

Fig 1 - Geosynthetic Separator preventing Aggregate Loss

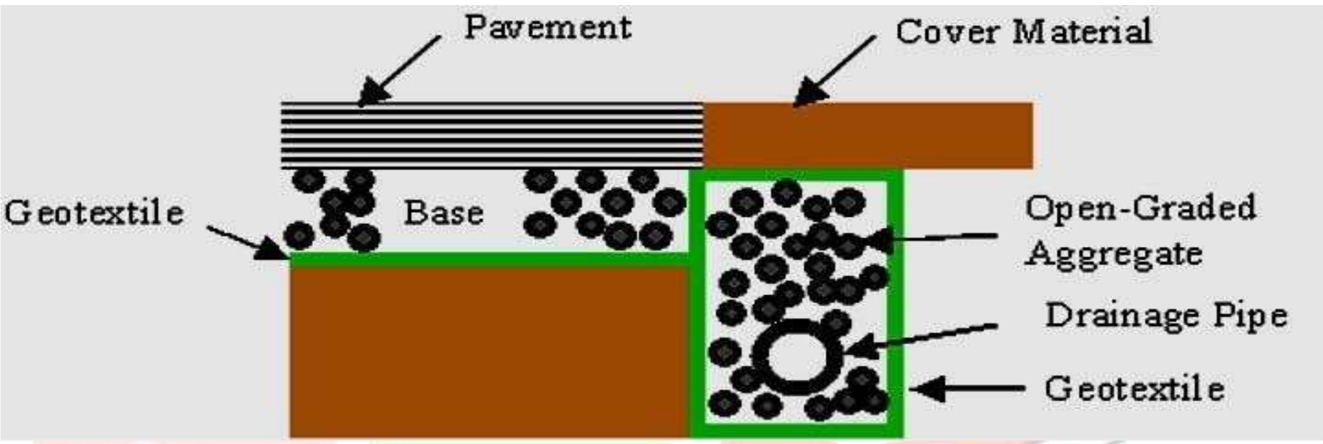
a) Aggregate Loss due to lack of separation b) Separator prevents Aggregate Loss



B. Filtration

In this type of application, the geosynthetic acts as a filter by preventing material from washing out while allowing the water to flow through. The most common uses of this application are geotextiles which wrap around an edge drain, geotextiles placed under erosion control devices, and geotextiles used behind structures such as retaining walls.

Fig-2 Edge Drain wrapped with Geotextile



C. Drainage

Although filtering applications are commonly refers to as drainage applications, they are different. Drainage applications refer to situations where the water flows within the plane of the geosynthetic product (in-plane drainage). In filtration applications, the water flows across the plane of the material.Although certain types of geotextiles provide some in-plane drainage, most drainage situations require a geo-composite drainage product such as prefabricated sheet drains that provide a much greater drainage capacity.

D. Reinforcement

In this application, the structural stability of the soil is greatly improved by the tensile strength of the geosynthetic material. This concept is similar to that of reinforcing concrete with steel. Since concrete is weak in tension, reinforcing steel is used to strengthen it. Geosynthetic materials function in a similar manner as the reinforcing steel by providing tensile strength that helps to hold the soil in place. Reinforcement provided by geotextiles or geogrids allows embankments and roads to be built over very weak soils and allows for steeper embankments to be built.

Fig:3 Soil Reinforcement of an Embankment using a Geosynthetic

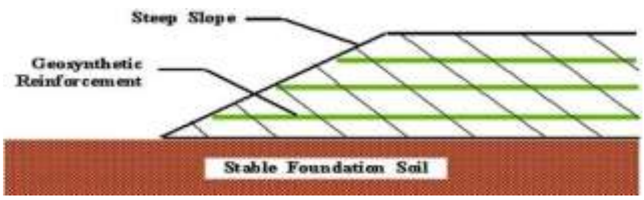
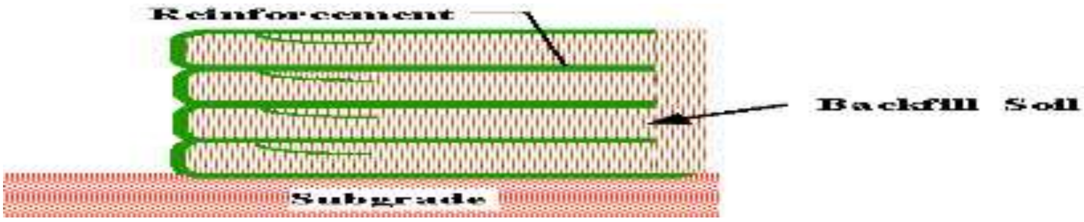


