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USE OF GEOSYNTHETIC TO IMPROVE THE PROPERTY OF FLEXIBLE PAVEMENTS

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ABSTRACT: Geogrids are single or multi-layer materials usually made by extruding and stretching high-density polyethylene or polypropylene, or by weaving or knitting and coating high-strength polyester yarns. The resulting lattice structure has large holes (called holes) thatimprove interaction with the soil or aggregate. Due to their high tensile strength and stiffness,geogrids are particularly effective as soil and aggregate reinforcement. . Roads in India mostly have problems like formation of potholes, ruts, cracks and localized depressions and settlements especially during rainy season. The reason is primarily the insufficient bearing capacity of the subsoil in a state saturated with water. The subgrade usually provides a low CBR value of 2-5%. In the CBR method of pavement design (IRC:37-2012), the total pavement thickness increases exponentially as the CBR value of the subgrade decreases, which in turn increases the cost of construction. So it was tried to use the geogrid material to increase the bearing capacity of the subsoil.
Laboratory and simulated field CBR tests are performed on soil samples with and withoutby including a geogrid layer and also changing its position in the form. Use
the geogrid increases the CBR value of the base and thereby reduces the road surface thickness significantly up to 40%. This study will have a positive cost impact as it will reduceboth project and road maintenance costs.

KEYWORDS: Geogrids, Reinforcement, CBR Value, Flexible Pavement, Subgrade,Highway, Design, Expansive Soil

I. INTRODUCTION

Geosynthetics have proven to be one of the most versatile and cost-effective soil improvement materials. Their use has rapidly spread to almost all areas of civil, geotechnical,environmental, coastal and water engineering. Geosynthetics, including geotextiles, geomembranes, geogrids, geogrids, geocomposites and geosynthetic clay liners, often used in combination with conventional materials, offer the following advantages over traditional materials:
Material Quality Control – Soil and aggregate are generally heterogeneous materials that can vary significantly from site to site or borrow. Geosynthetics, on the other hand, are relatively homogeneous because they are manufactured under strictly controlled conditions in a factory.They are subject to strict quality control to minimize material deviations.
Construction Quality Control – Geosynthetics are manufactured and often “pre-fabricated” from the factory into large sheets. This minimizes the number of field joints or seams required. Factory and field seams are produced and tested by trained technicians. In contrast,layers of soil and aggregate are constructed in situ and are subject to changes due to weathering, handling and placement.
Cost savings – Geosynthetic materials are generally less expensive to purchase, transport andinstall than soils and aggregates.
Technical superiority – Geosynthetics have been designed for optimum performance in therequired application.
Construction Timing – Geosynthetics can be installed quickly and provide flexibility for construction during short construction seasons, inclement weather breaks, or without the needfor demobilization and remobilization by the earthworks contractor.
Material Deployment - Layers of geosynthetics are deployed sequentially, but with minimalgradation between layers, allowing a single crew to efficiently deploy multiple geosyntheticlayers.

Material Availability – Numerous suppliers of most geosynthetics and ease of transportation ensure competitive prices and easy availability of materials.
Environmental sensitivity – Geosynthetic systems reduce the use of natural resources and environmental damage associated with mining, transportation and other material handling.

A. Functions of Geo synthetics in road construction

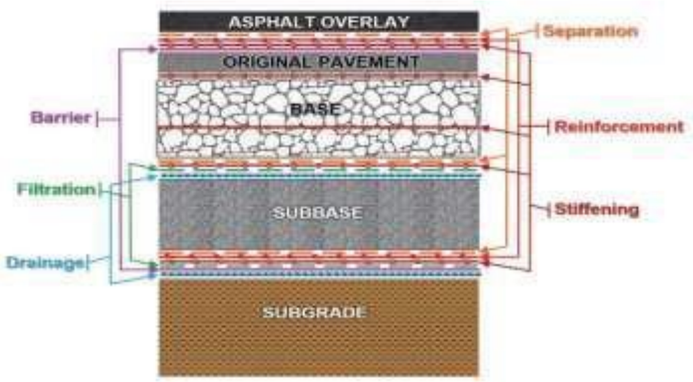


Figure 1. 1 Multiple functions of geosynthetics in roadway applications.

