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Influence of Position of Geosynthetic Layer in Pavement

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Abstract:- The rapidly increasing demand for more and more trafficable area has made it imperative to construct on weak and compressible soil subgrades. Whenever a road needs to be built on soft or saturated soil with low CBR value, settlement may take place during or after construction, with serious consequences in the lifespan of the road. It is a big challenge ahead of a civil engineer to build roads which are strong enough to bear the heaviest of traffic expected to move through those roads.Use of geo-synthetics serves as a solution to these problems. Geo-synthetics increase the strength of sub-grade soil and modify some of its properties so that the strength and lifespan of the road is increased.
This paper provides an overview of performance of geotextile reinforcement in enhancing the strength of pavements, influence of the position of reinforcement layer and use of multilayer geotextiles.

I. INTRODUCTION

Heavy traffic demands strong, smooth, durable and well maintained roads and hence healthy and strengthened road network is essential for socioeconomic development of a country. In a country like India which lacks wellorganized traffic system and where climatic conditions and topographic features vary from time to time and from place to place, the situation is further worse. Statistics show that about 40% of the road accidents occurring in India each year is due to poor road conditions. Generally, the traditional method of constructing an embankment above the subgradesoil using strong aggregates or high strength soil and laying the surface course of road above it is adopted in India. But thequality of roads remains poor and average life of roads is remarkably low. Geosythetics play a significant part in modern pavement design and maintenance techniques.

Geotextile Reinforcement:

A geotextile performs the reinforcement function by improving themechanical properties of a soil mass as a result of its inclusion. When soil and geosynthetic reinforcement are combined, a composite material, '*reinforced soil'*, possessing highcompressive and tensile strength is produced which prevents inadmissible deformations in geotechnical structures. In this process, the geosynthetic acts as a tensioned member coupled with the soil/fill material by friction, adhesion, interlocking or confinement and thus maintains the stability of the soil mass. The soil reinforced with extensible reinforcement (termed *ply-soil* by McGownand Andrawes (1977)) has greater extensibility and smaller losses of post peak strengthcompared to soil alone or soil reinforced with inextensible reinforcement (termed *reinforced earth* by Vidal (1969)).

Fluet (1988) subdivided the reinforcement function into the following two categories:
1).A tensile member, which supports a planar load.
2). A tensioned member, which supports not only a planar load but also a normal load.
Jewell (1996) and Koerner (2005) consider not two but three mechanisms for soil reinforcement,
1)Shear/*sliding*: The geosynthetic supports a planar load due to slide of thesoil over it.
2)Anchorage / *pullout*: Geosynthetic supports a planar load due to its pulloutfrom soil.
3) Membrane: The geosynthetic supports both planar and normal load when placed ona deformable soil.
A geosynthetic layer reduces the outward horizontal stresses transmitted from the overlying soil to the top of the underlying foundation soil. This action of geosynthetics is known as *shear stress reduction effect*. This effect results in a general shear, rather than a local-shear failure, thereby causing an increase in the load-bearing capacity of the foundation soil (Bourdeau*et al*., 1982; Guido *et al*., 1985; Love *et al*., 1987; Espinoza, 1994; Espinoza and Bray, 1995; Adams and Collin, 1997).

Geosynthetics in Roads

The granular upper layers in pavements should present good mechanical properties and enough thickness.The long-term interaction between a fine soil subgrade and the granular layer, underdynamic loads, is likely to cause pumping erosion of the soil subgrade and penetration ofthe granular particles into the soil subgrade, giving rise to permanent deflections andeventually to failure. At present, geosynthetics are being used to solve many such problems. The use of a geosynthetic layer also helps in enhancing the structural characteristics andin controlling the rutting of the paved roadway through its reinforcement function. It is to benoted that the principal reinforcing mechanism of the geosynthetic in paved roads is its *confinement effect*, not its *membrane effect*, which is applicable to unpaved roads allowing large rutting. The lateral confinement provided by the geosynthetic layer resists the tendency of the granular base courses to move out under the traffic loads imposed on the asphaltic or cement concrete wearing surface. In the case of paved roads on firm subgrade soils, prestressing the geosynthetic by external means can significantly increase lateral confinement to granular base course. It also significantly reduces the total and differential settlements ofthe reinforced soil system under applied loads (Shukla and Chandra, 1994b). The paved roadways with geosynthetic layers are usually designed for structural support using normal pavement design methods, as described by various agencies. Introduction of geotextile can modify the CBR value of subgrade soil and thickness of road is determined based on the new CBR value of soil(AASHTO, 1993; IRC: 37-2001; IRC: 58-2002). In the presence of a geosynthetic layer, especially a nonwoven geotextile, at the interface of granular subbase/base layer and the soil subgrade, the required additional granular layer thickness can be reduced by approximately 50% keeping the project cost effective (Holtz *et al*., 1997). Choudhary. A.K., *et.al*., (2010) has reported an increase in load carrying capacity with an increase in reinforcement layers and a reduction in capacity when reinforcement laid at greater depths.

