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A Review on Use of Synthetic Geogrids for Soil Reinforcement

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Abstract: - In recent times, soil reinforcement is considered as one of the most important tool in various civil engineering projects since removal and replacement is not an economically viable option. One of the most important applications is in field of subgrade stabilization of pavement. As the subgrade serves as the foundation for pavement it should have sufficient load carrying capacity. In India more than 20% land area is covered with soils having low CBR and shear strength values. The pavement constructed over such soils deteriorates significantly under heavy wheel loads. In order to overcome such situations recently use of geosynthetic materials comes into picture. Their use reduces the construction cost and time drastically in comparison to other conventional reinforcement materials. The present study reviews the available state of the art knowledge on use of synthetic geogrids in soil reinforcement purposes including their types, initial development and use areas.

Keywords: - geogrid, pavement, reinforcement, stabilization, subgrade

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I. INTRODUCTION

The life and quality of flexible pavements are greatly affected by the type of subgrade soil as it serves as the foundation for pavement. It is always recommended to use locally available materials if their strength and hydraulic characteristics permit. In India more than 8 lakh square kilometers of area is covered with soils having low strength and stability, high settlement and liquefaction potential. Moreover the demand of good quality aggregates is increasing day by day with present need of 3000 million tons annually. The use of geosynthetic products significantly reduces the thickness requirement of pavement thus saving costly sub-base and base aggregate materials. The present paper reviews the work of various researchers on use of geogrids for soil stabilization purpose.

II. INITIAL DEVELOPMENT

A geosynthetic reinforcement material consisting of connected parallel sets of polymeric tensile ribs with apertures of sufficient size to allow strike-through of surrounding soil, aggregate, or other particulate material. The aperture size varies from 10 – 100mm between the longitudinal and transverse ribs. The unitized or homogeneous geogrids are made by Tensor Corporation and first applied in North American countries in the year 1982. More flexible, coated yarn type geogrids were developed by ICI Linear Composites Limited in 1980's. Today more than 25 companies are manufacturing this type of geogrid globally. A third type of geogrid i.e. bonded rod or strap type is manufactured by NAUE, Germany and Colbond, Netherlands.

III. TYPES OF GEOGRID

Broadly there are three types of geogrids namely unitized/homogeneous, coated yarn type and bonded strap/rod type geogrid. All the three types of geogrids are discussed in the following sections.

3.1 Homogeneous/Unitized Geogrids

The polymers used to manufacture unidirectional homogeneous geogrids are high density polyethylene (PE), whereas polypropylene (PP) is used for bidirectional and tridirectional products. Holes are punched in polymer sheet and passed over rollers to get the desired shape. Uniaxial products are stretched longitudinally, whereas biaxial products are stretched in both longitudinal and transverse directions thus improving strength in both the directions. Fig. 1 shows the homogeneous polyethylene and polypropylene geogrids.

Fig. 1: Unitized PE or PP Geogrids

Source: http://www.technicaltextile.net

3.2 Coated Yarn Geogrids

These geogrids are formed by weaving high tenacity polyester yarn bundles on conventional textile machinery. The junctions are knitted together to connect transverse and longitudinal ribs together. By varying the number of filaments per yarn in machine and cross machine direction, strength can be varied giving rise to uniaxial and biaxial products. These geogrids are coated with polyvinyl chloride, latex or bitumen for durability, dimensional stability and resistance to installation damage. These geogrids are more flexible than other two. Fig. 2 shows coated yarn type geogrid.

Fig. 2: Coated Yarn Geogrids

Source: http://www.techfabindia.com

3.3 Bonded Rod/Strap Geogrids

These geogrids are formed from high tenacity polypropylene or polyethylene rods or straps. The individual rods are 1mm thick and 10mm wide. The junctions formed by overlapping machine and cross-machine direction ribs are connected by laser or ultrasonically. They are stiffest of all types of geogrids. Fig. 3 shows the bonded strap geogrid.

