International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 8 Aug 2023, pp: 340-344www.ijaem.net ISSN: 2395-5252

Reducing Highway Construction Costs by the Use of Geo-Grids in Flexible Pavement

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Date of Submission: 10-08-2023 Date of Acceptance: 20-08-2023

ABSTRACT: Road networks are like the veins & arteries of the economy in any country. Our country India is in the developing stage and second most populated in the world. Therefore road networks play a very important role in our economy. Now a day's road network in India is the second largest in the world after the United States of America. But roads are not giving desired output due to poor CBR value of soil.

A major deficiency in Indian roads is cracks in the surface, ruts, formation of potholes and localised depressions & settlements, especially in the rainy season.

These deficiencies are mainly due to the lower bearing capacity of the subgrade in water saturation conditions. The subgrade soil has a mostly low CBR value of 2 to 5%. Pavement design by CBR method of IRC: 37-2018 The total thickness of pavement increases exponentially with a decrease in the CBR value of subgrade soil which in turn increases the cost of pavement. Therefore, it has been tried to use the geogrid for increasing the bearing capacity of the subgrade. Laboratory and field CBR tests are conducted on soil samples with and without the inclusion of a geogrid layer and also by varying the position of it in the mould. Application of geogrid increases the CBR value of the subgrade and it reduces the pavement thickness considerably up to 40%. This study will have reduced the highway construction cost as well as maintenance cost. Our project will discuss in detail the process and its successful applications in flexible pavement.

KEYWORDS: Geogrids, Flexible Pavement, Pavement Design,CBR Value, Expansive Soil.

I. INTRODUCTION

Plains and coastal areas in India have soft & loose soil at ground level. Roads constructed over this loose soil required higher thickness of granular materials resulting in the higher construction cost. Alternate attempts to reduce the thickness of pavement layers to make an economic construction will lead to early damage of the pavement which in turn will make the road unserviceable within a short time. This condition may be further worsened if supplemented with poor drainage. 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 conditions in those states. Looking at the poor road condition in some states of India use of geogrid is an option for road construction to improve the performance of roads. Geogrid is a geosynthetic manufactured from polymers selected for road construction.

Fig-1: Representation ofthe use of Geogrid in Pavement

The use of Geogrids within pavement layers performs two of the primary functions of Geosynthetics i.e. Separation and Reinforcements. Due to the large aperture size associated with most commercial geogrid products, geo grids are typically not used for achieving the separation of dissimilar materials. 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

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materials. However, geo grids can theoretically provide some measure of separation. For this reason, separation is a secondary function of geo-grids used in pavement layers. The primary function of geo grids used pavements in reinforcement, in which the geo grid mechanically improves the engineering properties of the pavement system. The reinforcement mechanisms associated with geogrids.

II. LITERATURE REVIEW

Geogrids have been used in civil engineering constructions for the past 25 yrs. This is a result of continuous research in laboratory and field all over the world.

III. GEOGRID MATERIAL

Geogrids are commonly made of polymer materials, such as polyester, polyvinyl alcohol, polyethene or polypropylene. They may be woven or knitted from yarns, heat-welded from strips of material or produced by punching a regular pattern of holes in sheets of material, then stretched into a grid. The Geogrid can be installed in any weather conditions. Geogrids are flexible they are known for their versatility. Geogrids have high durability reducing maintenance costs. They are highly resistant to environmental influences. There are three types of geogrids i.e. **Uniaxial, Biaxial &Triaxial**.

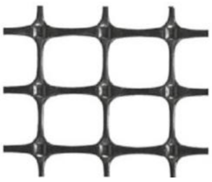

Fig-2: Uniaxial Geogrid Fig-3: Biaxial Geogrid

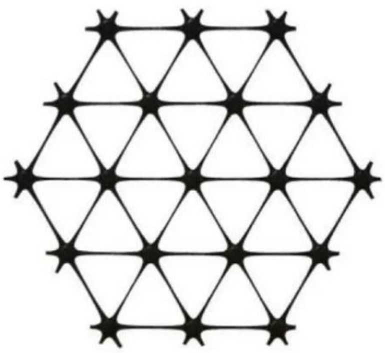

Fig-4: Triaxial Geogrid

IV. APPLICATION OF GEO GRIDS

The function of geogrids is to hold or capture the aggregates together. This method of interlocking 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 given below.