Fig:4 Earth Reinforced Retaining Wall using a Geosynthetic (Kercher et.al)



E. Barrier (Containment or Sealing)

The barrier or containment function involves the use of an impervious geosyntheticfor situations where structures require a waterproofing membrane, or to function as a no- leak ground lining for liquid and solid waste disposal sites and the top capping seal. This function is best performed by a geomembrane. A non-woven geotextile performs this function when impregnated with asphalt or other polymeric mixes rendering it relatively impermeable to both cross-plane and in-plane flow. The classic application of geotextile as a liquid barrier is paved road rehabilitation. Here, the nonwoven geotextile is placed on the existing pavement surface following the application of an asphalt tack cloth. The geotextile absorbs asphalt to become a waterproofing membrane minimizing the vertical flow of water into the pavement structures. Other appropriate geosynthetics are geosynthetic clay liners and certain geocomposites.

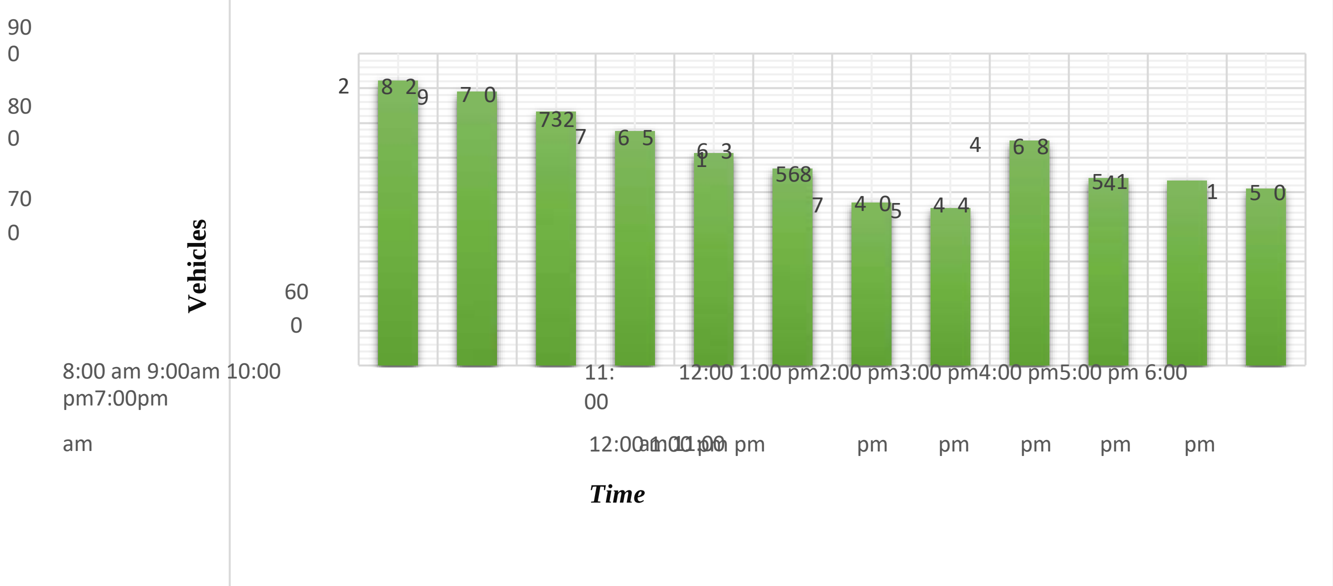
III. Experimental Programme

A. Traffic DataCollection

Table-1 Traffic Data Observables

Sl. NO	Timings:	H CV	M CV	L C V	TWO WHEELERS	CYCLES	Total
1	8:00 am - 9:00 am	76	11	212	518	5	822
2	9:00 am - 10:00 am	56	15	176	542	1	790
