Effect of Non-Woven Geotextile and Biaxial Geogrid Reinforcement on the Strength Behaviour of Subgrade Soil

[1]Ayush Mittal, [2]Shalinee Shukla

[1]*Assistant Professor, Department of Civil Engineering, REC Ambedkar Nagar, UP, India*

[2]*Associate Professor, Dept. of Civil Engineering, MNNIT Allahabad*

Abstract

The performance of flexible pavement depends mainly on the subgrade soil characteristics as it serves as a foundation for pavement. Roads constructed over poor subgrade soil i.e. soil having low California bearing ratio and undrained shear strength values fails frequently leading to heavy economic burden apart from high initial cost of construction because of thicker layer of aggregate base and sub-base. In order to overcome these problems soil reinforcement technique has to be adopted. The use of geosynthetic material is a new and emerging technique and is gaining importance due to cost and time saving apart from less environmental sensitive nature and is consistent over a wide range of soils. In the present study an attempt has been made to make use of non-woven geotextile and biaxial geogrid in various combinations. The geotextile and geogrid was selected from the list of materials accredited by Indian Roads Congress. The geogrid was placed above geotextile, both in layers from the top of mold and heavy compaction, soaked CBR and unconfined compressive strength (UCS) tests were performed as per relevant parts of Indian standard code (IS: 2720).

Keywords - *geotextile, geogrid, CBR, UCS*

I. INTRODUCTION

The development of any country is not possible without effective transportation system. Road transport contains major chunk of this as more than 90% of passenger traffic and 65% of freight traffic moves through roads. The functional and structural performance of pavement depends mainly on the properties of subgrade soil as it serves as the foundation for pavement. In case of flexible pavement the traffic loads get transmitted to lower layers through grain to grain transfer and finally to subgrade and hence overstressing can be a possibility leading to complete pavement deterioration in case of pavements constructed over weak subgrade soil. In India more than 20% land area is covered with soils having low CBR and shear strength values. The pavements constructed over such soils require thicker sub base and base thickness apart from frequent maintenance requirements leading to heavy economic burden. To overcome such a problem, soil reinforcement techniques have to be adopted. The use of geosynthetic material is a new and emerging technique and is gaining importance since it makes use of locally available materials in an efficient manner and is less costly apart from, longer life, greater strength improvement, time saving and environmental benefits. Many studies have been conducted using geogrids and geotextiles individually but very few studies were their using combinations of geotextile and geogrid. In the present work, effect of reinforcement on the strength behaviour of poor subgrade soil was analysed in terms of CBR and UCS values.

II. MATERIALS AND METHODS

A. Soil

The soil sample was collected from Chakghat area of Rewa district, Madhya Pradesh and was characterized by grain size analysis and Atterberg's limit tests. The liquid limit and plastic limit values of virgin soil are 52.20% and 32.88% respectively; whereas plasticity index value was 17.32%, therefore soil was classified as silt of high compressibility (MH) as per Indian standard classification (ISC) system. The route map of Chakghat from MNNIT campus from where soil was collected is shown in Figure 1. Various properties of soil are shown in Table 1. The particle size distribution curve of soil is shown in Figure 2.

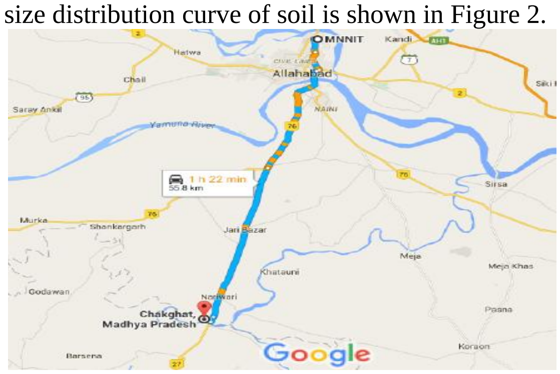

Fig. 1 Route Map of Chakghat, Rewa from MNNIT Allahabad

Table 1 Properties of Chakghat soil

Property	**Value**
Atterberg's Limits	
(a) Liquid Limit (%)	52.20
(b) Plastic Limit (%)	34.88
(c) Shrinkage Limit (%)	18.85
(d) Plasticity Index (%)	17.32
Grain Size Distribution	
(a) Gravel (%)	2.95
(b) Sand (%)	6.46
(c) Silt (%)	64.67
(d) Clay (%)	25.92
Water Content (%)	8.75
Specific Gravity	2.69
Free Swell Index (%)	42.10
pH value	7.72
Optimum moisture content (%)	14.80
Maximum dry density (g/cc)	1.828
Unsoaked CBR (%)	7.32
Soaked CBR (%)	2.09
Swelling pressure (Kg/cm^2)	0.57
Unconfined compressive strength (kN/m^2)	128.63

