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USAGE OF GEOGRIDS IN FLEXIBLE PAVEMENT DESIGN

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ABSTRACT

As on 31st March 2018, estimates the total road length in India 6,603,293km (4,103,096 mi) making the Indian road network, the second largest road network in the world after the united states. But the roads are not giving the desired result due to poor CBR value.

Roads in India have mostly the problems like the formation of potholes, ruts, cracks and localized depression and settlement, especially during rainy season. These are mainly due to the insufficient bearing capacity of the subgrade in water saturated condition. The subgrade soil mostly yields low CBR value 2-5%. In the CBR method of pavement design (IRC:37-2012) the total thickness of pavement increases exponentially with a decrease in the CBR value of subgrade soil which in turn increases the cost of construction. So, it has been tried to use the geogrid material for increasing the bearing capacity of the subgrade. Laboratory and simulated field CBR tests are conducted on soil samples with and without the inclusion of geogrid layer and also by varying the position of it in the mould. Use of geogrid increases the CBR value of the subgrade and thereby reduces the pavement thickness considerably up to 40%.

This study will have a positive impact on cost as it will reduce the Project as well as maintenance cost of the road. Our project will discuss in detail the process and its successful applications.

KEYWORDS: Geogrids, Reinforcement, CBR Value, Flexible Pavement, Sub grade, Highway, Design, Expansive Soil.

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. This condition may be further worsened if supplemented with poor drainage 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 those states.

Looking at the poor road condition of some states of India use of geogrid is thought for road construction to improve the performance of roads. Geogrid a geosynthetic manufactured from polymers is 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, geogrids are 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. The reinforcement mechanisms associated with geogrids.

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II. LITERATURE REVIEW

1. Over the last three decades, the use of geosynthetics has recorded a tremendous increase in civil engineering constructions. This is a result of continuous research in laboratory and field all over the globe.
2. **Giroud and Noirway** (1982) after an extensive study developed design chart of unpaved pavement for using geosynthetic at the interface of the base layer and subgrade soil. **Ramaswamy and Aziz** (1989) did an experimental investigation on the behaviour of jute reinforced subgrade soil under dynamic load.
3. **Mehndiratta et al** 1993 and Patel, 1990 have reported that standard mould of diameter equal to 3 times the plunger diameter is found to be inadequate for determination of CBR value as the small size mould will provide additional confinement to geotextile. Therefore, the diameter of the mould is increased to 5 times the plunger diameter. Also, to determine the effect of lateral confinement on CBR value of reinforced soil, mould-plunger diameter ratio (D/d) is varied from 2 to 5 while the vertical pressure (surcharge), the thickness of the specimen, method of compaction is kept the same as the standard test.
4. **Mehndiratta et al** (2005) conducted CBR and plate load test on unreinforced and geotextile reinforced subgrade. It was observed that the increase in elastic moduli of coir reinforced layer when coir is replaced by synthetic geosynthetic geotextiles are only 5 percent. They also investigated the durability of coir by accelerating its degradability It was observed that phenol treated coir extends the life of coir. Rao (2007) has published a compilation of his work on geosynthetics and state of the art developments.
5. **Babu et al**, 2008 has developed a design methodology using IRC guidelines for the design of coir geotextiles reinforced road on the basis of laboratory experiment data and mathematical formulations.

III. APPLICATIONS OF GEOGRIDS

Confining the Aggregates

The geogrids serve the function of holding or capturing the aggregates together. This method of interlocking the aggregates would help in an earthwork that is stabilized mechanically. The apertures in geogrids help in interlocking the aggregates or the soil that is placed over them. A representation of this concept is shown below.

Fig-1 Representation of Geogrid Confining the aggregates

The geogrids as mentioned above helps in redistribution of load over a wider area. This function has made the pavement construction more stabilized and strong. *It has the following functional mechanisms when applied for pavement construction:*

1. Tension Membrane Effect

This mechanism is based on the concept of vertical stress distribution. This vertical stress is from the deformed shape of the membrane as shown in the figure below. This mechanism was initially considered as the primary mechanism. But later studies proved the lateral restraining mechanism is the major criteria that must be taken into consideration.

