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Application of Geo-Grids in Enhancing Performance and Durability of Flexible Pavements

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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, Subgrade, 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

States that the first use of fabrics in reinforcing roads was attempted by the South Carolina Highway Department in 1926. A heavy cotton fabric was placed on a primed earth base, hot asphalt was applied to the fabric, and a thin layer of sand was put on the asphalt. The department published the results of this work in 1935, describing eight separate field experiments until the fabric deteriorated, the results showed that the roads were in good condition and that the fabric reduced cracking, raveling, and localized road failures. This project was certainly the forerunner of the separation and reinforcement functions of geosynthetic materials as we know them today. There are specific types of geosynthetics: geotextiles, geogrids, geonets, geomembranes, geosynthetic-clay liners, geofoams, and geo-composites.

Geogrids consist of heavy strands of plastic materials arranged as longitudinal and transverse elements to outline a uniformly distributed and relatively large grid-like array of apertures in the resulting sheet. These apertures allow direct contact between soil particles on either side of the sheet. Geogrids are characterized by integrally connected elements within-plane apertures (openings) uniformly distributed between the elements. The apertures allow the soil to fill the space between the elements, thereby increasing soil interaction with the geogrid and ensuring unrestricted vertical drainage. Their applications are not only in highway but also in railroad track construction and rehabilitation.

Geogrids have been used successfully in pavement layer studies; placed geogrid between gravel base course and sand subgrade and showed the increase in CBR value of the subgrade material. Gosavi et al also investigated the strength behavior of soils reinforced with mixed geogrid woven fabric and showed that the soaked CBR without the geogrid was about 4.9% and after application of the geogrid test results showed an improvement in the CBR value. Naeini and Moayed indicated that using a geogrid at top of the layer 3 in a soil sample with different plasticity index causes a considerable increase in the CBR value compared with unreinforced soil in both soaked and unsoaked conditions. In order to quantify the amount of increase in the penetration resistance, the reinforcement ratio is taken into consideration. The reinforcement ratio according to is defined as the ratio of the Load with the geotextile to the Load without the geotextile.

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.

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 behavior of jute reinforced subgrade soil under dynamic load.

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, mouldplunger 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.

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.

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.





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III. MATERIAL AND METHODOLOGY

3.1 EXPANSIVE SOIL

Expansive soil is a kind of special Cohesive soil. the kind of soil can significantly become to soften after it absorbs water, and it also can become to contract after it losses water. It is a kind of Strong hydrophilic mineral geological body that was formed in the process of long-term natural geological historical role.

Expansive soil is high plastic clay that contains montmorillonite and illite as the main mineral composition. The clay content of the expansive soil is high, the free expansion rate is commonly more than 40%, and the liquid limit is higher than 40%. The expansive soil has not only the commonness of clay soil but also has its own particularity. The expansive soil has a specialty that it can be repeated deformation of wet bilge and drying shrinkage.

The engineering properties of expansive soil have multiple fractures, over consolidation, swelling, collapse, weathering properties, the intensity attenuation, etc. Swell-shrink of expansive soil caused the destruction of buildings because of having repeatability and long-term potential hazards for many times, often can cause disasters to human beings.



- Ease of Construction: The Geogrid can be installed in any weather conditions. This makes it more demanding.
- Land Optimization: This method of Geogrid installation in soils makes an unsuitable area suitable for preparing it to meet desired properties for construction. Geogrid thus helps in proper land utilization.
- Geogrid promotes soil stabilization.
- A higher strength soil mass is obtained.
- Higher load bearing capacity.
- It is a good remedy to retain soil from erosion
- No requirement of mortar. The material is implemented dry.
- No difficulty in material availability.
- Geogrids are flexible in nature. They are known for their versatility.
- Geogrids have high durability reducing maintenance cost. They are highly resistant to environmental influences.
- Materials are tested based on standard codes and regulations.

The Geogrid construction in pavement construction have following features:

- **Improvement of subgrade:** The subgrade, which is the most important load-bearing strata, is made solid and strong by the Geogrids. The problem of soft subgrade can be solved by this method.
- **Reinforcement of pavement base:** The thickness of base if increased would increase the stiffness of base. But increasing thickness enormously is not economical. The reinforcement of a given base layer would give adequate stiffening that helps in reduction of thickness and time of construction. This also helps in increasing the life of the pavement.





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3.3 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. 3.2 Methodology of Project

3.4 INSTALLATION OF PAVING GEOGRID

Roll Placement

Successful use of geosynthetics in pavements requires proper installation, and Figure shows the proper sequence of construction. Even though the installation techniques appear fairly simple, most geosynthetic problems in roadways occur as the result of improper construction techniques. If the geosynthetic is ripped or punctured during construction activities, it will not likely perform as desired. If a geogrid is placed with a lot of wrinkles or folds, it will not be in tension, and, therefore, cannot provide a reinforcing effect. Other problems occur due to insufficient cover over the geotextiles or geogrids, rutting of the subgrade prior to placing the geosynthetic, and thick lifts that exceed the bearing capacity of the soil. The following step-by-step procedures should be followed, along with careful observations of all construction activities.

