Potential Benefits of Geogrid in a Flexible Pavement System

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Abstract:- Geosynthetics are defined herein as fabrics, grids, composites, or membranes. Application of geosynthetics for poor soil up-gradation has become a novel course in modern civil engineering projects, especially in road construction projects. Sub-grade soils which endorse the road surface in load carrying, its physical properties such as permeability, strength, etc. are critical to the pavement design. Moreover, a direct correlation has been found between cost and thickness of the pavement.

In the proposed work, Uni-axial geogrids (40 kN/m and 60 kN/m tensile strength) and Bi-axial geogrids (40 kN/m and 60 kN/m tensile strength) were used to investigate the effect on strength improvement of subgrade of flexible pavement. For this, CBR tests were performed on soil Samples (subgrade) consolidated with Uni-axial geogrids and Bi-axial geogrids of depth H/4, H/2, and 3H/4, and H/4, 3H/4 and 2H/3 respectively under soaked and unsoaked conditions. Moreover, in the present research work ideal location establishing the geogrid within the subgrade by changing its position along with the depth and finding the CBR value corresponding to each location. Similarly, for any specific depth, the effect of different types of geogrids towards CBR improvement was also studied.

It was found that CBR values improved significantly due to reinforcement. In case of single layer and double layer geogrid reinforcement maximum values were obtained when geogrids were placed at H/4 and H/3 and 2H/3 under soaked and unsoaked conditions respectively. Therefore, geogrids can be utilized to reduce the stresses in case of flexible road surfaces. However, further research should be carried out to confirm the same thing.

Keywords:- CBR, Sub-grade, Geogrid.

I. Introduction

In our country roads have been constructed with the use of old materials like stones, earth, sand, etc. A road has many aspects in its design and proper characterization of the soils for the satisfactory performance of road structures. The suitable percentage of constituents is of particular significance in the formation of the economical design of roads .

An ideal pavement should meet the following necessities:

a. It should have a satisfactory thickness to distribute the wheel load stresses to a harmless value on the subgrade soil
b. It should be mechanically robust to resist all types of stresses imposed on it
c. It should have an adequate coefficient of friction to avoid skidding of vehicles
d. It should have a smooth surface to offer relief to road users
e. It should produce the least noise as much as possible from mobile vehicles
f. It should provide dustproof surface,otherwise, that can reduce visibility
g. It should provide impermeable surface so that the subgrade is well protected

Mainly highway pavements can begenerally divided into two main categories: rigid (concrete) pavements and flexible pavements(Bituminous Pavements) based on design consideration (Fig. 1). The difference lies in their structural behavior. Rigid pavements possess remarkable flexural strength and are much stiffer due to the high modulus of elasticity of the material.Moreover, they have the slab action and are capable of transmitting load stresses through a wider area below. These pavement are made of Portland cement concrete either plain, reinforced or prestressed concrete and can have reinforcing steel. .

Flexible pavements also known as asphaltic concrete or hot mix asphalt (HMA) pavements consist of several granular layers with impervious bituminous layers, have low or negligible flexural strength and are rather flexible in their structural action under the loads.

The least flexible is in the upper layer and the most flexible is in the lower layer because the wheel load is applied to a small area, the result is high-stress levels, deeper down in the pavement, the wheel load is applied to a larger area, the result is lower stress levels thus enabling the use of weaker materials.These pavements constitute more than 94% of roadways in the United States (National Asphalt Pavement Association 2001). They transmit the vertical or compressive stress to the lower layers by grain to grain transfer through the points of contact in the granular structure.