3	10:00am- 11:00 am	41	15	183	492	1	732
4	11:00am-12:00 pm	45	10	160	459	1	675
5	12:00pm - 1:00 pm	37	8	151	414	3	613
6	1:00 pm - 2:00 pm	52	12	146	355	3	568
7	2:00 pm - 3:00 pm	43	16	116	291	4	470
8	3:00 pm - 4:00 pm	49	5	119	279	2	454
9	4:00 pm - 5:00 pm	51	12	177	407	1	648
10	5:00 pm - 6:00 pm	75	11	142	311	2	541
11	6:00 pm - 7:00 pm	56	23	124	330	0	533
12	7:00 pm - 8:00 pm	68	4	149	289	0	510
	Total	649	142	1855	4687	23	7356

Graph-1 Traffic Data



B. Tensile Test of Geogrid

Laboratory Testing: The supplied secugrid 40/40 Q1 was tested for its tensile strength as per ASTM D 6637-01.
Test Result: The test results are presented in table 2.

Table-2 Secugrid 40/40 Q1 Test Result

Sl. No	Specimen Number	Max. Tensile strength (KN/m)	Percent Elongation @ 40 (KN/m)
1	Specimen 1	41.86	7.86
2	Specimen 2	47.06	8.00
3	Specimen 3	40.02	7.93

C. Grain Size Distribution

Sample Weight:1000 Grams

Table-3 Grain Size Distribution Data

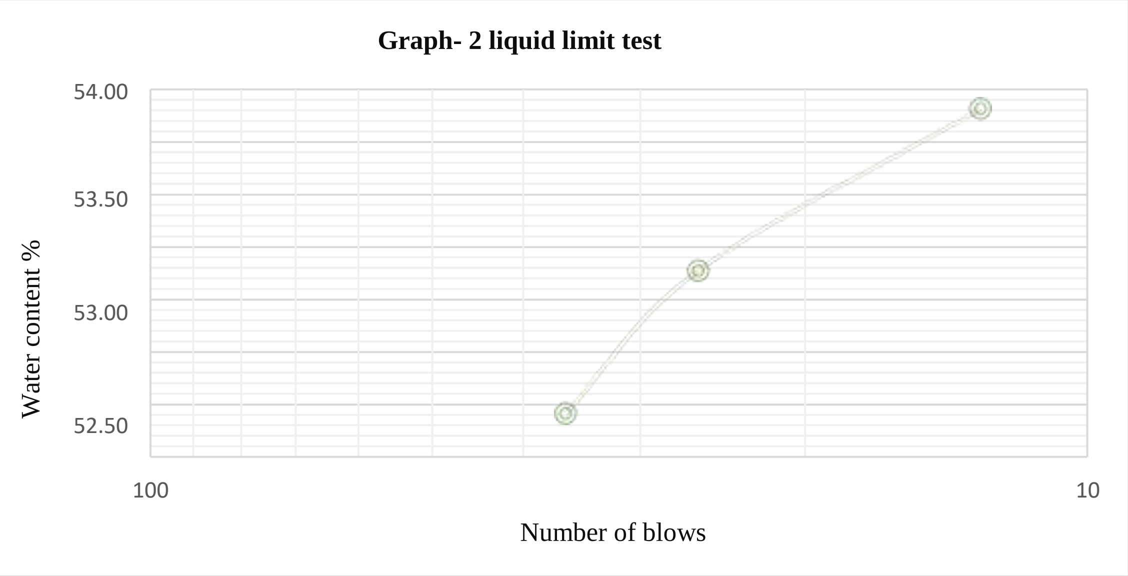
IS Sieve No (mm)	Wt. of Soil Retained in Grams	%Wt. Retained	Cumulative%Wt. retained	% finer
4.75	81.80	8.18	8.18	91.82
2.36	65.51	6.55	14.73	85.27
1.18	260.39	26.04	40.77	59.23
0.6	390.00	39.00	79.77	20.23
0.425	0.22	0.02	79.79	20.21
0.3	4.27	0.43	80.22	19.78
0.15	136.82	13.68	93.90	6.10
0.075	34.75	3.48	97.38	2.62
Pan	26.24	2.62	100.00	0.00