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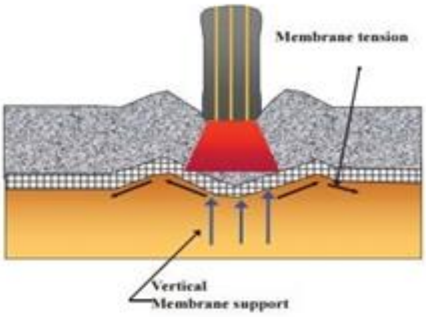

Fig-2 Tension Member Effect

2. Improvement of Bearing Capacity

One of the main mechanism happening after Geogrid installation in pavement is the reduction in lateral movement of the aggregate. This would result in the elimination of stresses; that if exists would have moved to the subgrade.

The Geogrid layer possesses sufficient frictional resistance that opposes subgrade lateral movement. This mechanism hence improves the bearing capacity of the layer. Reduction of outward stresses means inward stresses are formed, which is the reason behind the increase in bearing capacity.

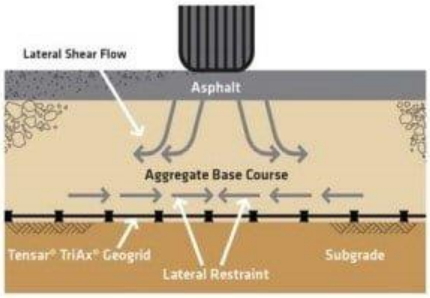

Fig-3 Mechanism for Improved Bearing Capacity

3. Lateral Restraining Capability

The stresses produced by means of the wheel loadings coming over the pavement results in the lateral movement of the aggregates. Which in turn affects the stability of the whole pavement arrangement. The Geogrid act a restraint against this lateral movement.

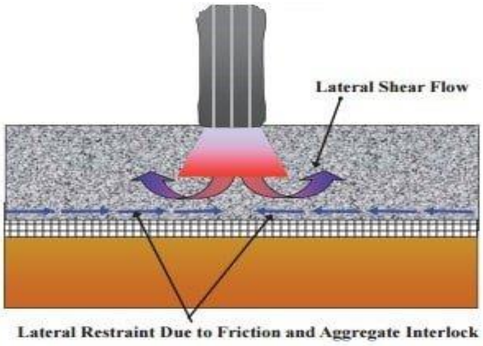

Fig-4 Lateral Restraining Capability

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Geogrid Material:

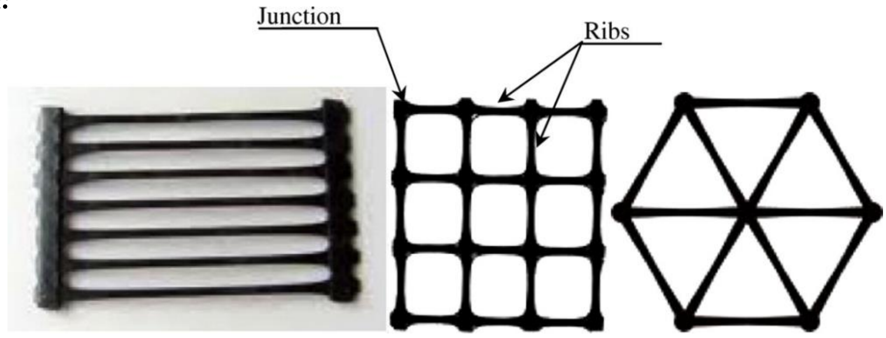

Fig-5 1. Uniaxial Geogrid 2. Biaxial Geogrid 3. Triaxial Geogrid

IV. OBJECTIVES OF THE STUDY

- To reduce the thickness of Pavement. So, as to reduce the cost of road construction.
- To Design Pavement thickness based on CBR and msa traffic as per IRC:37-2012.
- To increase the load carrying capacity of the road (Strength of road).
- Increase the Service Life of Road

V. METHODOLOGY

Laboratory and simulated field CBR tests are conducted on soil samples with and without the inclusion of Geo-grid and also by varying the position of it in the mould.