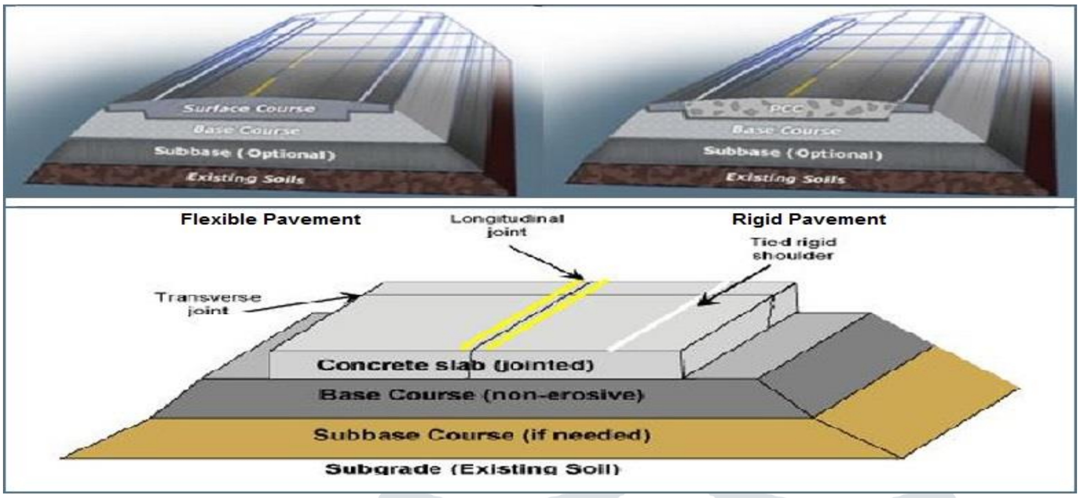


Fig. 1: Types of pavements: flexible pavement and rigid pavement

The principal role of flexible pavement is to make a harmless riding basement without any harm to the users and automobiles due to extreme distortion of pavement.In flexible pavements, the design concept is to place adequate films of base and transitional courses of the pavement so as to control the strains in the sub-grade so that no permanent deflections result. Loading of an asphalt pavement requires the stiffest layers to be placed at the surface with sequentially weaker layers down to the sub-grade. The types and thicknesses of subbase materials placed above the sub-grade should be selected with consideration of the strength of sub-grade as the resilience of flexible pavement is dependent on the thickness of layers, quality of material and surrounding environment circumstances.The utilization of local ingredients in stabilization is an economic requirement, however, due to the dearth of proper soil deposits, there is a dire requirement for stabilization of weak soil deposits and solid waste materials to be used as an engineered construction material in various geotechnical applications for bulk utilization. Flexible pavement is a load-bearing structure consisting of layers of different granular materials above the natural sub-grade which eventually support all the load coming on to the pavement.

Subgrades are considered to be an important portion of pavements. All the loads above the pavement are ultimately conducted to the sub-grade. So, sub-grades are to be developed in such a way that in no case they are poor stressed.Since sub-grade is the natural soil deposit in its *in-situ* form it can be strong or weak. Therefore, primarily, we need to perform certain tests on it in order to checkout its strength and stability. One such test is the CBR test. If the sub-grade turns out to be weak it needs to be upgraded. Among various methods of improvement of sub-grades, one such is to go for the application of geosynthetic materials like geo-grids.Geosynthetics are defined herein as fabrics, grids, composites, or membranes.Geo relates to earth or ground,while synthetic refers to man-made material.The prefix geo can also be used with fabric, grid, composite, or membrane.The rapid development of geo-synthetics for soil reinforcing is a historic milestone in soil improvement techniques. The characteristics of polymers such as high tensile strength and load installation costs made their function quite attractive.Geosynthetics are used successfully to reinforce soil structures in applications such as embankments, tunnels, earth retaining walls, dams, and unpaved roads.When geo-grids are placed inside the sub-grade its modulus of elasticity gets boosted because of the vertical strain at the top of subgrade, corresponding to any particular load gets reduced. In other words, we can say that the number of passes of any load on the pavement which would result in the same amount of rutting at the top of sub-grade increases with the use of geogrids, thus, the design life of pavements gets increased. Status of subgrade can be found experimentally by a test called CBR test. More value of CBR confirms a strong sub-grade. So, if geogrids are used in weak subgrades its CBR value increases. It needs a lot of experimental work to find out the optimal position of placement of geo-grids inside the subgrade. In this course of work focus was laid on finding the optimal position for the placement of geo-grid inside the subgrade.

Soil

Soil samples were taken from three different sites along the banks of Sindh Nalla at Ganderbal, J&K, India at a depth of about 0.7 – 0.8 m from the ground surface. After conducting all the basic tests on these three soils successfully the weakest one was chosen for the study.

Various laboratory tests performed on the soil include the determination of physical properties, index properties, and engineering properties. All the tests were carried out as per the relevant standards (IS:2720). following subsections describe the properties of the three soil samples obtained after conducting basic laboratory tests.

Physical properties

a) Field moisture content and dry unit weight

Field moisture content and bulk unit weight of the soil samples collected from three different sites were determined as per the relevant testing standards. Average values of moisture content are 33.82%, 33.23%, and 33.20% respectively for site 1, site 2 and site 3 samples. Similarly, average values of dry unit weight are 13.9 KPa, 13.6KPa and 14.8KPafor the three sites respectively.

1. **Specific gravity**

It is the density of soil with respect to water. It is frequently used in analysing the soil for most of the geotechnical properties. Specific gravity was determined as per IS 2720 Part 3 1980 by density bottle method using distilled water. An average value of specific gravity for Site 1, Site 2 and Site 3 came out to be 2.64, 2.65 and 2.66 respectively.

2. **Particle size analysis**

It is also known as mechanical analysis, is the major one of the proportions of the various sizes of primary soil particles as determined usually either by their capacities to pass through sieves of various mesh size or by rates of settling in the water. The proportions are usually presented by the relative weight of particles within stated size classes. Finally, a particle size distribution curve is plotted.