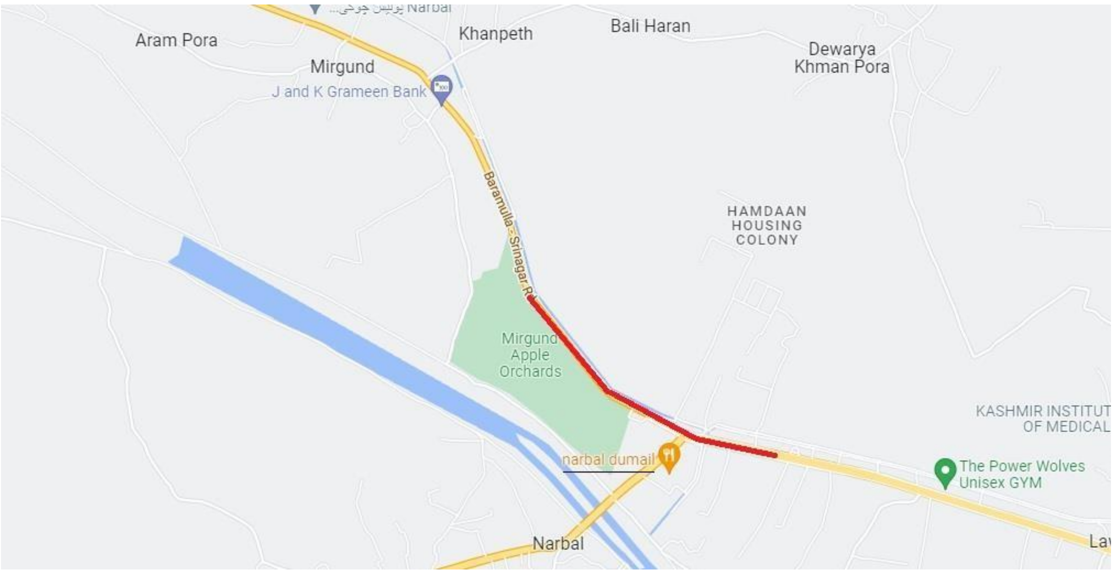
Although relatively less common in pavement applications, other geosynthetic features include:
Hydraulic / gas barrier: Geosynthetics minimize cross-plane seepage and provide containment of liquids or gases. Among the essential design properties to fulfill this role are those used to define the long-term durability of the geosynthetic material.
Protection: Geosynthesis creates a barrier over or under other materials (e.g., geomembrane) to mitigate damage during the placement of overlying materials. The basic design properties for quantifying this role include the properties used to describe the puncture resistance of the geosynthetic material.

II. RESEARCH METHODOLOGY

The methodology used for this thesis work. It includes:

1. Selection of Site
2. Collection of materials
3. Set of Samples
4. Testing
5. Analysis of Test Results.

SELECTION OF SITE: As I want to use geo-net in road construction in this thesis work, I have selected NH44, as construction of widening of this road is in progress, the available soil is taken for testing. This Highway extends from Narbal to Baramullah (J&K).



Geo-Grid

PP Geogrid has been purchased online from Jeevan Ecotex Pvt. Ltd. Through Indiamart.com. Following were the properties of online purched geogrid.

Property	Value
Thickness	10mm-13mm
Colour	Cream
Hole Shape	Square
Material	PP

TESTING OF MATERIALS

After collection of materials, I have done testing of all materials both individually and after mixing at SSM college of Engineering, Parihaspora, Pattan, Jammu & Kashmir. The varioustests done are.

- Traffic Data
- Grain Size Distribution
- Atterberg Limits
- Standard Proctor Compaction Test
- California Bearing Ratio Test

III. RESULTS AND DISCUSSION

1 TRAFFIC DATA ANALYSIS

Computation of Design Traffic:

$$N=\frac{365}{r} * [(1+r)^{n}-1]*A*D*F$$

Where,

N = Cumulative number of standard axles to be catered for in the design in terms of msa.

A=Initial traffic in the year of completion of construction in terms of the number of Commercial Vehicles per Day (CVPD).

D = Lane distribution factor = 0.5

F = Vehicle Damage Factor (VDF) = 3.5n = Design life in years = 15

r = Annual growth rate of commercial vehicles in decimal = 7.5%

The traffic in the year of completion is estimated using the following :Formula $A= P (1 + r)^{x}$.

Where,

P= Number of commercial vehicles as per last count = 2646

x = Number of years between the last count and the year of completion of construction. (Say 1 Year).