D. Atterberg limits

I. Liquid limit

Table-4 Liquid Limit Data of Soil Sample

SL.NO	Description	I	II	III
1	Number of Blows	13	26	36
2	Container Number	1	2	3
3	The weight of container + Wet Soil in grams	10.69	11.39	8.27
4	The weight of container +Dry Soil in grams	6.95	7.48	5.48
5	The weight of Water in grams	3.74	3.91	2.79
6	The weight of Dry Soil in grams	6.95	7.48	5.48
7	Water Content (w_L) in Percentages	53.81	52.27	50.91



From Graph:
Liquid Limit w_l=52.17

II. Plastic Limit

Table- 5 Plastic Limit Data of soil Sample

Sl.No.	Description	I_p	I_l
1	Container Number	1	2
2	The weight of container + Wet Soil in grams	2.1	1.17
3	The weight of container +Dry Soil in grams	1.77	0.99
4	The weight of Water in grams	0.33	0.18
5	The weight of Dry Soil in grams	1.76	0.97
6	Water Content (w_P) in Percentages	18.75	18.56
7	Average Plastic Limit W_P	18.65	

i.e., Plasticity index I_P: Liquid Limit I_l – Plastic Limit:

33.52 >17., High Plastic Soil

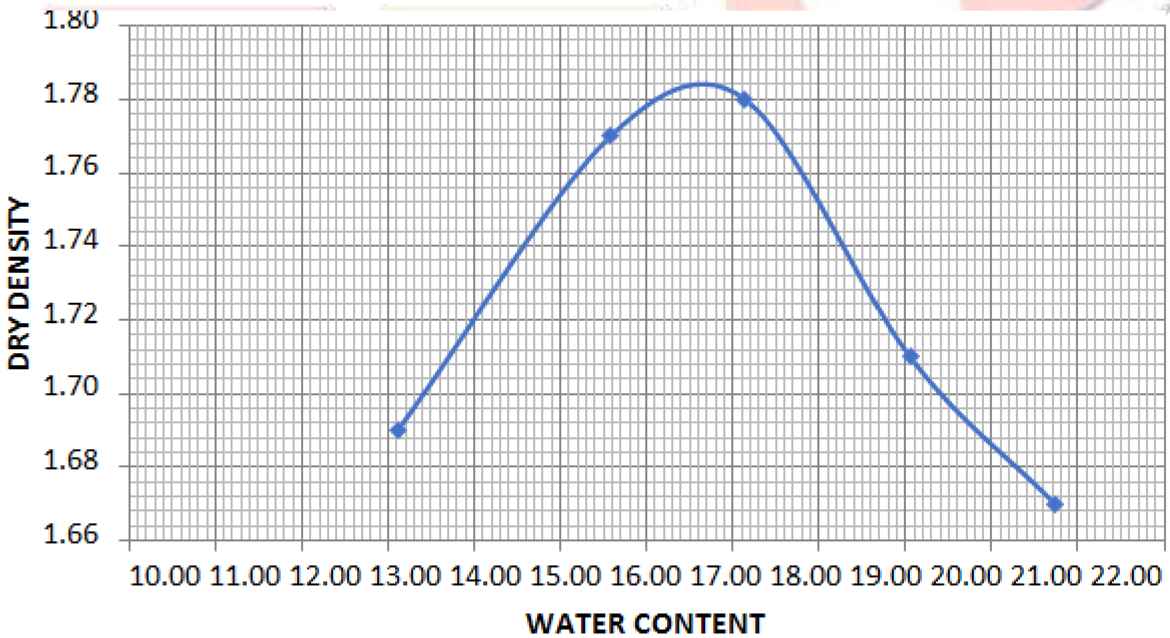
III. Standard Proctor Compaction Test

The weight of the Mould: 4260 grams, Volume of the Mould: 1000 cc

Table-6 Standard Proctor Compaction Test Observables

SL NO:	Description	I	II	III	IV	V