Mechanically analysis is done in two stages;

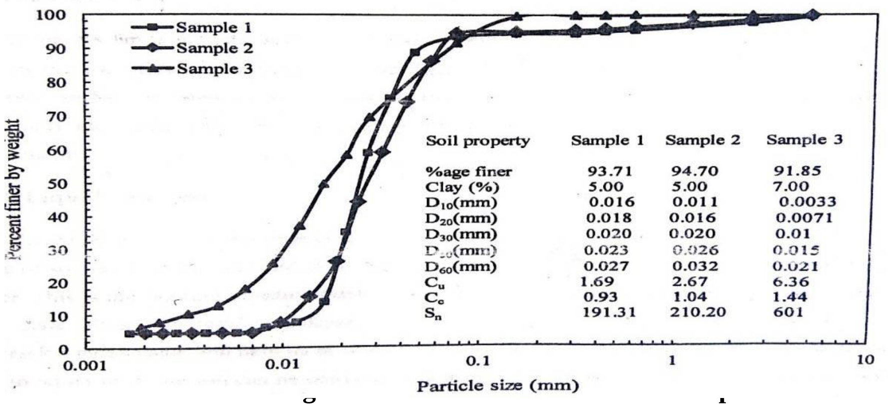
1. **Sieve analysis**
2. **Sedimentation analysis**

Sieve analysis is meant for coarse-grained particles that are particles which retain on 75 µ sieve. While as sedimentation analysis is meant for fine-grained particles that are particles passing 75 µ sieve. For any soil, we may require a combined analysis comprising of both sieves as well as sedimentation analysis. In the present study gradation analysis of all the three soil samples was carried out on own dried soil samples by dry and wet sieve analysis as per IS 1498- 1970 followed by sedimentation analysis as per IS:2720 Part 4 using a hydrometer. It was found that all the three soil samples collected from their respective sites contain 5% and 7 of the clay portion. All of these were silt dominated and the soils were poorly graded.

b) Index properties

These are indicative of the engineering properties of soil for fine-grained soils the main index properties are Atterberg's Limits and consistency while as for coarse-grained soils, these are particle size and relative density.

Atterberg's limits include liquid limit, plastic limit, and shrinkage limit. These limits are very useful in the classification of soils. The Atterberg's limits either individually or other soil properties can be correlated to other properties like compatibility, compressibility, shear strength, etc. soils with same consistency limits have been observed to behave somewhat in a similar manner.



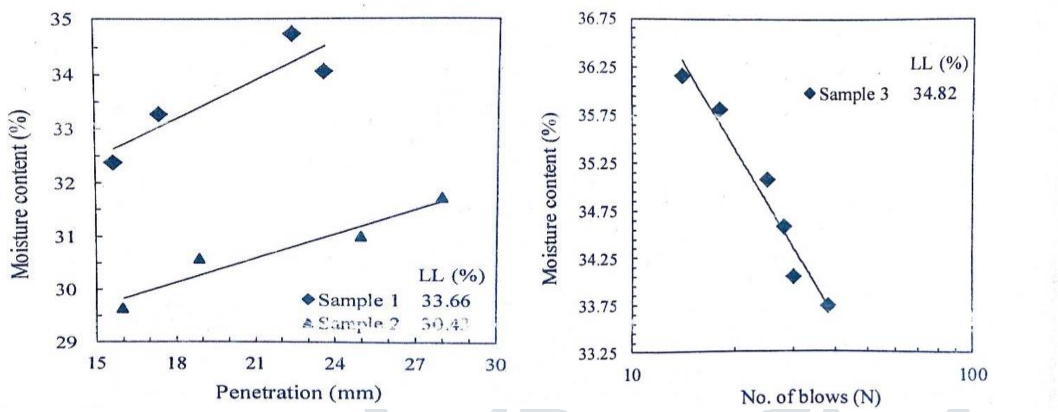
es

1. **Liquid limit test**

The liquid limit is the moisture content at which groove formed by a standard tool into the sample of soil taken in the standard cup closes for 12.5mm on being given 25 blows in a standard manner. this is the limiting moisture content at which the cohesive soil passes from liquid state to a plastic state. From the results of liquid limit, the compression index may be estimated. The compression index value will help us in settlement analysis if the natural moisture content of the soil is closer to the liquid limit, the soil can be considered as soft. If the moisture content is lesser than the liquid limit, the soil can be considered as brittle and stiffer.

2. **Plastic limit test**

The plastic limit test was determined only for sample 3 and it came out to be 29.1%, while as for Sample 1 and Sample 2 it could not be determined. The reason behind these is that in sample 1 and Sample 2 the sand content present was having large particle size as compared to that in Sample 3. Because of this, the thread formation was precluded in these samples, hence were regarded as non-plastic soils.



(a) (b)

Fig. 3:Flow curves of Samples obtained by Cone Penetration Method (a) and (b) Cassagrande Method.

Geogrid

In this study four different types of geogrids were used viz., uniaxial geogrid of 40 KN/m (U40) and 60KN/m (U60) tensile strength and biaxial geogrid of 40 KN/m (B40) and 60 KN/m (B60) tensile strength respectively.