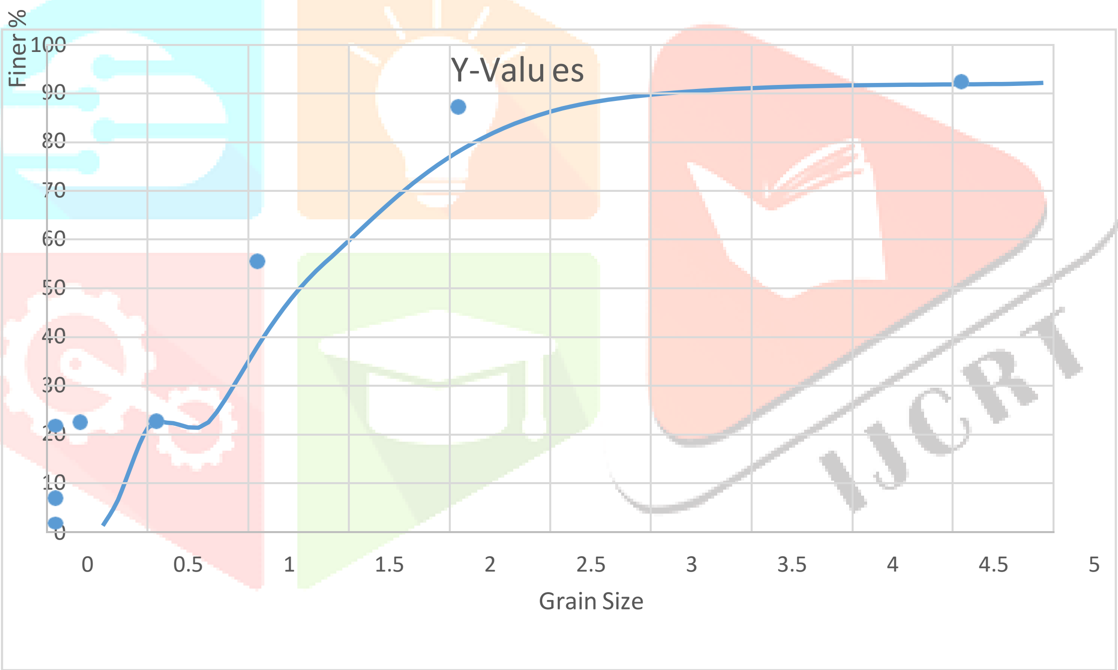
By substituting above Values, N Value is Computed as 47.45 msa.

5.2 GRAIN SIZE DISTRIBUTION

Sample Weight: 1000 Grams

Sieve No(mm)	oil Retained inGrams	%Wt. Retained	Cumulative %Wt. retained	% finer
4.75	79.30	7.93	7.93	92.07
2.36	52.49	5.249	13.179	86.821
1.18	316.10	31.61	44.789	55.211
0.6	327.40	32.74	77.529	22.471
0.425	2.21	0.221	77.75	22.25
0.3	8.60	0.860	78.61	21.39
0.15	149.1	14.91	93.52	6.5
0.075	52.80	5.28	98.8	1.2
Pan	12	1.2	100.00	0.00

Table-5.1 Grain Size Distribution DataPercentage Fines (size less than 75 μ)< 5%



From Graph $\quad$ $Cu = D_{60} / D_{10}$

$D_{10}=0.18$ $\quad$ Cu= 7.33

$D_{30}=0.54$ $\quad$ $C_c = D_{30}^{2} / D_{60} * D_{10}$

$D_{60}=1.32$ $\quad$ Cc = 1.182

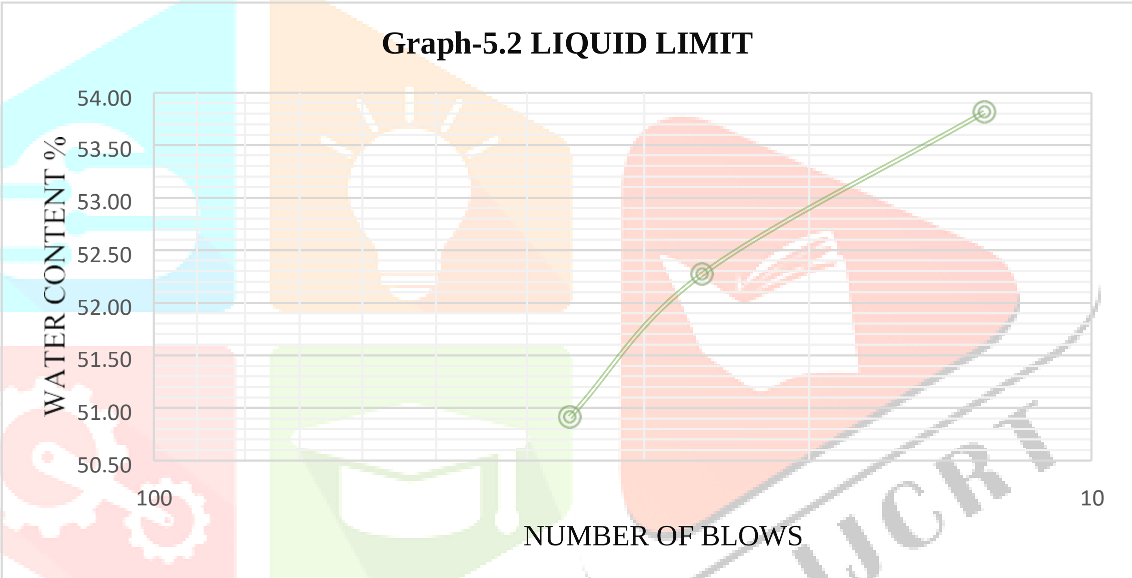
i.e., %age Finer < 5, C_u>4 & $C_c \approx 1 - 3$ then as per IS: 1498 the Soil is Well GradedGravel