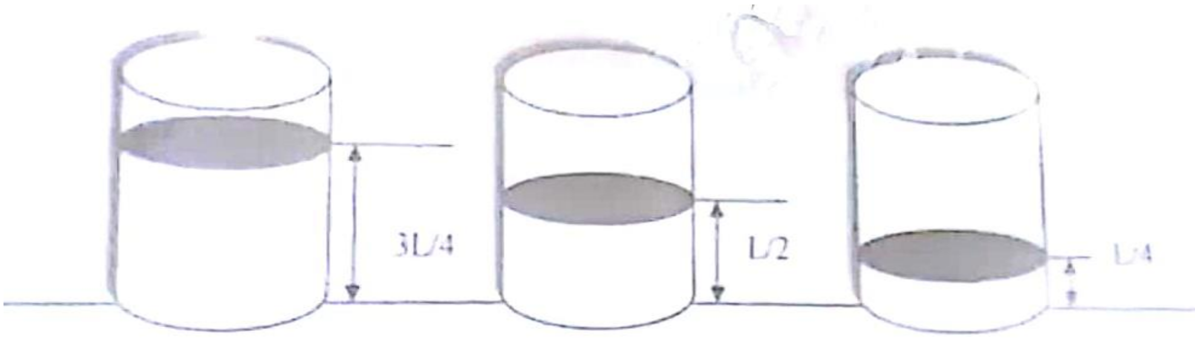

Fig-6 Inclusion of Geogrid at various Positions

VI. EXPERIMENTAL PROGRAMME, RESULTS & DISCUSSION

1) Traffic data

SL: NO	Timings:	HCV	MCV	LCV	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	10:00 am - 11:00 am	41	15	183	492	1	732
4	11:00 am - 12:00 pm	45	10	160	459	1	675
5	12:00 pm - 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

Table-1 Traffic Data Observables

P=HCV+MCV+LCV= **2646**

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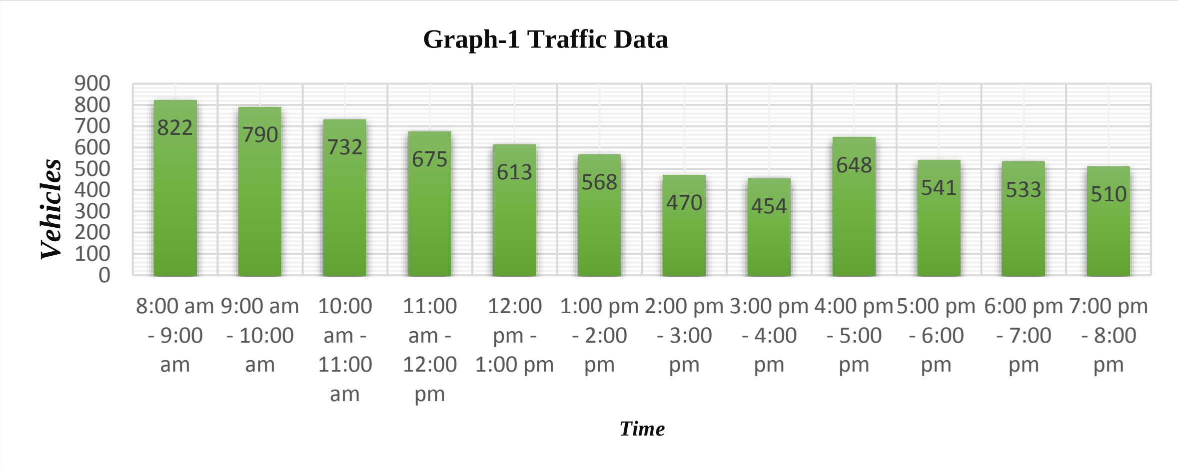

Computation of Design Traffic

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

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) = **3.5**
n = 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**

2) ***Grain size distribution:*** Sample Weight:1000 Grams

IS Sieve No (mm)	Wt of Soil Retained in Grams	%Wt Retained	Cummulative %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