Table 1: Basic properties of Soil Samples

Test	IS Code	Sample 1	Sample 2	Sample 3
(A). *In situ*				
Bulk unit weight	IS:2720 (Part XXIX)-1975	18.6	17.7	19.7
Moisture content (%)	IS:2720 (Part II)-1973	33.82	30.23	33.20
Dry unit weight (kN/m^3)	IS:2720 (Part XXIX)-1975	13.9	13.6	14.8
Direct Shear Test	IS:2720 (Part XIII)-1986	c = 1.03 kPa ǿ = 1.15°	c = 1.56 kPa ǿ = 1.31°	c = 1.33 kPa ǿ = 1.72°
Unconfined Compressive Test	IS: 2720 (Part X)-1991	q_u= 2.90kPa	q_u = 4.33 kPa	q_u= 5.50 kPa
(B). Remoulded				
Particle size distribution	Grain size analysis (IS:2720 (Part IV)-1985)	Sand = 1.49% Silt = 93.51% Clay = 5%	Sand = 5.35% Silt = 89.65% Clay = 5%	Sand = 8.1% Silt = 84.85% Clay = 7%
Atterberg Limits	IS:2720 (Part V)-1985	LL = 33.66% PL = - PI = Non plastic	LL = 30.43% PL = - PI = Non plastic	LL = 34.82% PL = 29.1% PI = 5.72

		(ML) I_c= N.D. I_L= N.D. Activity = N.D.	(ML) I_c= N.D. I_L= N.D. Activity = N.D.	(ML) I_c= 0.28 I_L= 0.72 Activity = 0.82
Specific gravity	IS:2720 (Part III/sec. 1)-1980	2.64	2.65	2.66
Compaction test	IS:2720 (Part VIII)	OMC = 18.34% MDU = 16.4 kN/m^3	OMC = 19.20% MDU = 16 kN/m^3	OMC = 21.35% MDU = 15.8 kN/m^3

Direst Shear Test	IS:2720 (Part XIII)-1986	c = 23.13 kPa ǿ = 21.65°	c = 26.64 kPa ǿ = 18.02°	c = 29.05 kPa ǿ = 24.14°
Unconfines Compressive Test	IS:2720 (Part X)-1991	q_u= 21 kPa c_u= 3.82 kPa	q_u= 25 kPa c_u= 4.55 kPa	q_u= 26.7 kPa c_u= 11.20 kPa

Table 2: Properties of these geogrid materials are given in the table below

Geogrid type	Tensile strength		Aperture size
Uniaxial (40 kN/m)	MD	40	1.8 × 2
	CMD	20	
Uniaxial (60 kN/m)	MD	60	1.8 × 2
	CMD	20	
Biaxial (40 kN/m)	MD	40	2.4 × 2.4
	CMD	40	
Biaxial (60 kN/m)	MD	60	1.7 × 2.1
	CMD	60	

II. Literature Survey

Nazzal,M. *et. al* 2006 the author gave the idea to examine the advantages of geogrid reinforcements in layers of pavement were analyzed by FE model. Geogrid of higher tensile stiffness and having more value of interface friction coefficient provides better performance as a result of a reduction in stress and deformation on the subgrade with the used of ABAQUS. Analyzed the improvement in pavement section using geogrid with consideration of different parameters like axial stiffness of geogrids and base course thickness.

Saride et. al 2010 These rutting models provided guidance for pavement structure design and analysis.Thermal cracking in flexible pavement occurs when the tensile stress surpasses the tensile strength of hot-mix asphalt at a given temperature or when fluctuating stresses and strains caused by temperature variation lead to a build-up of irrecoverable deformations over time.This distress is critical because it is associated with high repair costs and the acceleration of other failure mechanisms, such as weakening of subgrade and aggregate layers through water infiltration, stripping in hot-mix asphalt (HMA) layers, and loss of subgrade support Thermal cracking includes both low-temperature cracking and thermal fatigue cracking. Then **Sujata *et. al* 2012** the researcher found that when the geogrids are placed at a distance 2/3 of the subgrade depth from the base, it showed higher CBR value than when placed at ½ and 1/3 distance from the base. Also, CBR values obtained when two layers geogrids are placed are significant than when a single layer is used. They have also used three layers of geogrids inside the subgrade and found that the CBR value of this arrangement lies somewhere in between the two earlier mentioned cases.After that **Kuity and Roy 2013**, have studied both soaked and unsoaked CBR tests on the poor subgrade. The soil has been added with waste materials like pond ash and rice husk ash in different proportions. They have also added lime as an add mixture in different proportions. It was reported that with the use of geogrids there was a significant improvement in the CBR values of soaked samples as compared to the unsoaked ones.**Rajesh *et. al* 2016** author gave the idea about the tensile capacity and interaction of reinforcement are responsible for soil resistance to penetration. Higher CBR values are observed for higher grid capacities and lower fines content. Moreover, the field results reported are higher than that of the lab. However, the stress-strain response is similar in both the type of tests. They have presented their results in terms of performance ratio which is the ratio of CBR values of soil with reinforcement to that of original soil. This ratio is indicative of geogrid contribution towards CBR improvement for a given unsoaked or soaked condition. **Zornberg, 2017** as reported several functions that are satisfied by geosynthetics. These include separation, filtration, reinforcement, stiffening, drainage, hydraulic barrier, protection, etc. One or more of the seven aforementioned geosynthetic functions are used to enhance the roadway performance in different applications.**Ahirwar and Mandal , 2017** conducted research on the flexible pavements through finite element analysis using EXAXIS 2D software. They have used Mohr-Columb Model for materials in the base layer, subbase layer and subgrade layer and elastic model interface element for geogrids to simulate the interaction condition. They have also taken the traffic intensity and thickness of each layer according to code provisions of Indian Road Congress (IRC; 37-2012).