5.3 ATTERBERG LIMITS

I. LIQUID LIMIT

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

Table-5.2 Liquid Limit Data of Soil Sample



From Graph: Liquid Limit 52.17

II. PLASTIC LIMIT

SL.NO	DESCRIPTION	I	II
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	

Table-5.3 Plastic Limit Data of soil Samplei.e., Plasticity index IP: Liquid Limit – Plastic Limit:

33.52 I_P> 17, High Plastic Soil

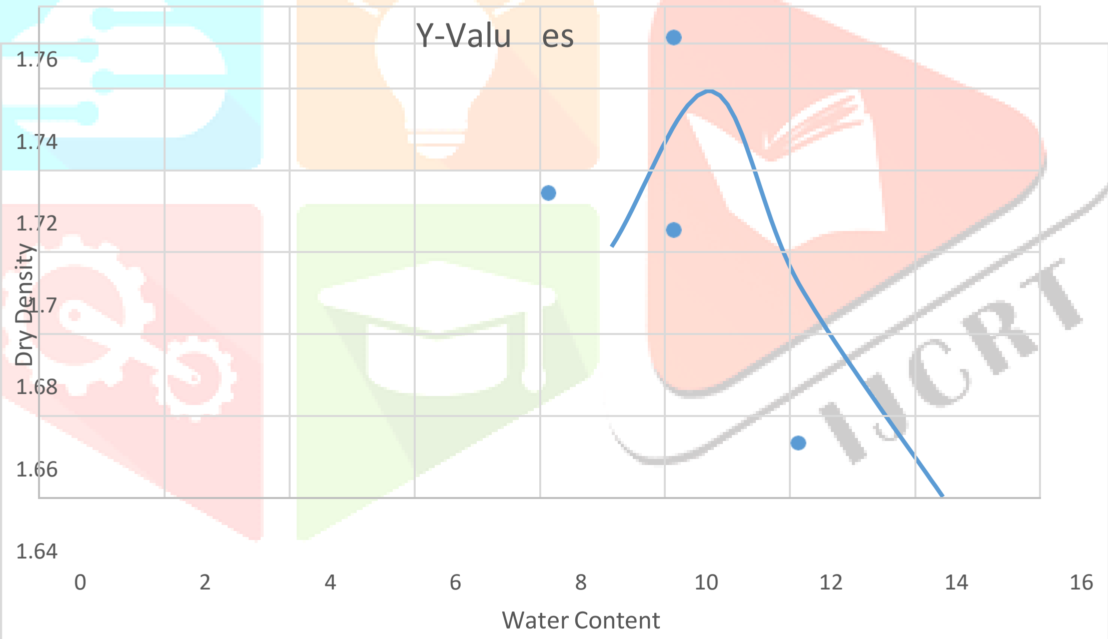
5.4 STANDARD PROCTOR COMPACTION TEST

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

SL NO:	DESCRIPTION	I	II	III	IV
1	The weight of mould + Wet soil in W_2 ingrams	5040	5100	5080	5060
2	The weight of Wet Soil (W_2-W_1) in grams	1770	1830	1810	1790
3	Moisture Content Container Number	1	2	3	4
4	Weight of Container +Wet Soil in grams	70	97.39	111.39	89.70
5	Weight of Container + Dry Soil in grams	64.05	87.63	98.59	77.33
6	Weight of Water (4-5) in grams	5.25	9.74	12.80	12.37
7	Weight of Dry soil in grams	62.46	79.51	129.82	93.89
8	Water Content w=6/7*100	8.5%	10.1%	11.49%	13.79%
9	Dry Density	1.714	1.752	1.705	1.653

Table-5.3 Standard Proctor Compaction Test Observables

Where, Bulk Density = Weight of wet soil / Vol of the Mould,Dry Density = Bulk Density / 1+Water Content



From Graph:

OMC (Optimum Moisture Content) : 10.1MDD (Maximum Dry Density) : 1.752

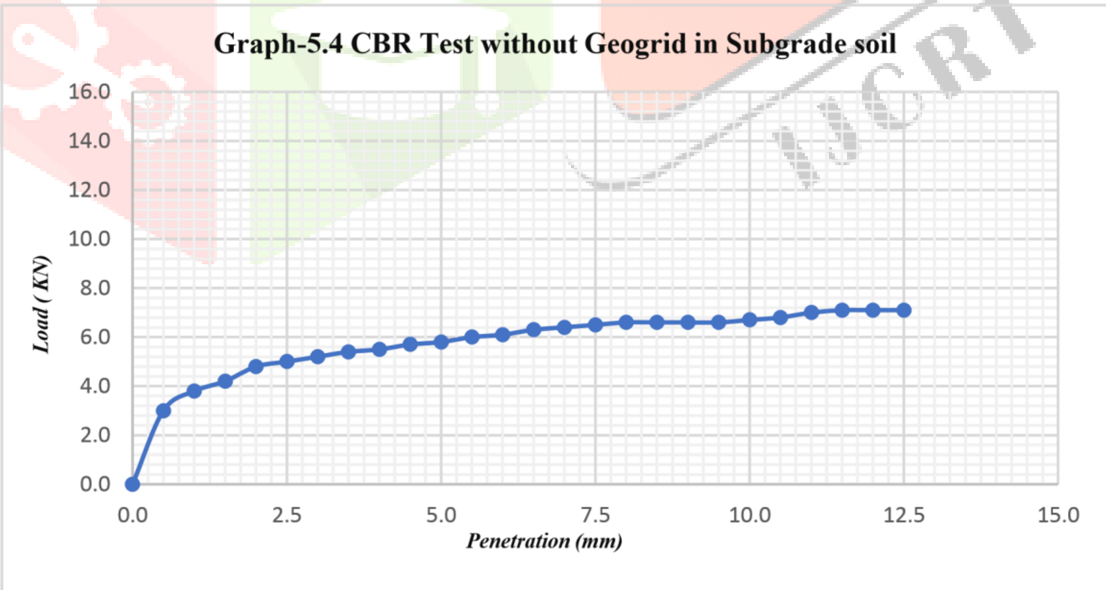
5.5 CALIFORNIA BEARING RATIO TEST

I. WITHOUT GEOGRID

SL No:	netration in mm (C_1)	Proving Ring Readings (C_2) KN	ving Ring Readings indivision ($C_3=C_2*5$)	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

Table-5.4 CBR Test Data Without Geogrid

Fig-5.1 Soil Sample without Geogrid



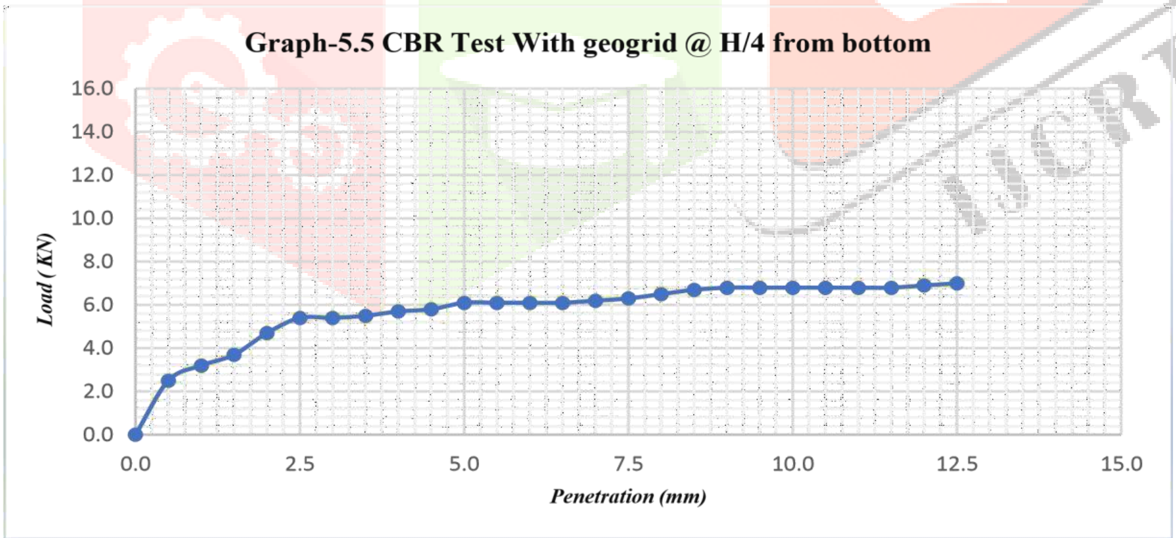
CBR @ 2.5 mm Penetration :1.67 , CBR @ 5.0 mm Penetration:1.36