II. MATERIALS AND METHODS

Design of pavements is based on the CBR value of the subgrade soil in that area. Thickness of the pavement required can be estimated from CBR design chart (IRC). Soil samples were collected from three different sites in and around Kothamangalam, Cochin and their index properties were tested in laboratory. Details of different tests performed on the collected soil samples are shown in table 1.1

Table 1.1 Geotechnical properties of the collected soil samples.

PROPERTY	SAMPLE 1	SAMPLE 2	SAMPLE 3
Specific Gravity	2.58	2.62	2.70
Permeability	$2.0x10^{-3}$	$1.3x10^{-3}$	$1.2x10^{-3}$
Liquid Limit	38	30	20
Plastic Limit	31	23	14
Plasticity Index	7	7	6
Flow Index	8.2	15.5	11.7
Toughness Index	0.45	1.44	0.88
Uniformity Coefficient	6.4	5.2	4.6
Coefficient of Curvature	1.3	1.0	0.9
Maximum Dry Density(g/cc)	1.58	1.88	1.62
O M C (%)	16	12	21
California Bearing Ratio (%)	7.6	12.0	12.9
Unconfined Compressive Strength (kg/cm^2)	2.62	2.37	0.34

The geotextiles used for CBR tests are commercially available and their properties are shown in the table 1.2

Table 1.2 Properties of Geotextiles

Name	Geotextile: 201 GRK 3 C
Raw material	polypropylene (PP)
Colour	White
Mass per unit area	$200g/m^2$
Thickness	1.2 mm
Maximum tensile strength	8kN/m
Roll Dimensions	5.90m x 150m

CBR tests were conducted on soil samples with and without geotextile layer, using light compaction method as specified in IS 2720to find out how geotextile reinforcement influences the strength of subgrade soil. Also tests were carried out to study the effect of position of geotextile and use of multilayer geotextile. The load penetration graphs of the CBR tests on the three samples are shown in Fig 1.1 – Fig 1.5. Details of each curve are listed below

- **Curve A -** CBR test on subgrade soil without geotextile reinforcement
- **Curve B -**CBR Test on Subgrade soil with geotextile reinforcement placed at 4 cm from top surface of soil sample
- **Curve C -**CBR Test on Subgrade soil with geotextile placed above the surface of soil sample
- **Curve D -**CBR Test on Subgrade soilusing multilayers of geotextiles, geotextiles are placed at the surface and at 4 cm depth from the surface of soil sample
- **Curve E -**CBR Test on Subgrade soilusing multilayersof geotextiles, both geotextiles are placed above the surface of soil sample

Soil Sample 1

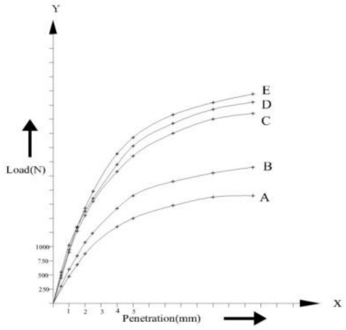

Fig 1.1 Effect of position of geotextile on Soil Sample 1

Table 1.3 CBR variation due to different positions of geotextile in Soil Sample 1

Curve	A	B	C	D	E
CBR	7.6	9.2	13	13.6	14.2

Soil Sample 2

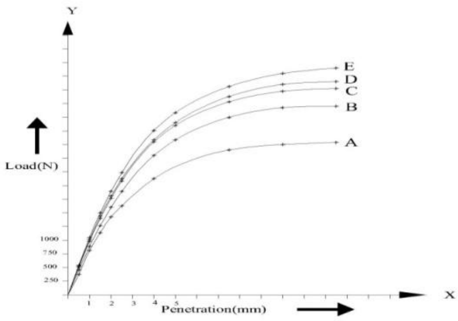

Fig1.2 Effect of position of geotextile on Soil Sample 2

Table 1.4 CBR variation due to different positions of geotextile in Soil Sample 2