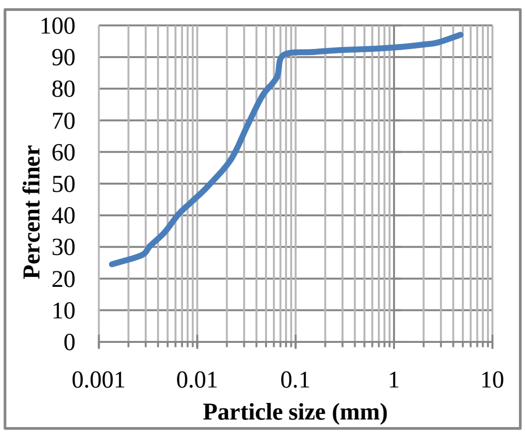

Fig. 2 Particle size distribution of Chakghat soil

B. Geotextile

The geotextile used is non-woven polypropylene type of 200 GSM (gram per square meter) selected from the list of materials accredited by Indian Roads Congress for a period of two years (2015-2017). The geotextile (PR 20) supplied by TechFab India is shown in Figure 3. The index properties of geotextile as provided by manufacturer and tested in Bombay Textile Research Association (BTRA) are shown in Table 2.

Table 2: Index Properties of Non-Woven Polypropylene Geotextile

Particulars	**Value (Manufacturer)**	**Value (BTRA)**
Wide width tensile strength [KN/m]	11/13 (MD/CD)	13.94/19.77 (MD/CD)
Tensile elongation [%]	55/55 (MD/CD)	59.8/58 (MD/CD)
Grab tensile strength [N]	720/770 (MD/CD)	749/891 (MD/CD)
Grab elongation [%]	60/60 (MD/CD)	67.2/60.8 (MD/CD)
Trapezoidal tear strength [N]	320 (Weaker direction)	332 (Weaker direction)
Index Puncture resistance [N]	420	552
Mass / Unit Area [g/m^2]	200	223.1

Fig. 3 View of Non-woven polypropylene geotextile

C. Geogrid

The geogrid used is a biaxial type (SG3030), shown in Figure 4, supplied by Strata Geosystems (India) Pvt. Ltd is a high performance geogrid constructed from high tenacity and high molecular weight knitted polyester yarns. The index properties of geogrid as provided by manufacturer and tested in Bombay Textile Research Association (BTRA) are shown in Table 3.

Table 3. Index Properties of Geogrid (SG3030)

Particulars	**Value (Manufacturer)**	**Value (BTRA)**
Tensile strength [KN/m]	30/30 (MD/CD)	34.32/32.30 (MD/CD)
Tensile elongation [%]	---	11.6/13.4 (MD/CD)
Junction strength [KN]	---	0.234
Grid aperture size [mm]	18/18 (MD/CD)	18.4/18.2 (MD/CD)
Aperture shape	Square	Square

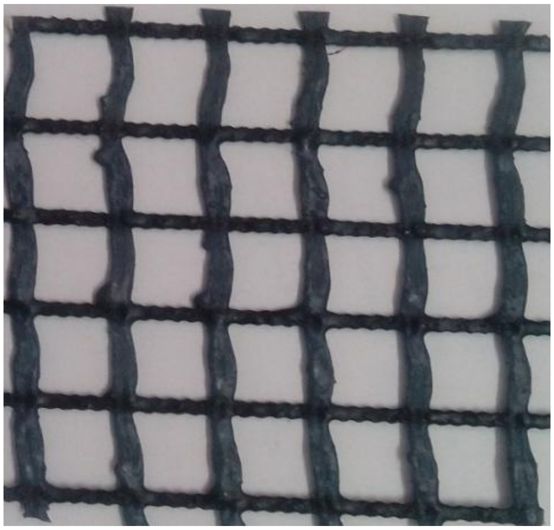

Fig. 4 Biaxial geogrid SG3030

D. Experimental Work

Heavy compaction, soaked CBR and UCS tests were performed as per relevant parts of Indian standard code (IS: 2720) for soil alone and by using geotextile and geogrid in various combinations placed in layers. Table 4 shows the layer number corresponding to position of geosynthetic from top of mold.