1	The weight of mould + Wet soil in W2 in grams	6170	6310	6340	6300	6260
2	The weight of Wet Soil (W2-W1) in grams	1910	2050	2080	2040	2000
3	Moisture Content Container Number	1	2	3	4	5
4	Weight of Container +Wet Soil in grams	70.65	91.90	152.08	111.78	134.85
5	Weight of Container + Dry Soil in grams	62.46	79.51	129.82	93.89	111.70
6	Weight of Water (4-5) in grams	8.19	12.39	22.26	17.89	23.15
7	Weight of Dry soil in grams	62.46	79.51	129.82	93.89	111.70
8	Water Content w=6/7*100	13.11	15.58	17.15	19.05	20.73
9	Bulk Density	1.91	2.05	2.08	2.04	2.00
10	Dry Density	1.69	1.77	1.78	1.71	1.66

Graph- 3 Standard Proctor Compaction Test



From Graph:

OMC (Optimum Moisture Content) : 16.65 MDD (Maximum Dry Density) : 1.784

E. California Bearing Ratio Test

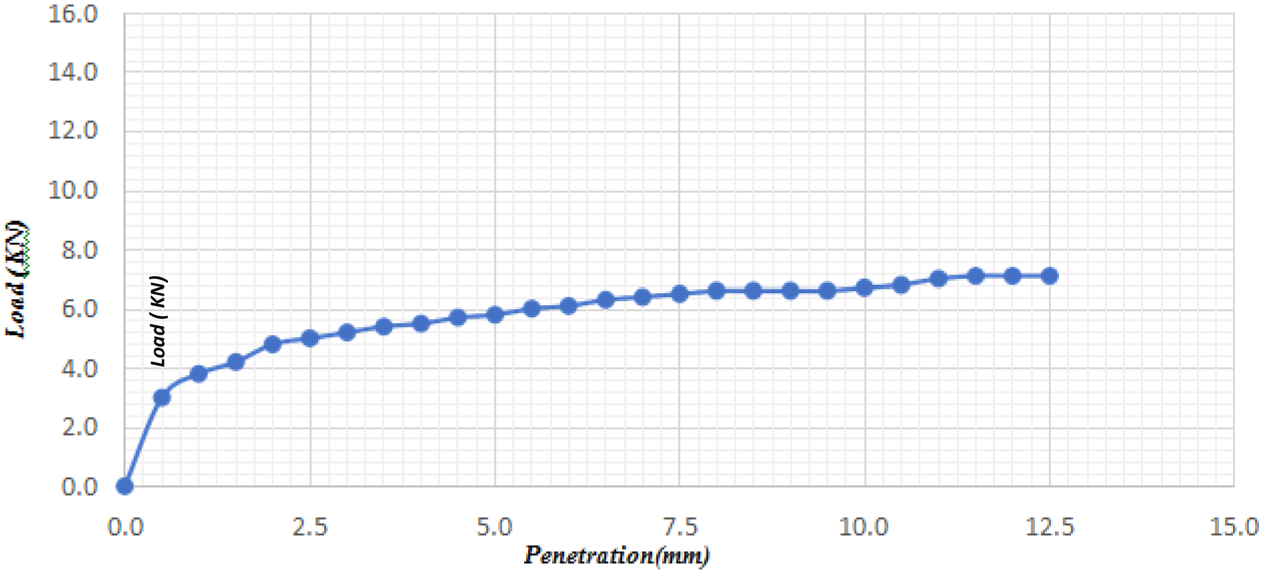
I. Without Geogrid

Table – 7 CBR Test Data Without Geogrid

SL No:	Penetration in mm (C_1)	Proving Ring Readings (C_2) KN	Proving Ring Readings in division ($C_3=C_2*5$)	Load in Kg $C_4=C_4*0.915$
1	0.0	0.0	0.0	0.0
2	0.5	3.0	15.0	13.7
3	1.0	3.8	19.0	17.4
4	1.5	4.2	21.0	19.2
5	2.0	4.8	24.0	22.0
6	2.5	5.0	25.0	22.9
7	4.0	5.5	27.5	25.2
8	5.0	5.8	29.0	26.5
9	7.5	6.5	32.5	29.7
10	10.0	6.7	33.5	30.7
11	12.5	7.1	35.5	32.5