- 1. The site should be cleared, grubbed, and excavated to design grade, stripping all topsoil, soft soils, or any other unsuitable materials. If moderate site conditions exist, i.e., CBR greater than 1, lightweight proof rolling operations should be considered to help locate unsuitable materials. Isolated pockets where additional excavation is required should be backfilled to promote positive drainage. Optionally, geotextile wrapped trench drains could be used to drain isolated areas.
- 2. During stripping operations, care should be taken not to excessively disturb the subgrade. This may require the use of lightweight dozers or grade-all's for low strength, saturated, noncohesive and low-cohesive soils. For extremely soft ground, such as peat bog areas, do not excavate surface materials so you may take advantage of the root mat strength if it exists. In this case, all vegetation should be cut at the ground surface. Sawdust or sand can be placed over stumps or roots that extend above the ground surface to cushion the geogrid. Remember, the subgrade preparation must correspond to the survivability properties of either the geogrid.
- 3. Once the subgrade along a particular segment of the road alignment has been prepared, the geogrid should be rolled in line with the placement of the new roadway aggregate. Field operations can be expedited if the geogrid is manufactured to design widths in the factory so it can be unrolled in one continuous sheet. Geogrids should be placed directly on top of geotextiles when used together. The geosynthetic should not be dragged across the subgrade. The entire roll should be placed and rolled out as smoothly as possible. Wrinkles and folds in the geogrid should be removed by stretching and staking as required.
- 4. Parallel rolls of geotextiles or geogrids should be overlapped, sewn, or joined as required.
- 5. For curves, the geogrid should be cut and overlapped in the direction of the turn.
- 6. When the geogrid intersects an existing pavement area, the geosynthetic should extend to the edge of the old system. For widening or intersecting existing roads where geotextiles or geogrids have been used, consider anchoring the geogrid at the roadway edge. Ideally, the edge of the roadway should be excavated down to the





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existing geosynthetic and the existing geosynthetic mechanically connected to the new geosynthetic (i.e., mechanically connected with plastic ties to the geogrid). Overlaps, staples, and pins could also be utilized.

- 7. Before covering, the condition of the geogrid should be checked for excessive damage (i.e., holes, rips, tears, etc.) by an inspector experienced in the use of these materials. If excessive defects are observed, the section of the geosynthetic containing the defect should be repaired by placing a new layer of geosynthetic over the damaged area. The minimum required overlap required for parallel rolls should extend beyond the defect in all directions. Alternatively, the defective section can be replaced.
- 8. The base aggregate should be end-dumped on the previously placed aggregate. For very soft subgrades, pile heights should be limited to prevent possible subgrade failure. The maximum placement lift thickness for such soils should not exceed the design thickness of the road.
- 9. The first lift of aggregate should be spread and graded to 12 in. (300 mm), or to the design thickness if less than 12 in. (300 mm), prior to compaction. At no time should traffic be allowed on a soft roadway with less than 8 in. (200 mm), (or 6 in. {150 mm} for CBR \geq 3) of aggregate over the geogrid. Equipment can operate on the roadway without aggregate for geocomposite installation under permeable bases if the subgrade is of sufficient strength. For extremely soft soils, lightweight construction vehicles will likely be required for access on the first lift. Construction vehicles should be limited in size and weight so rutting in the initial lift is limited to 3 in. (75 mm). If rut depths exceed 3 in. (75 mm), it will be necessary to decrease the construction vehicle size and/or weight or to increase the lift thickness. For example, it may be necessary to reduce the size of the dozer required to blade out the fill or to deliver the fill-in half-loaded rather than fully loaded trucks.
- 10. The first lift of base aggregate should be compacted by tracking with the dozer, then compacted with a smoothdrum vibratory roller to obtain a minimum compacted density. For the construction of permeable bases, compaction shall meet specification requirements. For very soft soils, design density should not be anticipated for the first lift and, in this case, compaction requirements should be reduced. One recommendation is to allow compaction of 5% less than the required minimum specification density for the first lift.
- 11. Construction should be performed parallel to the road alignment. Turning should not be permitted on the first lift of base aggregate. Turn-outs may be constructed at the roadway edge to facilitate construction. On very soft subgrades, if the geogrid is to provide some reinforcing, pretensioning of the geosynthetic should be considered. For pretensioning, the area should be proof rolled by a heavily loaded, rubber-tired vehicle such as a loaded dump truck. The wheel load should be equivalent to the maximum expected for the site. The vehicle should make at least four passes over the first lift in each area of the site. Alternatively, once the design aggregate has been placed, the roadway could be used for a time prior to paving to prestress the geogrid-aggregate system in key areas.

IV. RESULTS AND DISCUSSION

4.1 TRAFFIC DATA ANALYSIS

Computation of Design Traffic:

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

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 formula $A = P (1 + r)^{x}$. Where,

P= Number of commercial vehicles as per last count = **2646.** \mathbf{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.





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4.2 GRAIN SIZE DISTRIBUTION

Sample Weight:1000 Grams

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

Table-5.1 Grain Size Distribution Data

4.3 ATTERBERG LIMITS

I. LIQUID LIMIT

SL. NO	DESCRIPTION	Ι	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

II. PLASTIC LIMIT

SL.NO	DESCRIPTION		II
1	Container Number		2
2	The weight of container + Wet Soil in grams		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	Average Plastic Limit W _P 18.65	

Table-5.3 Plastic Limit Data of soil Sample





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4.4 STANDARD PROCTOR COMPACTION TEST

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

SL NO:	DESCRIPTION	Ι	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 5.4 Standard Proctor Compaction Test Observables

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

4.5 CALIFORNIA BEARING RATIO TEST

Description	CBR Value @ 2.5mm
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 -5.9 CBR Value Variation with Geogrid Application in Soil Sample

V. 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.

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. Further research should be analyzed in ascertaining the effect of geogrids on subgrade soils under the unsoaked condition.





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