II. WITH GEOGRID AT H/4 FROM THE BOTTOM

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	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
11	12.5	7.0	35.0	32.0

Table-5.5 CBR Test Data with geogrid @ H/4 from bottom

Fig-5.2 Laboratory Experiment with Geogrid in CBR Mould



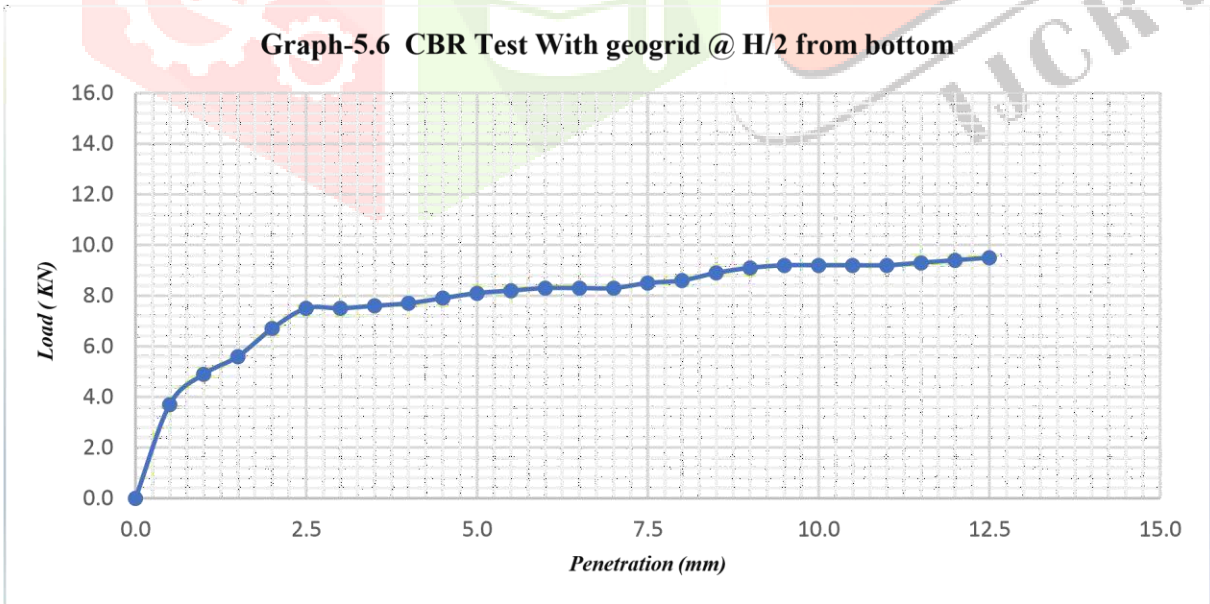
CBR @ 2.5 mm Penetration :1.80, CBR @ 5.0 mm Pemetration:1.

III. WITH GEOGRID AT H/2 DISTANCE FROM THE BOTTOM

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	3.7	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

