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APPLICATION OF GEOSYNTHETICS IN FLEXIBLE PAVEMENT

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ABSTRACT:- *In India, most of the flexible pavements are need to be constructed over weak sub-grade soil having low modulus values. This Study examined the basic engineering and geotechnical properties of poor sub-grade soils using geosynthetics like Woven Geotextile to improve its strength. CBR tests were carried out by placing the Woven Geotextile in single layer at depths 0.33H, 0.66H and 0.8H (H- height of mould in CBR test) from bottom of mould under soaked condition to determine the strength of the soil. Flexible pavement was designed for both fatigue and rutting life of 100MSA at 90% reliability, when the Woven Geotextile was placed at three different depth in subgrade soil The critical strain value for both fatigue and rutting life were analyzed by IITPAVE software and the allowable strain values were computed by IRC: 37-2012. The result shows that the strength of subgrade soil was considerably increased by introducing Woven Geotextile reinforcement in the soil. From this study, single layer of Woven Geotextile introduced at the depth of 0.8H from the bottom of the mould shows better performance as compared to those when Geotextile was placed at other depth of mould. Pavement thickness and Cost for Construction of Pavement reduces when Geotextile was placed at different depth of subgrade soil with minimum being when Geotextile placed closer to top of mould.*

Index terms - *CBR Test, Woven Geotextile, IITPAVE software.*

INTRODUCTION

Flexible pavements are generally designed to have multiple layers, including the bitumen layer, surface course, aggregate base layer, aggregate subbase layer and subgrade soil. The quality and life of pavement is greatly affected by the type of sub-grade, sub-base and base course layers. Subgrade soil is the bottom most layer of the pavement whether it is rigid or flexible. The function of the subgrade is to give adequate support to the road crust and to support the traffic in the form of foundation. Generally, subgrade consists of various locally available soil materials that sometimes might be soft or that cannot have enough strength to support the traffic in the form of foundation structure.

The strength of the sub grade soil is evaluated in terms of California Bearing Ratio (CBR) value. Lesser the CBR value of subgrade soil, weaker is the subgrade soil therefore requires more thickness of road crust whereas higher the CBR value of subgrade soil stronger is subgrade requires less thickness of each pavement layers. IRC-37, 2012 gives the detailed guidelines for the design of pavement layers based upon the California Bearing Ratio value of the subgrade soil sample soaked for four days for different traffic conditions using the design charts as listed in code.

Geosynthetics have been found to be very cost effective alternative to improve the weak subgrade soils in adverse locations. Geo-synthetics are the synthetic products, where at least one of the components is made from a synthetic or natural polymer in nature, in the form of a sheet or a three dimensional structure.

METHODOLOGY ADOPTED

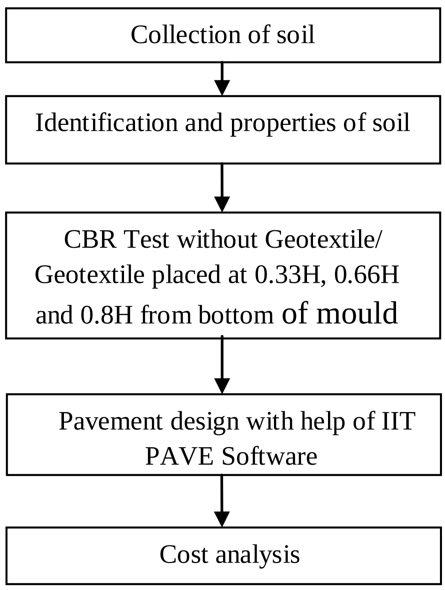

Figure1: Flow chart showing the methodology adopted in the study

Subgrade soil is collected from the field. Soil Identification and properties of collected soil are determined in laboratory. Woven Geotextile is used in the study to improve the strength of Subgrade soil. CBR test is performed on Subgrade soil under Soaked condition with no Geotextile and Geotextile placed at height of 0.33H, 0.66H and 0.8H from the bottom of mould (H- height of soil sample in CBR test=125mm). Then pavement is designed for soil with the help of IITPAVE software corresponding to traffic of 100MSA at 90% reliability and cost for construction of pavement is evaluated when geotextlie is placed at different depth .

MATERIAL USED IN THE STUDY

SOIL

Soil sample is obtained locally for the study. The properties of the soil are determined in laboratory and represented in table 1.

Table 1: Properties of Soil used in the Study

S.No	Tests	Properties	Description
1.	Grain Size Analysis	Fines, < 75µ (%)	96
		Sand (%)	4
2.	Compaction Test	MDD (g/cc)	1.51
		OMC (%)	18%
3.	Atterberg Limits	Liquid Limit (%)	46
		Plastic Limit (%)	23
		Plasticity Index (%)	23
4.		Classification	CL (Clay and silt with Intermediate compressibility

GEOTEXTILE

The properties of the Geotextile used in this study are as under claimed by manufacturer as shown in table 2.

Table 2: Properties of Geotextile

S. No.	Description	Properties
1	Type of Geotextile	Woven
2	Type of fiber	Polypropylene
3	Thickness	0.6 mm
4	Weft strength	1926 N
5	Weft elongation	44.64%
6	Warp strength	2035 N
7	Warp elongation	78%

EXPERIMENTAL PROGRAMME AND RESULTS

Series of CBR Tests were performed without Geotextile/ Geotextile placed at 0.33H, 0.66H and 0.8H from bottom of mould respectively under Soaked condition. Results of CBR test are Shown in table 3.