Fig-1 Soil Sample without Geogrid

Graph- 2 CBR Test without Geogrid in Subgrade soil



CBR @ 2.5 mm Penetration:1.67, CBR @ 5.0 mmPenetration:1.36

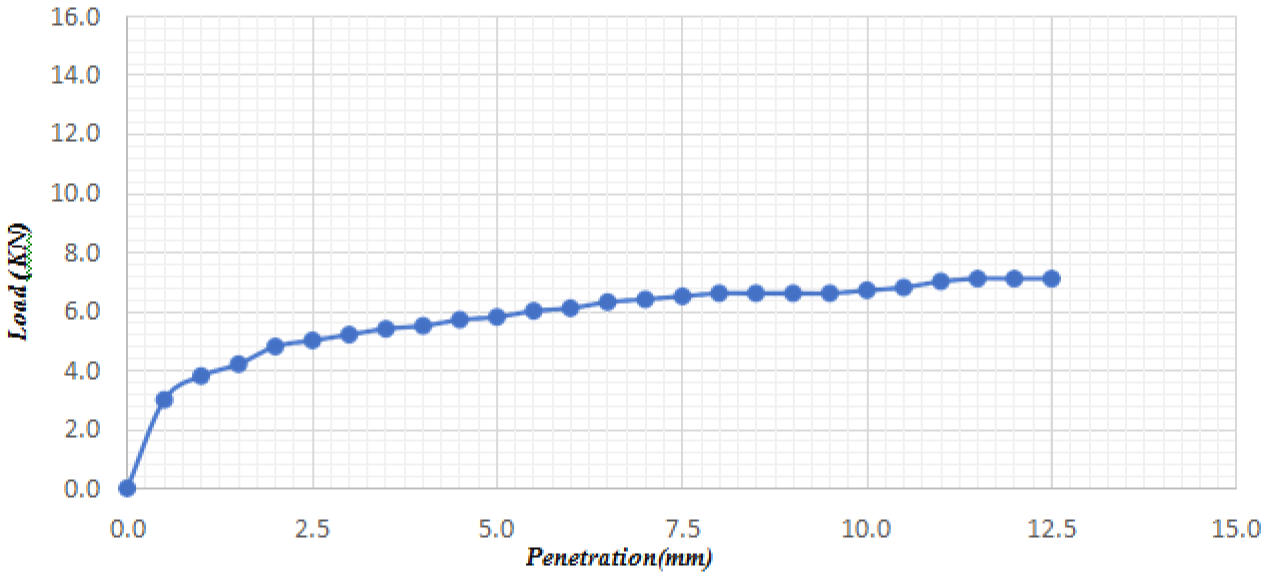
II. With Geogrid At H/4 From The Bottom

Table-8 CBR Test Data with geogrid @ H/4 from bottom

SL No:	**Penetration in mm (C1)**	**Proving Ring Readings (C2) KN**	**Proving Ring Readings in division (C3=C2*5)**	**Load in Kg C4=C4*0.915**
1	0.0	0.0	0.0	0.0
2	0.5	2.5	12.5	11.4
3	1.0	3.2	16.0	14.6
4	1.5	3.7	18.5	16.9
5	2.0	4.7	23.5	21.5
6	2.5	5.4	27.0	**24.7**
7	4.0	5.7	28.5	26.1
8	5.0	6.1	30.5	**27.9**
9	7.5	6.3	31.5	28.8
10	10.0	6.8	34.0	31.1