III. Methodology

Sample preparation and methodology adopted

Since the soil chosen for this research is to be taken as the subgrade of flexible pavements therefore in order to check strength a common laboratory test known as CBR test was conducted on the soil both with and without using geogrid. Both soaked, as well as unsoaked CBR tests, were conducted. Initially, soaked as well as unsoaked CBR tests were conducted on the soil with no reinforcement being used. then all the four types of geogrids were used separately at different locations *viz.*, H/4. H/2 and 3H/4 in case of single layer reinforcement and H/4 and 3H/4 and H/3, 2H/3 in the case of double layer reinforcement and then the tests were conducted under both soaked and unsoaked conditions. After conduction of all the tests successfully inside the laboratory, results thus obtained were compared. For any particular depth selected for the placement of geogrid, effect of different types of geogrids towards CBR improvement was studied. Similarly, for any particular geogrid. Its effect in the CBR improvement was studied by varying its position along with the depth of CBR mould and also by increasing the number of layers of geogrid to be used inside the CBR mould.

Following the procedure, as per IS: 2720-16, was adopted for preparing the sample for CBR test

1. Take a required amount of soil passing 20 mm sieve and add water (OMC) by weight to it and then mix them thoroughly.
2. Fix the extension collar and the base plate to the mould. Insert the spacer disk over the base.
3. Place the filter paper on the top of the spacer disk.
4. Compact the mixed soil in the mould using either light compaction or heavy compaction. For light compaction compact the soil in three equal layers each layer being given 56 blows by the 2.6 kg rammer. For heavy compaction the compact the soil in five layers, 56 blows to each layer by the 4.89 kg rammer. In this study, light compaction was carried out.
5. Remove the collar and trim off excess soil.
6. Turn the mould upside down and remove the base plate and the displace disk.
7. Weigh the mould with compacted soil and determine the bulk density and dry density.
8. Put filter paper on the top of the compacted soil (collar side) and clamp the perforated base plate on to it.

For the unsoaked test, we can directly go for testing the soil sample at this stage. But if the sample is to be kept for soaking then before going to the test, the following few steps are to be followed.

1. Place the swell plate with the adjustable stem on the soil sample in the mould and apply sufficient annular weights to produce an intensity of loading equal to the mass of the subbase and base courses and surfacing above the tested material.
2. Immerse the mould in water to allow free access of water to the top and bottom of the specimen. During soaking maintain the water level in the mould and the soaking tank approximately 25 mm above the top of the specimen. Soak the specimen for 96 hours.

Now the actual testing for both soaked as well as unsoaked samples is as follows:

1. Place the mould assembly with the surcharge weights on the penetration test machine.

2. Seat the penetration piston at the centre of the specimen with the smallest possible load but in no case in excess of 4 kg so that full contact of the piston on the sample is established.
3. Set the stress and strain dial gauge to read zero. Apply the load on the piston so that the penetration rate is about 1.25 mm/mint.
4. Record the load readings at penetration of 0.5, 1.0, 1.5,2.0, 2.5, …, 18 mm.
5. Detach the mould from the loading equipment. Take about 20 – 50 g of soil from the top three-centimetre layer and determine the moisture content.
6. A load penetration curve of load against penetration is then plotted with load in ordinate axis and penetration in abscissa axis.
7. The loads corresponding to 2.5 and 5mm penetration values are noted, then CBR value is calculated for both these points. The higher of the two values is noted as the CBR of soil.

Calculation of CBR from load penetration curve

1. Plot the load penetration curve in natural scale. Load on Y-axis and penetration on X-axis.

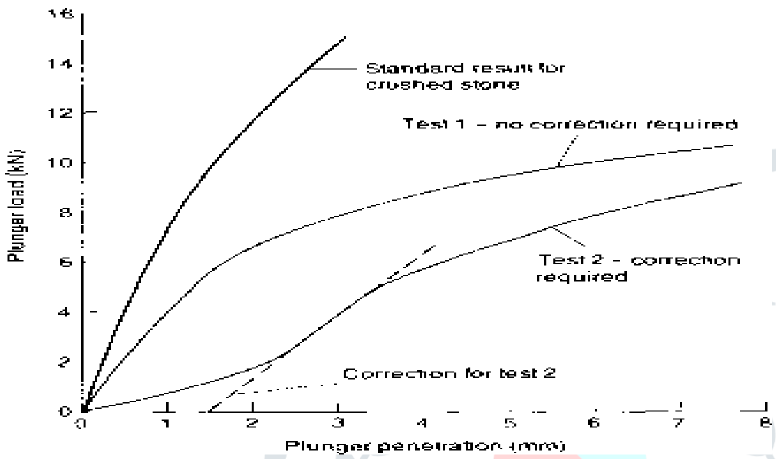


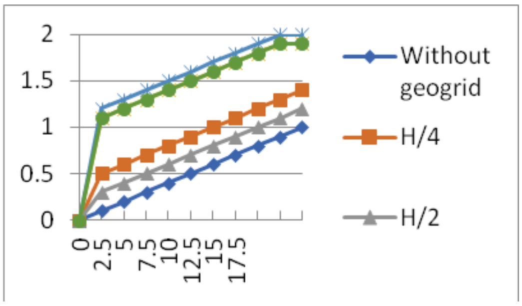
Fig. 4 : Corrected CBR with initial concavity