Table 4. Layer Number Corresponding to Position of Geogrid and Geotextile

Layer Number	**Position of geosynthetic from top of mold**
L4 Geogrid, L3 Geotextile	H/5 & 2H/5
L4 Geogrid, L2 Geotextile	H/5 & 3H/5
L3 Geogrid, L2 Geotextile	2H/5 & 3H/5
L4 Geogrid, L3-2 Geotextile	H/5, 2H/5 & 3H/5
L4 Geogrid, L3-1 Geotextile	H/5, 2H/5 & 4H/5
L4-3 Geogrid, L2 Geotextile	H/5, 2H/5 & 3H/5
L4-3 Geogrid, L1 Geotextile	H/5, 2H/5 & 4H/5

The term H used in above table is the height of soil specimen in heavy compaction, CBR and UCS test. This height is 127.3mm in heavy compaction and CBR test and 87mm in UCS test.

1. Heavy Compaction Test

About 2.8 kg of air dried soil was taken and initial moisture content was determined. The soil was initially mixed with 10% water and packed in polythene bag for 24 hours for its uniform distribution in soil sample. Five such samples were prepared and then water was added in increment of 2% for each sample during the test. Table 5 shows the OMC-MDD values for various combinations of geotextile and geogrid.

Table 5. OMC-MDD value of soil reinforced with geogrid and geotextile

Position from top of specimen	**Experimental Value**	
	MDD (g/cc)	**OMC (%)**
Without Geosynthetic	1.828	14.80
H/5 geogrid and 2H/5 geotextile	1.922	13.90
H/5 geogrid and 3H/5 geotextile	1.938	13.80
2H/5 geogrid and 3H/5 geotextile	1.904	15.00
H/5 geogrid and 2H/5, 3H/5 geotextile	1.886	14.90
H/5 geogrid and 2H/5, 4H/5 geotextile	1.892	14.80
H/5, 2H/5 geogrid and 3H/5 geotextile	1.888	15.20
H/5, 2H/5 geogrid and 4H/5 geotextile	1.914	14.90

2. CBR Test

Soaked CBR test was conducted with a soaking period of 4 days. Sample was prepared based on the OMC and MDD values obtained from heavy compaction test. First the soil was tested alone for CBR and then geogrid and geotextile were placed in double and triple layers. The CBR value obtained for virgin soil sample was 2.09% which increases to maximum of 3.83% for double layer (L4 geogrid and L2 geotextile) and 4.18% for triple layer (L4-3 geogrid and L2 geotextile) reinforcement respectively. Table 5 shows the CBR values for various combinations of geogrid and geotextile.

Table 5. CBR value of soil reinforced with geogrid and geotextile

Position from top of specimen	**Experimental Value**
	CBR (%)
Without Geosynthetic	2.09
H/5 geogrid and 2H/5	3.31

geotextile	
H/5 geogrid and 3H/5 geotextile	3.83
2H/5 geogrid and 3H/5 geotextile	3.31
H/5 geogrid and 2H/5, 3H/5 geotextile	3.14
H/5 geogrid and 2H/5, 4H/5 geotextile	3.66
H/5, 2H/5 geogrid and 3H/5 geotextile	4.18
H/5, 2H/5 geogrid and 4H/5 geotextile	3.66

3. UCS Test

Soil samples were prepared by compacting it dynamically in standard cylindrical split mold of 38mm diameter and 87mm height using tamping rod of diameter slightly less than the diameter of split mold based on OMC and MDD obtained from heavy compaction. Soil sample was tested initially without geosynthetic and then introducing geogrid and geotextile at various depths as in the compaction test. Table 6 shows the UCS and failure strain values for various combinations of geogrid and geotextile. The UCS value obtained for virgin soil sample was 128.63 KN/m^2 which increase to maximum of 185.80 KN/m^2 for double layer (L4 geogrid and L2 geotextile) and 208.28 kN/m^2 for triple layer (L4 geogrid and L3-2 geotextile) reinforcement respectively.