Fig-2 Laboratory Experiment with Geogrid in CBR Mould

Graph- 3 CBR Test with Geogrid @H/4 in Subgrade soil



CBR @ 2.5 mmPenetration:1.80, **CBR @ 5.0 mmPemetration:1.29**

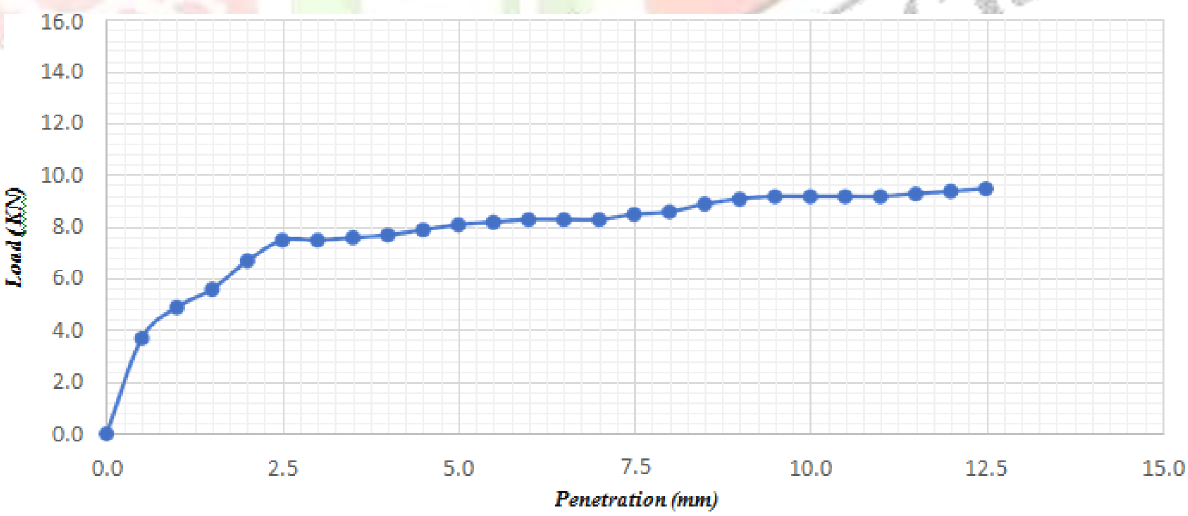
III. **With Geogrid At H/2 Distance From Thebottom**

Table-9 CBR Test Data with Geogrid @ H/2 from bottom

SL No:	Penetration in mm (C1)	Proving Ring Readings (C2) KN	Proving Ring Readings in division (C3=C2*5)	Load in Kg C4=C4*0.915
1	0.0	0.0	0.0	0.0
2	0.5	3.7	18.5	16.9
3	1.0	4.9	24.5	22.4
4	1.5	5.6	28.0	25.6
5	2.0	6.7	33.5	30.7
6	2.5	7.5	37.5	**34.3**
7	4.0	7.7	38.5	35.2
8	5.0	8.1	40.5	**37.1**
9	7.5	8.5	42.5	38.9
10	10.0	9.2	46.0	42.1
11	12.5	9.5	47.5	43.5

Fig-3 Tests Conducted in Laboratory With Geogrid At H/2 Distance From the bottom

Graph- 4 CBR Test with Geogrid @H/2 in Subgrade soil



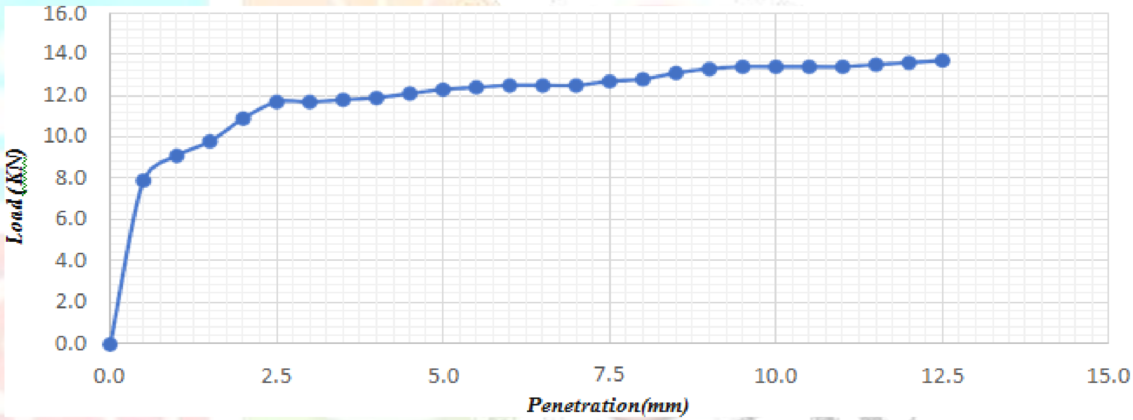
CBR @ 2.5 mm Penetration: 2.50, **CBR @ 5.0 mm Penetration : 2.74**