Table-2 Grain Size Distribution data

Percentage Fines (Size Less than 75μ) < 5%

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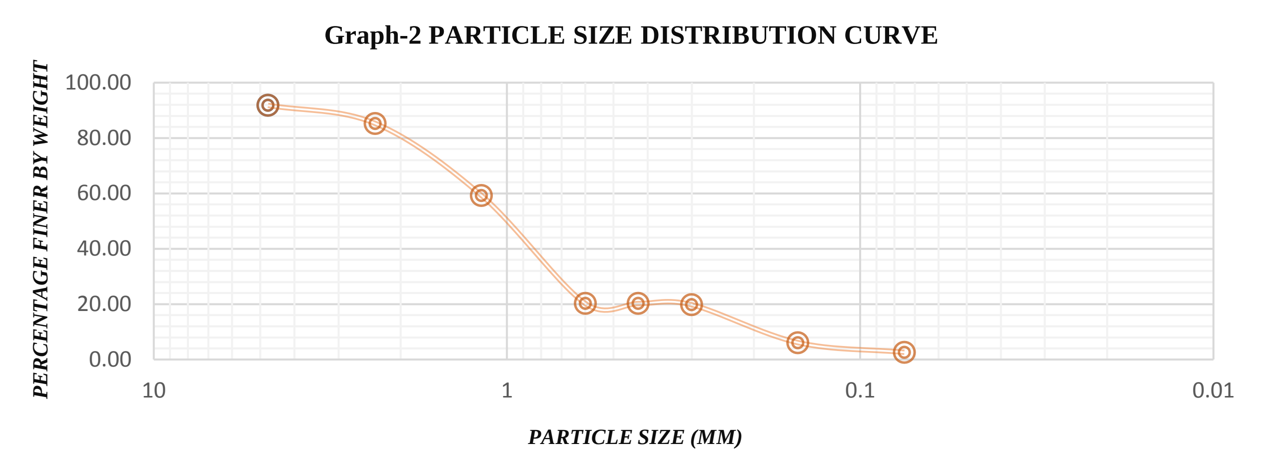


From Graph: $C_u = \frac{D_{60}}{D_{10}} = \frac{1.4}{0.18} = 7.78$

$D_{10}=0.18$

$D_{30}=0.74$ $C_c = \frac{D_{30}^2}{D_{60} * D_{10}} = \frac{0.74^2}{1.4*0.18} = 2.17$

$D_{60}=1.4$

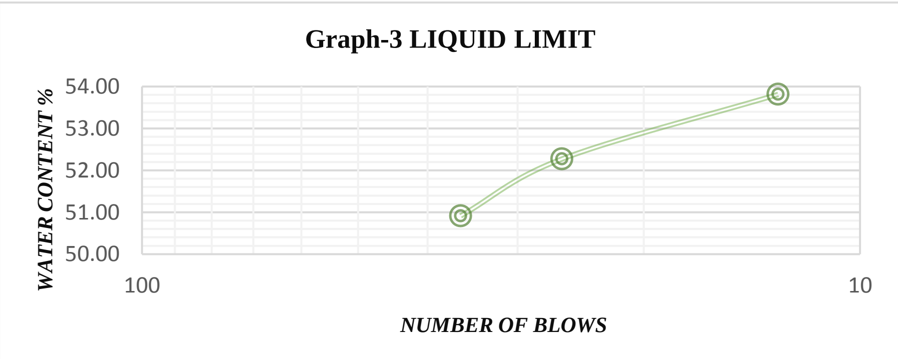
i.e., %age Finer < 5, C_u>4 & $C_c \approx$ 1 – 3 then as per IS :1498 the Soil is <u>Well Graded Gravel</u>

3) Atterberg Limits

1. Liquid limit of soil used

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-3 Liquid Limit Data of soil sample



Liquid Limit w_L=52.17

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2. 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	