Table 6. UCS value of soil reinforced with geogrid and geotextile

Position from top of specimen	Experimental Value	
	UCS (KN/m^2)	Failure Strain (%)
Without Geosynthetic	128.63	4.022
H/5 geogrid and 2H/5 geotextile	169.72	4.022
H/5 geogrid and 3H/5 geotextile	185.80	4.022
2H/5 geogrid and 3H/5 geotextile	135.77	4.022
H/5 geogrid and 2H/5, 3H/5 geotextile	208.28	5.172
H/5 geogrid and 2H/5, 4H/5 geotextile	171.22	5.172
H/5, 2H/5 geogrid and 3H/5 geotextile	173.69	5.747
H/5, 2H/5 geogrid and 4H/5 geotextile	167.69	5.172

III. DISCUSSION

The MDD value for virgin soil was 1.828 g/cc which increase for all double and triple layer geosynthetic reinforced specimens with more pronounced effect in (L4 & L2) layer. This is due to more compactness achieved with geosynthetic placement at a particular depth resulting in reduction of voids with void spaces occupied by solid particles having greater specific gravity. The CBR value for virgin soil was 2.09% which increased by 83% for double layer and 100% for triple layer geosynthetic reinforcement. The UCS values also show a similar trend with maximum improvement of 44% and 62%, respectively. More ductile behaviour and improved rupture strength was observed in reinforced soil specimen which is evidence from smaller loss of post peak strength and failure occurring at greater strain level, respectively.

IV. CONCLUSION

As the value of MDD increases the OMC value gets reduced due to reduction in void spaces. All geosynthetic reinforced specimens show increased MDD values as compared to virgin soil sample due to confinement effect of geotextile and interlocking effect of geogrid. The CBR value increases for all cases with placement of geogrid and geotextile in soil layers, since it offers more resistance to penetration of plunger which is lacking in unreinforced soil. UCS test results shows increase in peak strength, smaller loss of post peak strength and failure occurring at greater strain level for reinforced samples. This ductile behaviour of reinforced soil construction is important for seismic regions where it can withstand severe earthquakes. The use of geosynthetic in soft subgrade causes reduction in thickness requirement of pavement, increases the service life and reduces the frequency of maintenance required, resulting in economical pavement design. From the experimental results obtained, it can be said that significant improvement in properties of subgrade soil occur with use of geotextile and geogrid in combinations.

REFERENCES

[1] Elshakankery MH, Almetwally AA, Tawfik KA (2013) Experimental study of Bearing Capacity for Egyptian soils reinforced by geo textiles. Journal of Applied Sciences Research 9:2378-2385.
[2] Kumar PS, Rajkumar R (2012) Effect of Geotextile on CBR strength of unpaved road with soft sub grade. EJGE 17:1355-1363.
[3] Sivapragasam C, Vanitha S, Arun VM, Sutharsanam S (2010) Study on Synthetic Geotextiles for Road Pavements. IGC Mumbai Chapter & IIT Bombay, pp 255-258.

[4] Tailor RM, Desai MD, Shah NC (2011) Geotextile as reinforcement in flexible pavement for swelling subgrade. IGC Koch, pp 565-568.

[5] Viswanadham BVS, Satkalmi V (2008) Field trials with polypropylene woven geotextiles. First pan American geosynthetics conference and exhibition – Mexico, pp 1112-1118.

[6] Noorzad R, Mirmoradi SH (2010) Laboratory evaluation of the behaviour of a geotextile reinforced clay. Geotextiles and Geomembranes, ELSEVIER 28:386-392

[7] Raisinghani DV, Viswanadham BVS (2010) Evaluation of permeability characteristics of a geosynthetic-reinforced soil through laboratory tests. Geotextiles and Geomembranes, ELSEVIER 28:579-588.

[8] Ghazavi M, Roustaei M (2013) Freeze-thaw performance of clayey soil reinforced with geotextile layer. Cold regions science and technology, ELSEVIER 89:22-29.

[9] Naeini SA, Mirzakhanlari M (2008) The effect of geotextile and grading on the bearing ratio of granular soils. EJGE 13:1-10.

[10] Ingle GS, Bhosale SS (2013) Geo synthetic Reinforced Flexible Pavement: Gateway of the sustainable pavement. Indian Highways, 41:6-15.