Curve	A	B	C	D	E
CBR	12	13.8	15.2	15.5	16.3

Soil Sample 3

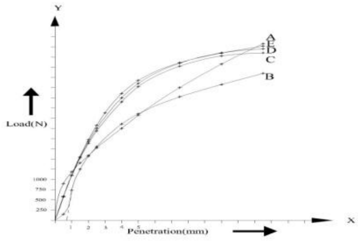

Fig 1.3 Effect of position of geotextile on Soil Sample 3

Table 1.5 CBR variation due to different positions of geotextile in Soil Sample 3

Curve	A	B	C	D	E
CBR	12.9	15.44	16.0	16.4	17

A comparison of CBR tests results with single layer of geotextile placed on surface of the three soil samples is given in fig 1.4and table 1.6

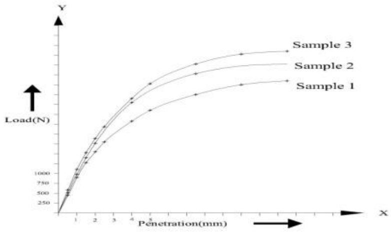

Fig 1.4CBR variation on three samples

Table 1.6 CBR variation with single layer of geotextile placed on surface of the three soil samples

Sample	Sample 1	Sample 2	Sample 3
	13	15.2	16

A comparison of CBR tests results with multiple layers of geotextiles placed on surface of the three soil samples is given in fig 1.5 and table 1.7

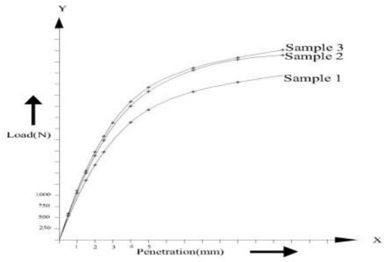

Fig 1.5 CBR variation on three samples

Table 1.7 CBR variation with multiple layers of geotextiles placed on surface of the three soil samples

Sample	Sample 1	Sample 2	Sample 3
CBR	14.2	16.3	17

Based on the experimental studies carried out, it can be concluded that the CBR value is minimum for soil without geotextile reinforcement and maximum when multiple layers of geotextiles are placed at top of subgrade soil. When single layer or multiple layers of geotextiles is used, maximum CBR value is attained by placing it on top of subgrade soil.

Percentage increase in CBR value

Fig 1.6 is the bar chart showing the percentage variation in CBR vale due to different positions of geotextile layer.

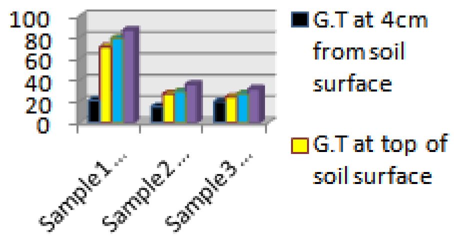

Fig 1.6 Percentage increase in CBR value

From the above chart it can be inferred that after geotextile reinforcement, the percentage increase in CBR is maximum for soil with least CBR value. The percentage increase in CBR value is more when the geotextile layer is placed at top of the subgrade soil. The percentage increase in CBR value due to multilayer reinforcement does not show considerable variation from the CBR value due to single layer reinforcement. Hence multilayer reinforcement is considered uneconomical.

III. CONCLUSION

Geosynthetics play a significant part in modern pavement design and maintenance techniques. Experimental studies show an increase in subgrade strengthas a result of geotextile reinforcement. Geotextile as reinforcement is more effective in soil with least CBR value. The subgrade strength improvement is more when the geotextile layer is placed at top of the subgrade soil. The percentage increase in CBR value due to multilayer reinforcement doesnot show considerable variation from that ofsingle layer reinforcement. Hence multilayer reinforcement is considered uneconomical.

It is expected that use of geosynthetics in pavements proves to be more beneficial in the long time run, as life expectancy of a geosynthetic reinforced road is more.

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