Fig. 3: Bonded Rod/Strap Geogrids

Source: http://www.maccaferri.com

IV. USE AREAS OF GEOGRIDS

Geogrids primarily works as a reinforcement material. However, it can be used for separation purposes for very coarse gravels and other materials having large size only. Geogrids can be used as basal reinforcement over soft soils, facing of retaining walls, erosion control in slopes, embankment fill reinforcement, asphalt and concrete reinforcement in pavements.

V. LITERATURE REVIEW

Zornberg and Gupta (2009) studied the effect of geogrid reinforcement in mitigation of longitudinal cracks induced in pavements constructed over highly plastic, expansive clay subgrades. Three field evaluations are done on pavements constructed in the Forth Worth-Dallas area, Texas. It was found that geogrid reinforcement in FM 1915, Milam County, Texas significantly reduces the longitudinal cracks in the reinforced portion. In FM 542, Leon County it was observed that cracks are present outside the reinforced area and in FM 1774, Grimes County cracks developed even in the reinforced zone due to low junction efficiency of geogrids.

Naeini and Moayed (2009) studied the effect of reinforcement and variation in plasticity index (PI) on CBR values. The soil sample used was collected from Khatoon Abad, Iran and was classified as clay of low plasticity (CL). The geogrid used was GS-50 made of low density polyethylene fibers having a weight of 300GSM with 2mm aperture size. It was found that the CBR values for both unsoaked and soaked specimens decreased with increase in plasticity index. It was also found that single layer reinforcement in unsoaked condition and double layer in soaked condition was more effective with improvement of 40% and 35% in CBR values respectively for soils having different plasticity index values.

Azadegan and Pourebrahim (2010) studied the effect of geogrid reinforcement on UCS and elastic modulus of cement/lime treated soil. The soil sample was collected from Kerman, Iran. The geogrid used was made from polypropylene material. The amount of lime varies from 4.5 to 6.8% and cement varies from 4.5 to 5.6% by weight of dry soil. A single layer geogrid was placed at the centre of the sample. It was found that as the cement/lime ratio increases there is increase in compressive strength and modulus of elasticity of soil.

Adams et al. (2014) studied the effect of triaxial geogrids on the CBR value of soil. The soil sample was taken from Kumasi, Ghana and was classified as sandy silt (SM) as per USC. Two different types of triaxial geogrids are used, namely TriAx Tx 130s and TriAx Tx 170 and both are placed at the layer 3 level. An increase of 11% and 112% was observed for soaked and unsoaked condition when TriAx Tx 130s was placed at layer 3 level, whereas this increase was 72% and 135% respectively for TriAx Tx 170. It was concluded that TriAx Tx 170 shows a much greater improvement in CBR value especially in the soaked condition where its effect was about 60% more than that of the TriAx Tx 130s.

Tiwari and Vyas (2017) studied the effect of geogrid reinforcement on strength behaviour of black cotton soil. The soil sample was collected from Govindpura near Bhopal and classified as clay of intermediate compressibility (CI) as per ISC. Laboratory CBR tests are conducted with and without reinforcement. The geogrid sheets are placed in single layer at various depths (i.e. 0.2H, 0.4H, 0.6H and 0.8H) from top of specimen. It was observed that geogrid placed at 0.2H depth showed maximum improvement. The CBR value increased from 4.77% to 13.13% for soaked condition and from 6.53% to 19.66% for unsoaked condition.

VI. CONCLUSION

Thus it can be concluded that geogrids can be used in various engineering applications such as embankments, pavements, landfills, as mattresses, as facing panels in retaining walls, stabilize leachate, within ballast in railroad construction. Due to versatility of functions like reinforcement and separation it can used effectively in various civil engineering works as compared to other conventional materials such as lime, cement and fly ash. Their use in subgrade will significantly reduce the thickness requirement of pavement thus saving costly base and sub-base aggregate materials which are neither easily available nor economical. Non-biodegradable behaviour of such synthetic geogrids provides additional benefits. Thus it's time to support more and more use of geogrids.

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