Table-5.6 CBR Test Data with Geogrid @ H/2 from bottom

Fig-5.3 Tests Conducted in Laboratory

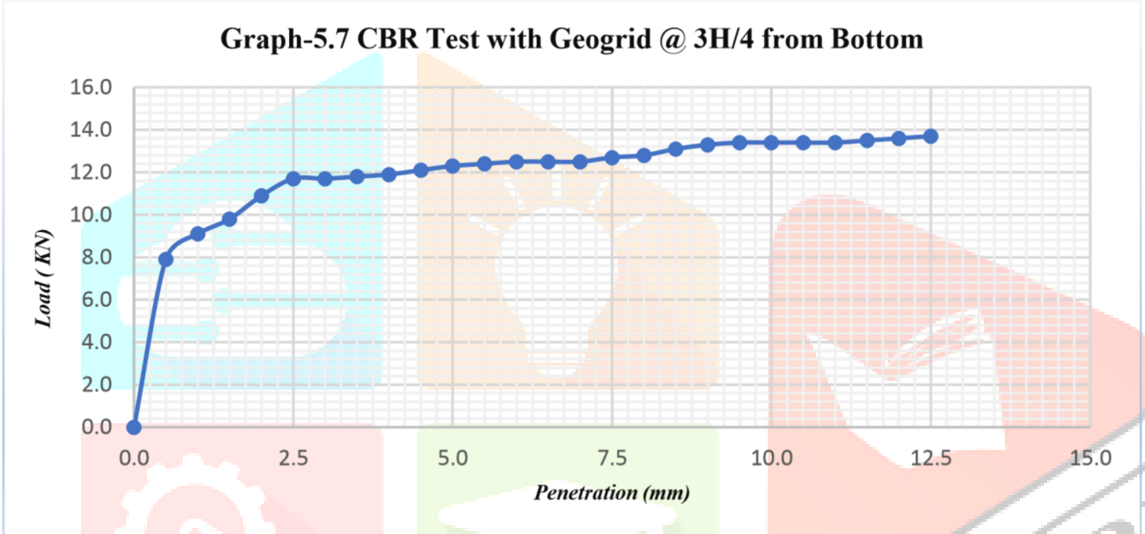


CBR @ 2.5 mm Penetration :2.50, CBR @ 5.0 mm Penetration : 2.74

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

SL No:	netration in mm (C1)	Proving Ring Readings (C2) KN	ving Ring Readings indivision (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

Table-5.7 CBR Test Data with Geogrid @3H/4 from bottom

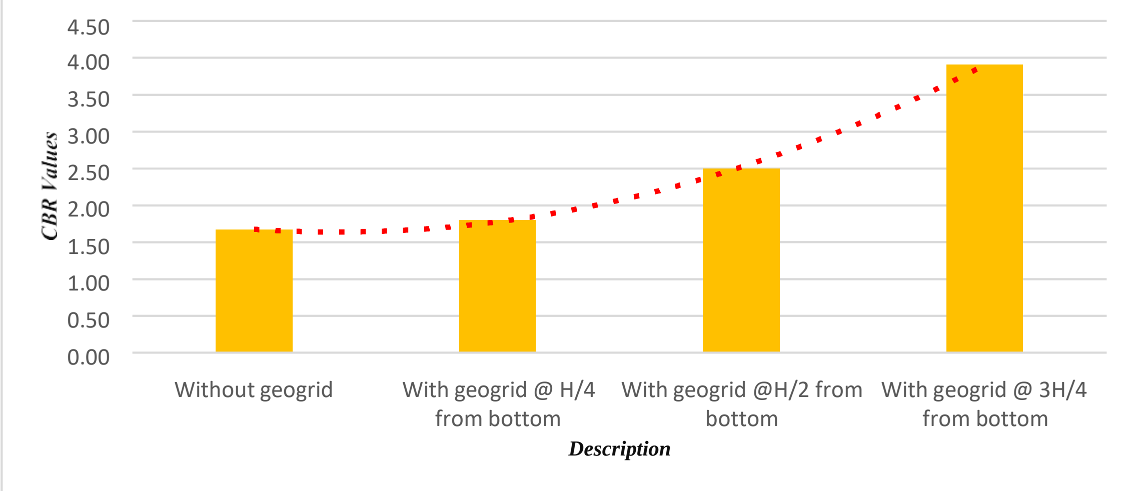


CBR @ 2.5 mm Penetration :3.91, CBR @ 5.0 mm Penetration :1.80

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

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

Graph-5.8 CBR Contrast with geogrid Application



CHAPTER-6

DESIGN OF PAVEMENT as per (IRC: 37-2012)