Fig-5: Representation of Geogrid confining the aggregates

The geogrids as discussed above helps in redistribution of load over a large area. This function has made the pavement construction more stabilized and strong. Following functional mechanisms 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.

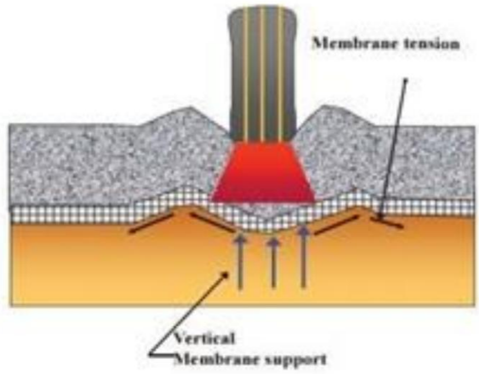

Fig-6: Tension Member Effect

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.

2. Improvement of Bearing Capacity

One of the main mechanisms 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. A representation of this concept is given below

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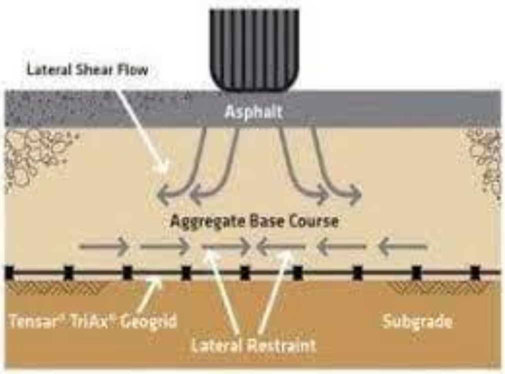


Fig-7: Mechanism for Improved Bearing Capacity

The Geogrid layer possesses sufficient frictional resistance that opposes subgrade lateral movement. This mechanism 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.

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. This in turn affects the stability of the whole pavement arrangement. The Geogrid act a restraint against this lateral movement.

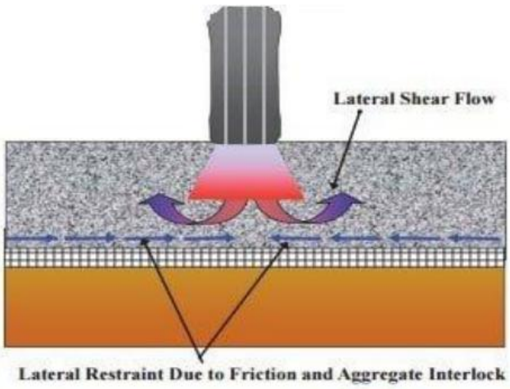


Fig-8: Lateral Restraining Capability

V. OBJECTIVES OF THE STUDY

- ❖ To reduce the thickness of Pavement. So, as to reduce the construction cost of road.
- ❖ To Design Pavement thickness based on CBR and MSA traffic as per IRC: 37-2018.
- ❖ To increase the load carrying capacity of the road (Strength of road).
- ❖ Increase the Service Life of Road

VI. EXPERIMENT, RESULTS & ANALYSIS

Laboratory and field CBR tests are conducted on soil samples with and without the inclusion of Geogrid and also by varying the position of geogrid in the mould at H/4, H/2 and 3H/4 from bottom. Where H is the height of the mould.