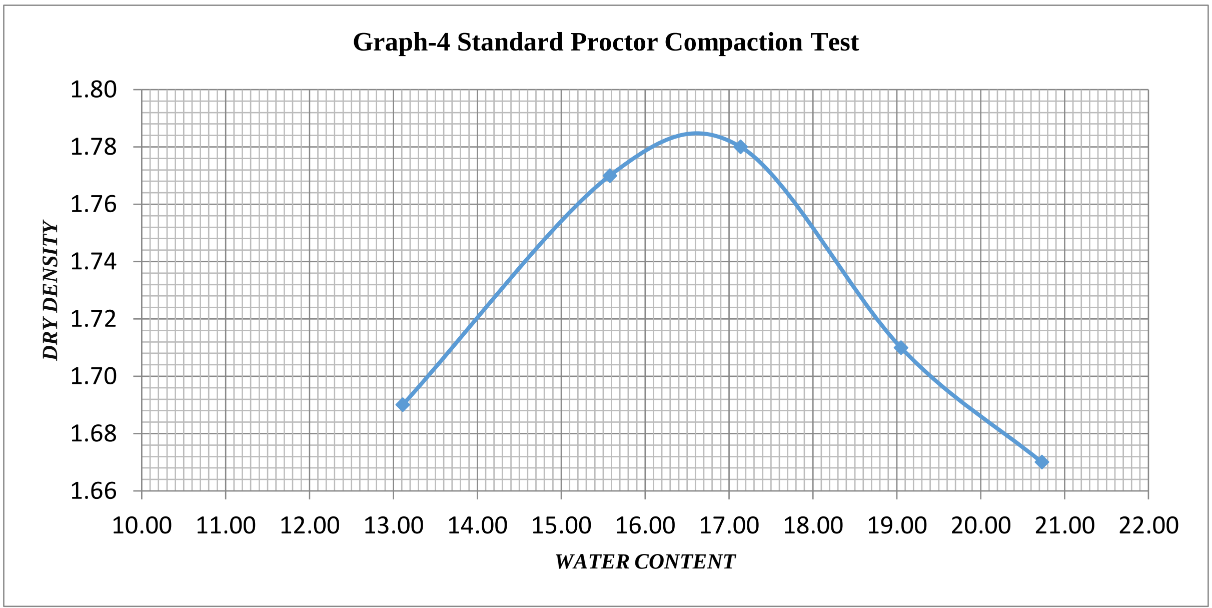
Table-4 Plastic Limit data of soil sample

Plasticity index I_P: Liquid Limit – Plastic Limit: 33.52
I_P> 17., **High Plastic Soil**

4) Standard Proctor compaction test

SL NO:	DESCRIPTION	I	II	III	IV	V
1	The weight of mould + Wet soil in W_2 in grams	6170	6310	6340	6300	6260
2	The weight of Wet Soil (W_2-W_1) 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

Table-5 Standard Proctor Compaction Test Observables



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The weight of the Mould: 4260 grams
The volume of the Mould: 1000 cc

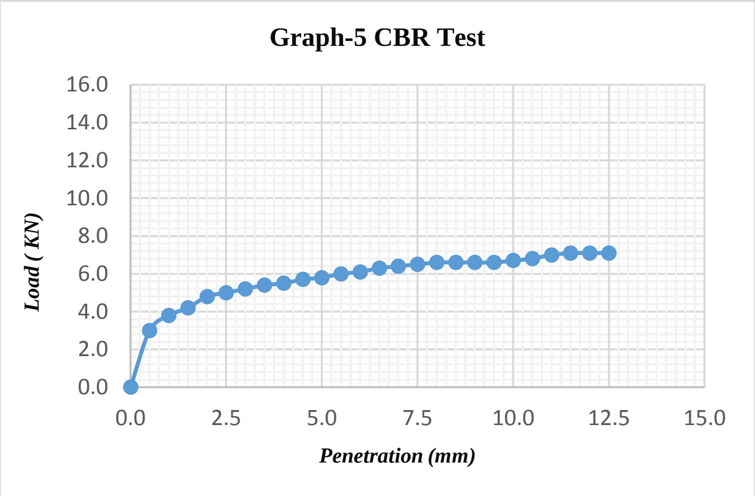
Where., Bulk Density=$\frac{Weight\ of\ wet\ soil}{Volume\ of\ the\ Mould}$ **, Dry Density=**$\frac{Bulk\ Density}{1+Water\ Content}$