Bituminous Surfacing with Granular Base and Granular Sub-base

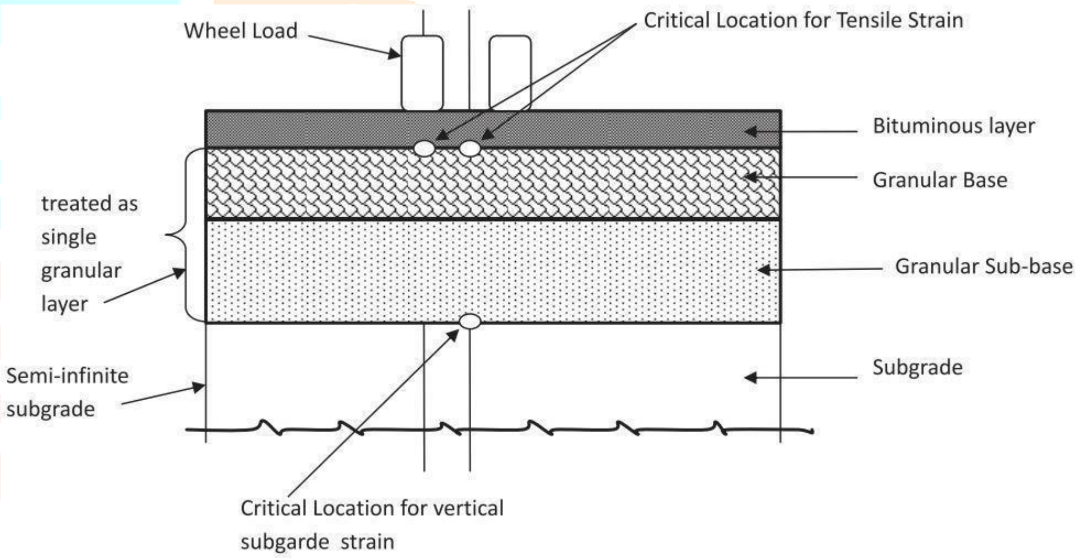
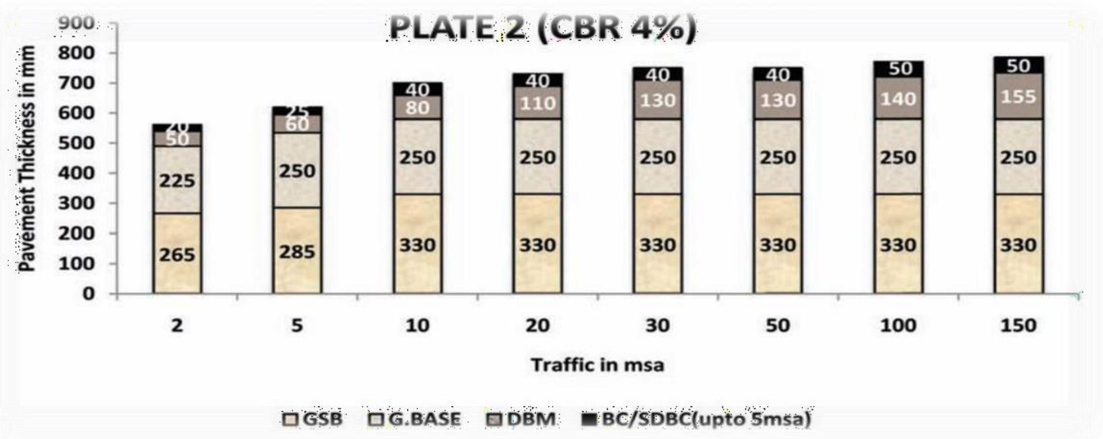


Fig-6.1 Bituminous Surfacing with GB and GSB

IRC: 37-2012



Graph-6.1 Plate-2 (IRC:37-2012) Pavement Design CataloguesWITHOUT GEOGRID: CBR: 1.67 %, N: 47.45 msa ≈ 50 msa

i.e., not fit for laying a road directly on the Subgrade soil; which needs Stabilization to it.

WITH GEOGRID AT 3H/4 FROM BOTTOM: CBR: 3.91 %, N: 47.45 msa ≈ 50 msa i.e.,

the thickness of GSB: 300 mm, G. Base:250, DBM: 115 mm, BC/SDBC:40mm

Where; GSB: Granular Sub-base, G. Base: Granular Base, DBM: Dense BituminousMacadam, BC: Bituminous Concrete, SDBC: Semi-Dense Bituminous Concrete.

The thickness of pavement required in MM:

Thickness	Without grid	With Geogrid @ H/4 from bottom
GSB	NA	300
G.BASE	NA	250
DBM	NA	115
BC	NA	40
Total	NA	705

Table-6.1 Thickness of Pavement in mm contrast with the application of geogrid

CONCLUSION AND RECOMMENDATIONS

The positive effects of subsoil layers reinforced with geogrids can be economically and ecologically used to reduce aggregate thickness. And it can also increase the service life of the pavement and also can reduce the overall cost of constructing the pavement withincreased service life.

The study investigated the application of geogrids to subgrade material as a form of reinforcement in road construction. The inclusion of a geogrid significantly increases the strength of poor soils, which is reflected in higher CBR values. The study shows that the strength of the subsoil is significantly positively changed by placing the geogrid at different depths. It was observed that the highest subgrade strength is achieved when it is placed at3H/4 for one layer, although it has a satisfactory result at H/2 and H/4. When strengtheningthe soil, there is a significant increase in the performance of the subsoil in a non-soaked state. The use of geogrids as a reinforcement of poor soils improves its strength. It is non-biodegradable and therefore durable; it also increases the final life of the road. The use ofgeogrids should therefore be encouraged as an effective and modern form of improving road construction on poor base materials. Further research should be analyzed in investigating the effect of geogrids on the subsoil in a non-soaked condition

FUTURE SCOPE

From the above discussion, it can be said that geogrids can serve better even in waterlogged conditions. We collected traffic data for two-lane bi-directional traffic only

It can also be used for multiple lanes. It can also be used on flat, undulating, hilly andsteep roads. For any industrial region where there is high traffic, it is recommended toplace more than one layer of geogrid.

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