CBR test result is presented below:-

Without geogrid

CBR @ 2.5 mm Penetration	2.15
CBR @ 5.0 mm Penetration	1.85

With geogrid at H/4 from bottom

CBR @ 2.5 mm Penetration	2.75
CBR @ 5.0 mm Penetration	2.25

With geogrid at H/2 from bottom

CBR @ 2.5 mm Penetration	3.35
CBR @ 5.0 mm Penetration	3.55

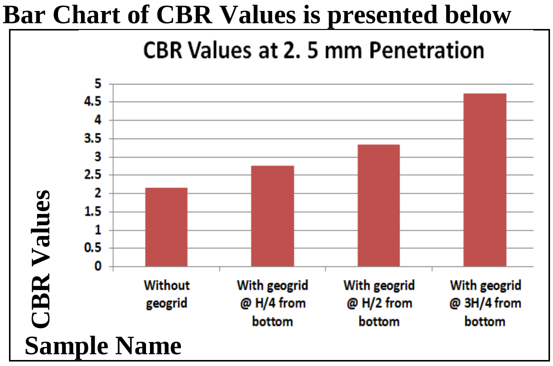
With geogrid at 3H/4 from bottom

CBR @ 2.5 mm Penetration	4.75
CBR @ 5.0 mm Penetration	3.25

Summary of CBR Values at 2.5 mm Penetration

Sample Name	CBR Value
Without geogrid	2.15
With geogrid @ H/4 from bottom	2.75
With geogrid @H/2 from bottom	3.35
With geogrid @ 3H/4 from bottom	5.75

Bar Chart of CBR Values is presented below



Traffic data analysis

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.

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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) = 3.75
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 = 1920 No
x = Number of years between the last count and the year of completion of construction. (Say 2 Year).
By substituting above Values, N Value is Computed as 39.66 MSA, **Say 40 MSA**

VII.DESIGN OF FLEXIBLE PAVEMENT

(As per IRC: 37-2018)

Bituminous Surfacing with Granular Base and Granular Sub-base:

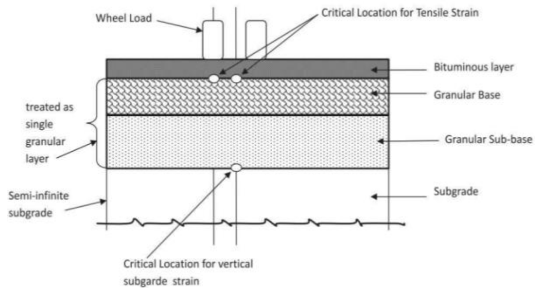

Fig-9: Bituminous Surfacing with Granular Base and Granular Sub-base

IR: 37-2018: Pavement Design Catalogues

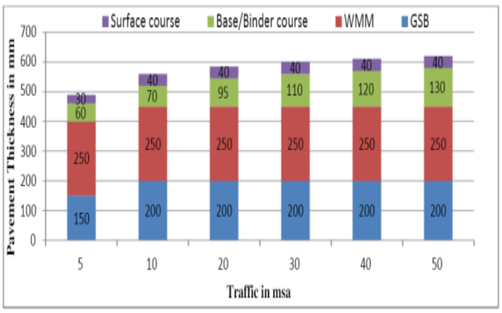

Fig-10: Catalogue for pavement with bituminoussurface course with granular base and sub-base - Effective CBR 6% (Plate-2)

Pavement Thickness without Geogrid:
CBR Value: 2.15 %,
Traffic (N): 40.00 MSA

Result: Not fit for laying pavement layers directly on the Subgrade soil, required Stabilization of soil.

Pavement Thickness with Geogrid at 3H/4 from bottom:
CBR Value: 5.75 %, Say 6%,
Traffic (N): 40.00 MSA

Result: Thickness of GSB: 200 mm, WMM: 250, DBM: 130 mm, BC: 40mm
The thickness of pavement required in MM:

Layer Name	Without geogrid	With geogrid @ 3H/4 from bottom
GSB	N.A	200
WMM	N.A	250
DBM	N.A	130
BC	N.A	40
Total Pavement Thickness	Soil Stabilization required	620

N.A: Not Applicable

VIII. CONCLUSION

The positive effects of geo grid reinforced sub grade courses can economically and ecologically be utilized to reduce pavement thickness. And it can also increase the life of the pavement and can also decrease the overall construction cost.

The study investigated the application of geo grids to sub grade 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 sub grade is significantly altered positively by the positioning of the geo-grid at varying depth. It was observed that the highest sub grade 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 sub grade in the soaked condition. The use of geo grids as reinforcement to poor soils improves its strength. It is non-bio degradable therefore it is durable; it also increases the ultimate service life of the pavement. The use of Geo grids should, therefore, be encouraged as an effective and modern form of improving road construction on poor sub-grade materials.

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