Table 3: CBR values of Soil with and without Geotextile under Soaked condition

Sample	Soil without Geotextiles (%)	Soil with Geotextiles at different depths (%) from the base of the mould		
		0.33H	0.66H	0.8H
Clayey Soil	2.78	3.28	6.13	7.38

CBR value increases when subgrade is reinforced with Geotextile. In this study it is maximum when Geotextile is placed at 0.8H from bottom of mould. CBR value increases by 165% when Geotextile is placed at 0.8H as compared to no Geotextile.

PAVEMENT DESIGN FOR SOIL USED IN STUDY

In the present study, flexible pavement is designed for traffic of 100msa at 90% reliability during design life. Table 4 shows the pavement composition for Soil with Geotextile at different location for both fatigue and rutting life of 100msa. Horizontal strain and Vertical strain is taken from IITPAVE software whereas allowable horizontal and vertical strain are calculated from equation given in IRC 37-2012 for Fatigue model and Rutting model respectively.

Table 4: Pavement Composition for Soil with Geotextile at different location for both Fatigue Life & Rutting Life = 100MSA at 90% reliability.

S.No.	Design CBR (%)	Placement of Geotextile from bottom the of mould	GSB (mm)	WMM (mm)	DBM (mm)	BC (mm)	Total Thickness (mm)	εt*	εt**	εv*	εv**
1.	2.78	No Geotextile	350	250	160	50	810	166.1	170	315.3	319
2.	3.28	0.33H	325	250	150	50	775	168.4	170	307.4	319
3.	6.13	0.66H	200	250	130	50	630	164.2	170	294.5	319
4.	7.38	0.8H	200	250	120	50	620	165.6	170	284.2	319

εt* = Horizontal strain value in micron (10^{-6}), εt** = Allowable horizontal strain value in micron (10^{-6}),
εv* = Vertical strain value in micron (10^{-6}) εv** = Allowable vertical strain value in micron (10^{-6})

COST ANALYSIS

Cost analysis for Pavement designed with the help of Soil used in the study has been shown in Table 5 for length of 1km and 7.5m width.

Table 5: Cost Analysis for Pavement designed with Soil used in the Study

S.No.	Description	Layers	Layer Thickness (mm)	Cost of layer/m^3 (Rs.)	Total Cost of layer/Km (Rs.)
1.	Soil with CBR= 2.78% (No Geotextile) for Fatigue& rutting life = 100MSA	GSB	350	762	20,00,250
		WMM	250	1148	21,52,500
		DBM	160	8268	99,21,600
		BC	50	10895	40,85,625
		Total Cost of Pavement per km (Rs.)			**1,81,59,975**
2.	Soil with CBR=3.28% (Geotextile at 0.33H from the bottom of the mould) for fatigue and rutting life=100MSA	GSB	325	762	18,57,375
		WMM	250	1148	21,52,500
		DBM	150	8268	93,01,500
		BC	50	10895	40,85,625
		Cost of Geotextile @60/sq. mtr			4,50,000
		Total Cost of Pavement per km (Rs.)			**1,78,47,000**
3.	Soil with CBR=6.13% (Geotextile at 0.66H from the bottom of the mould) for fatigue and rutting life=100MSA	GSB	200	762	11,43,000
		WMM	250	1148	21,52,500
		DBM	130	8268	80,61,300
		BC	50	10895	40,85,625
		Cost for Geotextile @60/sq. mtr			4,50,000
		Total Cost of Pavement per km (Rs.)			**1,58,92,425**
4.	Soil with CBR=7.38% (Geotextile at 0.8H from the bottom of the mould) for fatigue and rutting life=100MSA	GSB	200	762	11,43,000
		WMM	250	1148	21,52,500
		DBM	120	8268	74,41,200
		BC	50	10895	40,85,625
		Cost for Geotextile @60/sq. mtr			4,50,000
		Total Cost of Pavement per km (Rs.)			**1,52,72,325**

CONCLUSIONS

Following conclusions has been drawn on the basis of above study :-

1. In weak & soft Subgrade soil, Woven Geotextiles increases the penetration resistance resulting in higher value of CBR, when the Geotextiles are placed at varying depths under Soaked condition owing to its high tensile strength.
2. The CBR value is maximum under Soaked condition when Geotextile is placed closer to top of mould. In this study it is maximuim when Geotextile is placed at 0.8H from bottom of mould.
3. Soaked CBR value increases by 165% when Geotextile is placed at 0.8H from bottom of mould as compared to no Geotextile
4. The percentage reduction in the DBM layer thickness when the pavement is designed for fatigue and rutting life of 100MSA at 90% reliability is 6%, 18% & 25% when Geotextile is placed at 0.33H, 0.66H & 0.8H from the bottom of the mould respectively.
5. The percentage reduction in the Granular layer thickness when the pavement is designed for fatigue and rutting life of 100MSA at 90% reliability is 4%, 25% & 25% when Geotextile is placed at 0.33H, 0.66H & 0.8H from the bottom of the mould respectively.
6. The total thickness of road crust also reduces when Geotextile is used for reinforcing the Subgrade soil reduces by 4%, 22% & 23.4% when Geotextile is placed at 0.33H, 0.66H & 0.8H from bottom of mould respectively.
7. The pavement construction cost per km for two lane national highway also reduces when Subgrade is reinforced with Geotextile. In this study, 16% saving in cost when pavement is designed for both rutting and fatigue life of 100MSA at 90% reliability with Geotextile placed at 0.8H from bottom of mould .

FUTURE SCOPE OF WORK

1. Geotextile can be introduced at interface of base course and surface course and performance of pavement can be evaluated,
2. Geogrid can be used to investigate the improvement in strength of subgrade soil and effect of opening size of geogrid can also be studied.
3. Effect of seam strength of geotextile can also be investigated when geotextile is used in flexible pavement.

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