IV. WITH GEOGRID AT 3H/4 DISTANCE FROM THE BOTTOM

Table-10 CBR Test Data with Geogrid @3H/4 from bottom

S L N o:	Penetration in mm (C1)	Proving Ring Readings (C2) KN	Proving Ring Readings in division (C3=C2*5)	Load in Kg C4=C4*0.915
1	0.0	0.0	0.0	0.0
2	0.5	7.9	39.5	36.1
3	1.0	9.1	45.5	41.6
4	1.5	9.8	49.0	44.8
5	2.0	10.9	54.5	49.9
6	2.5	11.7	58.5	53.5
7	4.0	11.9	59.5	54.4
8	5.0	12.3	61.5	56.3
9	7.5	12.7	63.5	58.1
10	10.0	13.4	67.0	61.3
11	12.5	13.7	68.5	62.7

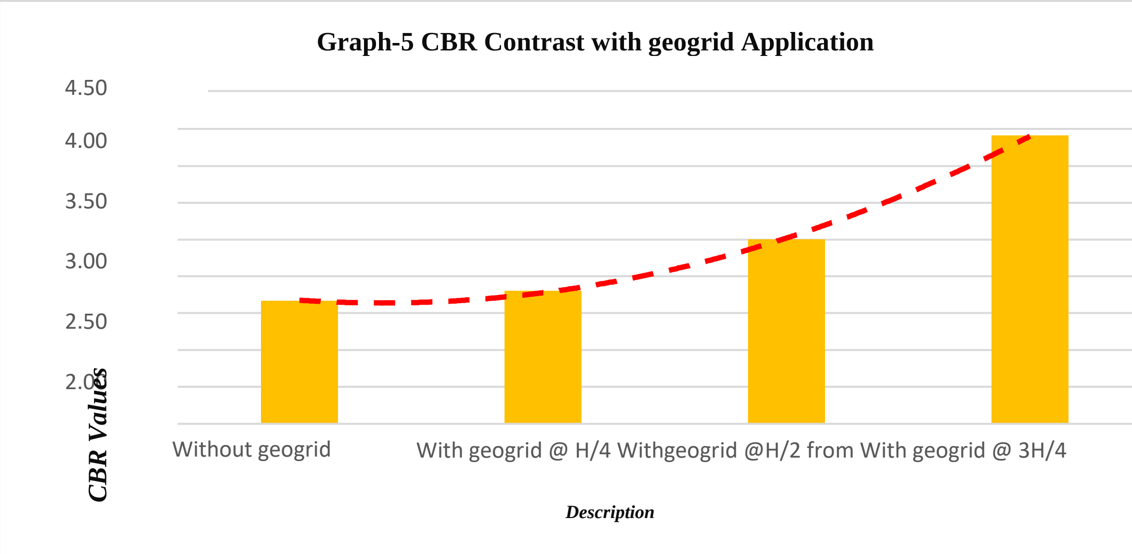
Graph- 4 CBR Test with Geogrid @3H/4 in Subgrade soil



CBR @ 2.5 mmPenetration:3.91, **CBR @ 5.0 mm Penetration :1.80**

Table -6 CBR Value Variation with Geogrid Application in Soil Sample

Description	CBR Value
Without geogrid	1.67
With geogrid @ H/4 from the bottom	1.80
With geogrid @H/2 from the bottom	2.50
With geogrid @ 3H/4 from the bottom	3.91



Conclusion:

The study investigated the application of geogrids to subgrade material as a form of reinforcement to road construction. The inclusion of the geo-grid considerably increases the strength of poor soils, which is reflected in the higher CBR values. The study shows that the strength of the subgrade is significantly altered positively by the positioning of the geo-grid at varying depth. It was observed that the highest subgrade strength is achieved when it is placed at 3H/4 for a single layer although has a satisfactory result at H/2 and H/4 respectively. On reinforcing the soil,there is a considerable increase in performance of the subgrade in the unsoaked condition. The use of geogrids as reinforcement to poor soils improves its strength. It is non-bio degradable and therefore durable; it also increases the ultimate service life of the pavement. The use of Geogrids should, therefore, be encouraged as an effective and modern form of improving road construction on poor sub-grade materials.

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