2. If the curve if uniformly convex upwards. Although the initial portion of the curve may be concave upwards due to surface irregularities make a correction by drawing a tangent to the upper curve at the point of contraflexure as shown in the figure A typical testing apparatus is shown above.
3. Take the intersection point of the tangent and the X-axis as the origin. Calculate the CBR values for penetration of 2.5 and 5 mm.
4. Corresponding to the penetration value at which CBR is to be desired take the corrected load values from the load penetration curve and calculate the CBR .

IV. Result and Analysis

a) Unsoaked CBR test Results

Figures from 5 to 7 below indicate the Unsoaked CBR test results separately for different geogrids used inside the mould at various locations and with a varying number of layers.



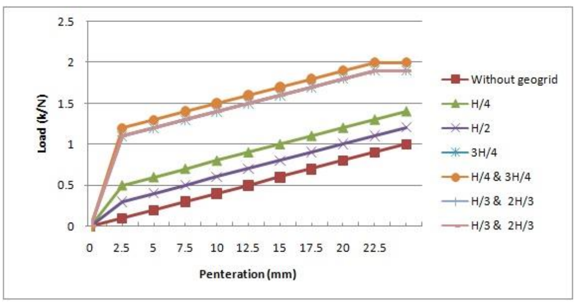
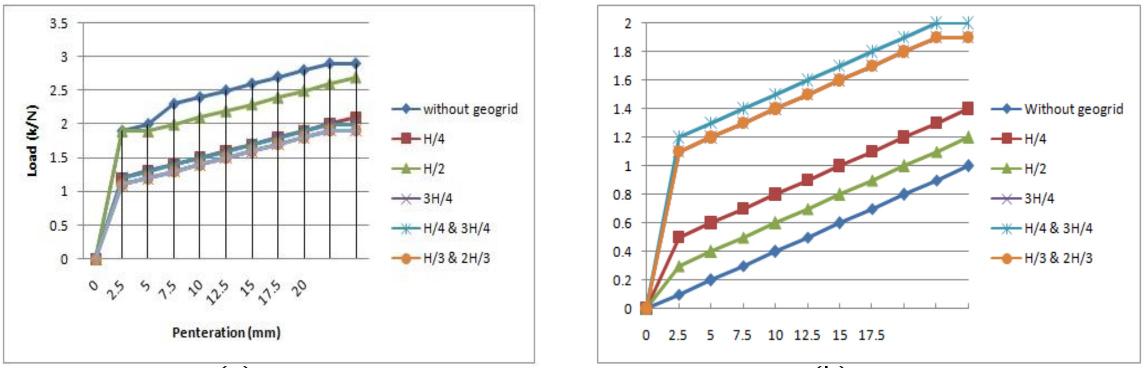


Fig.5:Unsoaked CBR curves for the soil with, U -40 geogrid placed at various locations

Fig.6: Unsoaked CBR curves for the soil with U-60 geogrid placed at various locations



(a) (b)

Fig.7: Unsoaked CBR curves for the soil with a) B - 40 , b) B - 60 geogrid placed at various locations

Figures from 5 to 7 reveal that by using geogrid, CBR value increases substantially. For all the types of geogrids used in this study maximum CBR value is obtained when Geogrid is placed at H\4 from the top and at 3H\4 from the top in single layer reinforcement. Similarly, for double layer, geogrid reinforcement maximum CBR value is achieved when Geogrid layers are placed at H\3 and 2H\3 from the top.

Since stresses due to vehicular loads are maximum at the top of subgrade than at lower layers, therefore when geogrid is placed near the top it takes maximum load than when placed at lower layers. With the results lesser amount of load is to be supported by the subgrade. Thus, the CBR of subgrade gets improved maximum when geogrid is placed near the top. Also, double layer reinforcement revealed higher values as compared to single layer reinforcement. Reason for this is quite obvious. Two layers of geogrids are able to resist more load as compared to one layer. Hence, they contribute more towards CBR improvement. A similar trend was also observed by Sujatha et al. (2012).