From Graph:

OMC: 16.65
MDD: 1.784

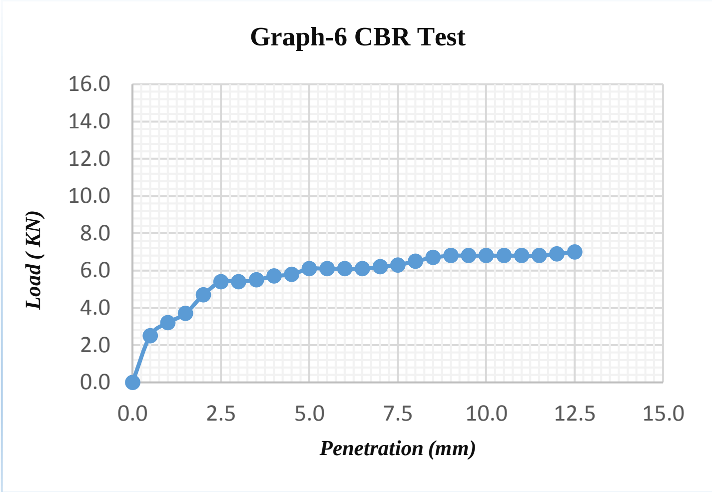
5) California Bearing Ratio Test

I. Without geogrid



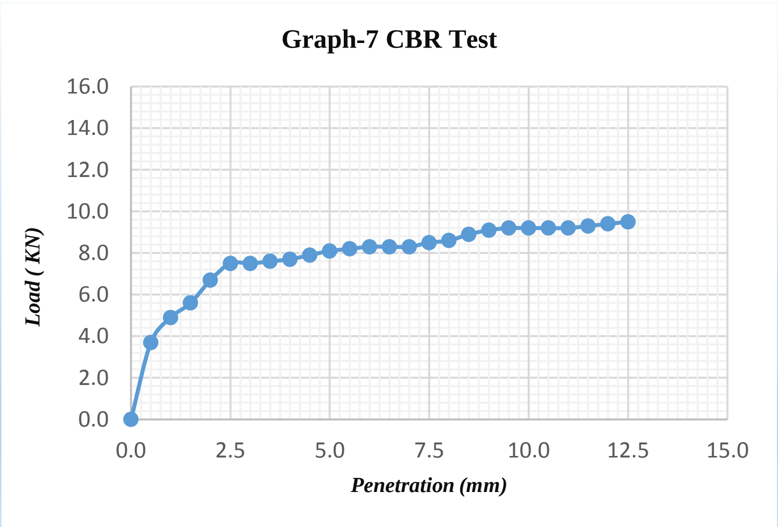
CBR @ 2.5 mm Penetration :1.67
CBR @ 5.0 mm Pemetration:1.36

II. With geogrid @ H/4 distance from the bottom



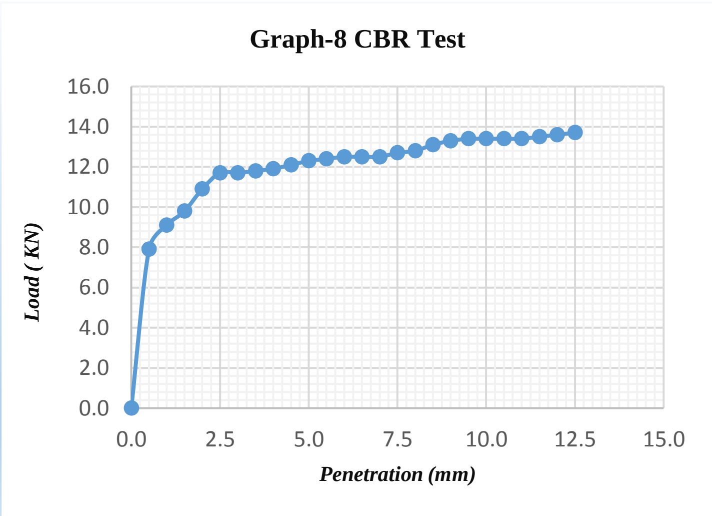
CBR @ 2.5 mm Penetration :1.80
CBR @ 5.0 mm Pemetration:1.29