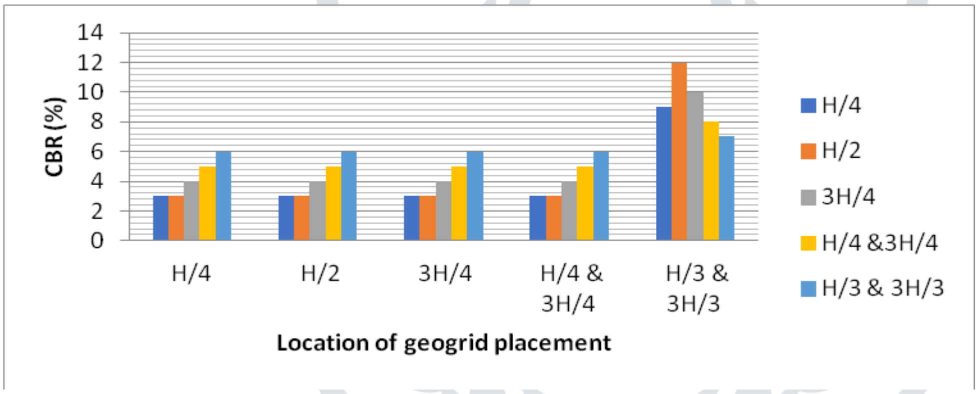


Fig.8: Effect of various types of geogrids towards CBR improvement under unsoaking conditions

Fig 8. above compares the effect of various types of geogrids towards CBR improvement when placed at any particular location under unsoaking condition. From fig 4.5, it is quite evident that the maximum value of CBR is obtained when B- 60 is used. It is also seen that in the case of U -40 geogrid, CBR value was seen to increase by the factors ranging from 1.26 to 2.1. For other geogrid types i.e.; U-60, B-40, and B-60, these factors were found ranging from 1.46 to 2.31, 1.1 to 1.92 and 1.56 to 2.54 respectively.

4.1. Soaked CBR test results

Figures from 9 and 10 below show the soaked CBR test results separately for different geogrids used inside the mould at various locations and with a varying number of layers. For soaked tests, the sample was kept under the soaking condition for 96 hours. Then it was removed and excess water was allowed to drain out before the sample was tested.

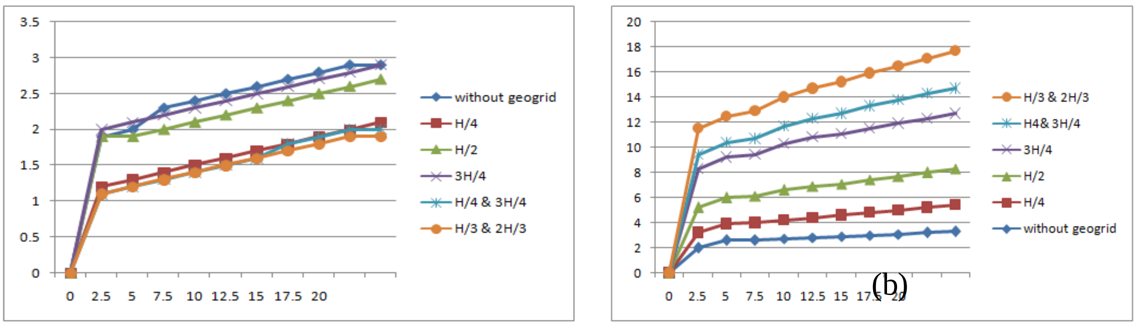
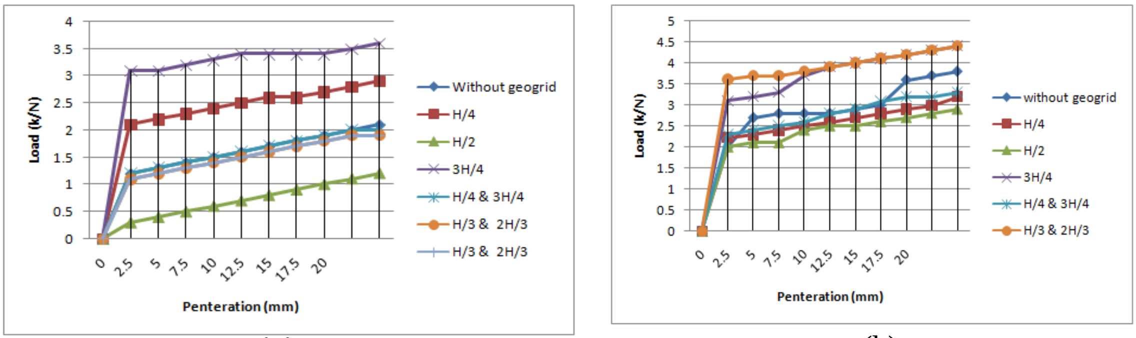


Fig. 9: Soaked CBR curves for the soil with a) U- 40 , b) U- 60 geogrid placed at various locations



(a) (b)

Fig. 10: Soaked CBR curves for the soil with a) B- 40 , b) B- 60 geogrid placed at various locations

From figures 9 and 10 we can see that soaked tests followed the same trend as is followed by unsoaked tests. But the effect of geogrids is more prominent in soaked tests as compared to unsoaked ones. In double layer geogrid placement, almost same CBR values were obtained in both the types of placement of geogrids, still the case when geogrids were placed at H\3 and 2H\3 from the top showed slightly higher value.