III. With geogrid @ H/2 distance from the bottom



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

IV. With geogrid @ 3H/4 distance from the bottom



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

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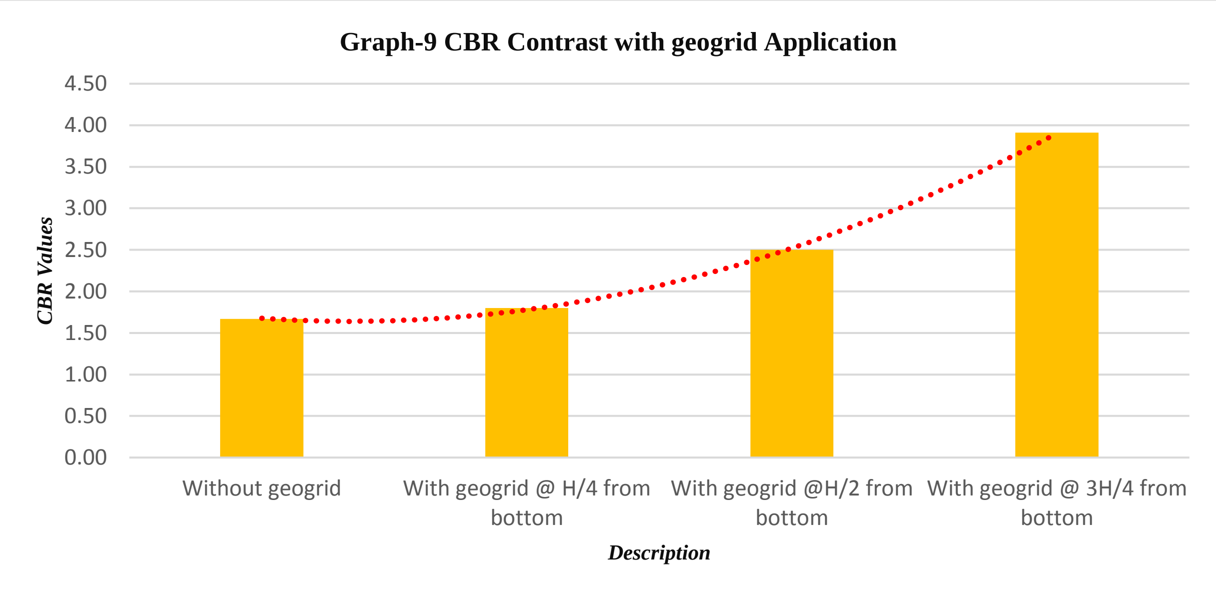
Description	CBR Value
Without geogrid	1.67
With geogrid @ H/4 from bottom	1.80
With geogrid @H/2 from bottom	2.50
With geogrid @ 3H/4 from bottom	3.91

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



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

Bituminous Surfacing with Granular Base and Granular Sub-base:

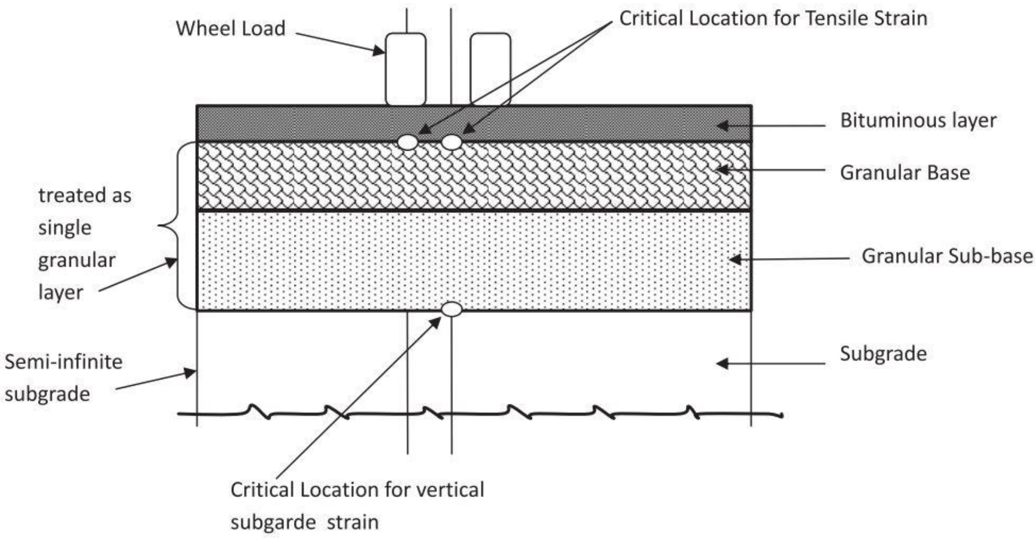
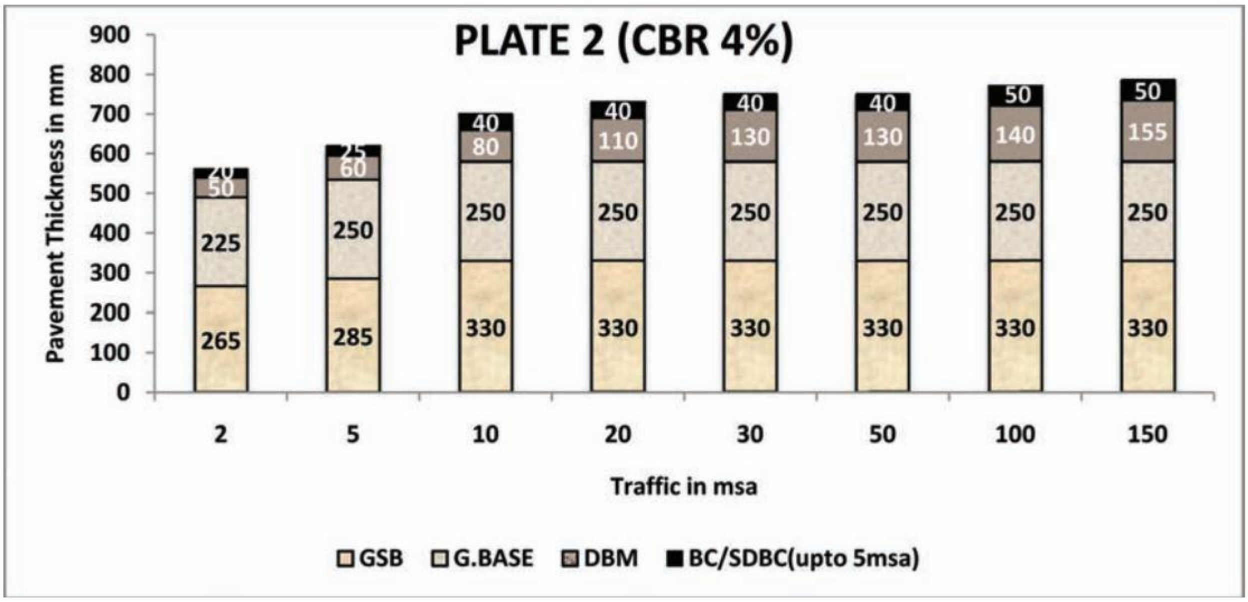


Fig-7 Bituminous Surfacing with Granular Base and Granular Sub-base

IRC: 37-2012



Graph-10: Plate-2 (IRC:37-2012) Pavement Design Catalogues

WITHOUT 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., thickness of GSB: 300 mm, G. Base:250, DBM: 115 mm, BC/SDBC:40mm

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 Pavement thickness	Stabilization required	**705**

Table-7 Thickness of Pavement in mm contrast with the application of geogrid

VIII. CONCLUSION

The positive effects of geogrid reinforced subgrade courses can economically and ecologically be utilized to reduce aggregate thickness. And it can also increase the life of the pavement and can also decrease the overall cost of the pavement construction with an increased lifetime.

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