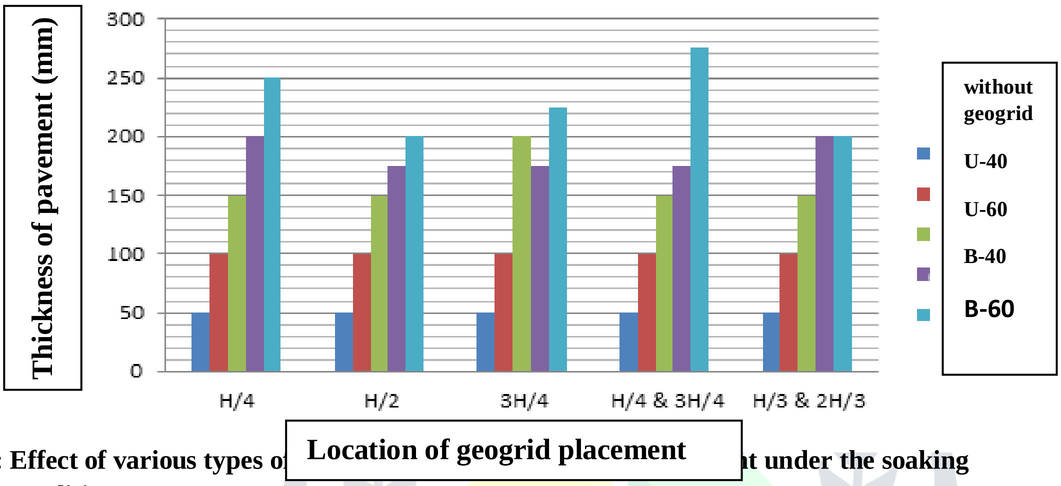


Fig .11: Effect of various types o[...]t under the soaking condition

From figure 11, it can be seen that just like in unsoaked tests, the maximum value of soaked CBR is obtained when B-60 is used. However, again usage of B-40 geogrid revealed minimum CBR values due to the same reasons as are already mentioned for unsoaked tests.

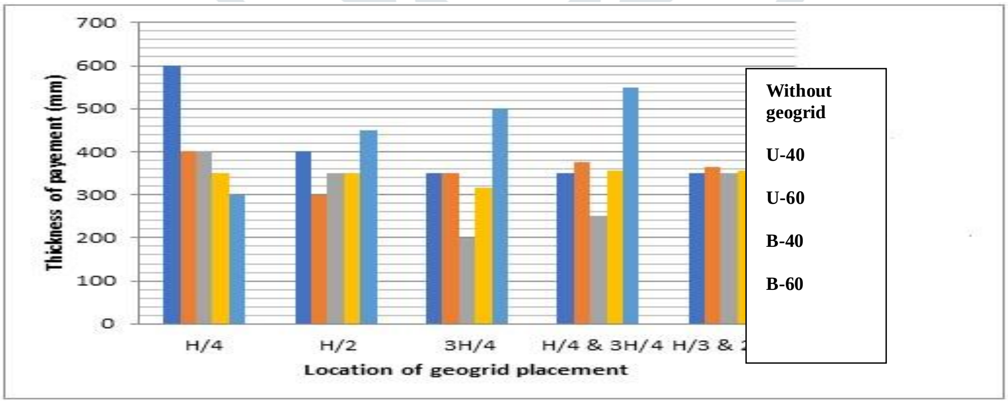


Fig. 12: Thickness of pavements corresponding to different geogrids at different locations

Thus, it is quite evident from the above two figures that with the use of geogrids, the thickness of flexible pavements gets drastically reduced. Hence, we can economize the construction to a large extent.

V. Conclusion and Future Scope

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.

1. By using geogrid, CBR value increases substantially. For all the types of geogrids used in this study maximum CBR value is obtained when Geogrid is placed at H\4 from the top and at 3H\4 from the top in single layer

reinforcement. Similarly, for double layer, geogrid reinforcement maximum CBR value is achieved when Geogrid layers are placed at H\3 and 2H\3 from the top.

2. Two layers of geogrids are able to resist more load as compared to one layer.
3. It is quite evident that the maximum value of CBR is obtained when B- 60 is used
4. Soaked tests followed the same trend as is followed by unsoaked tests. But the effect of geogrids is more prominent in soaked tests as compared to unsoaked ones
5. In double layer geogrid placement, almost same CBR values were obtained in both the types of placement of geogrids, still the case when geogrids were placed at H\3 and 2H\3 from the top showed slightly higher value.
6. The maximum value of soaked CBR is obtained when B-60 is used. However, again usage of B-40 geogrid revealed minimum CBR values due to the same reasons as are already mentioned for unsoaked tests.
7. The effect of geogrids is relatively more prominent in soaked CBR tests as compared to unsoaked ones

The use of Geogrids should, therefore, be encouraged as an effective and modern form of improving road construction on poor sub-grade materials. Further research should be analyzed in ascertaining the effect of geogrids on subgrade soils under the unsoaked condition.

5.1 Future Scope

From above discussion, it can be said that geogrids may serve better even on soaked conditions too. We have collected traffic data only for two-lane two-way traffic It can be applicable to more lanes also. It can be applicable for plain, rolling, hilly and steep roads also. For any industrial region where the traffic is high, it is suggested to place more than a single layer of geogrid.

VI. References

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