CBR Strength of Soil Aggregate System using Geotextile and Geomembrane

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Abstract. Geosynthetics materials are having wide application in Geotechnical Engineering field. It is available in different forms and can be applied as per the different functions like separator, lining, barrier, filter, reinforcement, etc in various application area of Geotechnical Engineering field. One of the application of Geosynthetics material in pavement construction as a separator and/or moisture barrier enhances the performance of pavement. In this study the strength parameter of woven coir mat, Jute mat and geomembrane was analyzed through CBR (California Bearing Ratio) test. In this study soil aggregate system was used in the CBR mould with and without the geosynthetics material. The soaked and unoaked CBR value of geotextile and geomembrane was determined and found that their application in the pavement construction can be very effective.

Keywords: CBR Strength. Soaked .Unsoaked .Geosynthetics

1 Introduction

Geosynthetic material has wide applications in civil engineering field. These materials are available in various forms and used for the different functions like separator, moisture barrier, reinforcement, filtration, drainage, protection and stiffening. One of the major application of civil engineering field is pavement construction, where geosynthetic material applications enhance the performance of road pavement through different functions. Geosynthetic material has wide variety of natural and synthetic products for its application. Since past few years, there are many projects where Geosynthetic materials have been applied and the use of Geosynthetic materials have been increasing. The application of Geosynthetics in pavement construction plays various roles. The geosynthetic placed at different location in flexible pavement plays specific role like separation, reinforcement, stiffening, barrier, filtration and drainage as discussed by J.G.Zonberg [1]. Thus the geosynthetic material prevent the migration of material from one course to another course. Indirectly due to preventing material migration, that will enhance the drainage performance and strength performance of the material. The pavement is not remain strong up to its design period due to mixing of material of different layer. It also fails due to the poor bearing capacity of subgrade material. The pavement failure occurs due to ground water fluctuation, lack of proper drainage design and water penetration during rainy season. To solve this problem Geosynthetics can be used as a moisture barrier or lateral drainage layer.

There are different materials available which can be used as a separator in pavements. The research has been done regarding the utilization of various materials as a separator. The materials used as a separator are polymer based synthetics material or natural fiber based material, which are available in a form of woven or non-woven sheets. C. Sumesh, P. K. Jayasree, K. Balan [2] developed Coir fiber Latex Composites sheet to be used as a separator. This developed sheet was analyzed for its strength and permeability. V.Athira, P. Leema, P. K. Jayasree and K. Balan [3] analyzed the long term performance of the natural fiber composite sheets through CBR test and found that the woven coir fiber latex composite has superior strength properties. M.N.Asha and G. Latha [4] performed the modified CBR test on geosynthetic reinforced soil-aggregate system to check the effect of the type of reinforcement, anchorage effect and mould size. The effect of boundary condition is very high and performance of reinforced soil aggregate system is better compared to the unreinforced one. K. Rajagopal and S.Ramakrishna [5] reported the results of experimental work about the use of coir geotextile as a separator in pavement application. The result of plate load test shown the improvement in stiffness and bearing capacity of soft soil subgrade. The properties of coir geotextile like stiffness, bearing capacity and hydraulic parameter are comparable with the intermediate to high density polypropylene based geotextiles. This type of geotextile can be effective and economical solution for the low volume traffic roads. Nithin S., K. Rajagopal, A. Veraragavan [6] also recommended the use of coir and jute geotextile in the unpaved road of low traffic volume. A. J. Khan, F. Huq, S. Z. Hossain [7] reported through case study of application of jute geotextile in rural pavement construction as a field trial at different location of Bangladesh. The rural road section of 5 km reinforced with jute geotextile was constructed at various location and performance was analyzed. The CBR of soft subgrade increased with the application of Jute geotextile. They also concluded that the jute geotextile performed its task of strengthening of soft subgrade before its decomposition.

2 Materials and Methodology

The present study required soil, aggregate, coir and jute as woven geotextile and geomembrane as non-woven geosynthetic material. The soil samples were collected from two different location of Gujarat. (i.e. Ahmedabad and Surat). The aggregate sample , coir and jute geotextile were taken from local market of Ahmedabad and the geomembrane sample of 2 mm thick was used of one geotextile manufacture company of Gujarat as shown in Fig.1. The index properties of both soil samples are shown in Table 1. Technical specification of geomembrane was taken from the manufacturer company as shown in Table 2. The aggregate used as base course in the CBR mould were taken as WMM (wet mix macadam) as given in the Ministry of Road Transport and Highways (MORTH) Specification for Road and Bridge Works (5^{th} revision) 2013 [8] is shown in Table 3. A series of CBR tests were carried out on unreinforced and reinforced soil-aggregate systems. The reinforced soil aggregate systems comprises of the reinforcement like coir mat and jute mat as woven geotextile and non-woven as commercially available geomembrane was placed at the between soil and aggregate layers. The details of experiment carried out were given in Table 4. The CBR test was performed for soaked and unsoaked conditions as per the IS: 2720 (Part-16)-1987 [9]. The CBR measures the strength parameter of the soil subgrade or different layer of roads and pavements. In the present study soil aggregate system was used to check the performance of geosynthetic material (coir mat, jute mat and geomembrane) as a separator in case of woven coir and jute geotextile and moisture barrier in case of geomembrane. The soil aggregate system is represented in Fig.2, the CBR mould was filled with soil as a soil subgrade up to 125 mm height and remaining 50 mm height is filled up with aggregates. The soil used in the tests was filled in 3 equal layers as per the standard proctor density. The aggregates were compacted in two layer in the collar placed over the compacted soil such that the total height of the soil aggregate system is 175 mm. The geotextile or geomembrane were placed at the interface layer. As per the procedure of CBR test cylindrical plunger with 50mm diameter penetrated in a pavement material with a constant strain rate of 1.25 mm/minute. The loads for 2.5mm and 5mm were recorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain CBR value. This is the most widely used method for the design of flexible pavement. The results of soaked and unsoaked CBR test were represented in Table 5.

Fig.1 (a) Coir fibre mat

Fig.1 (b) Jute fibre mat

Fig.1 (c) Geomembrane

Table 1. Index Properties of Soil Sample

Sr. No.	Description	SS1	SS2
1	Specific gravity	2.72	2.67
2	Liquid Limit	51%	26%
3	Plastic Limit	21%	19%
4	Optimum Moisture Content	13.5%	13%
5	Maximum Dry density	1.54 gm/cc	1.95 gm/cc

Table 2.Technical Specification for HDPE Liner/Geomembrane

Sr. No.	Property	Test Standard	Value
1	Thickness min (avg.)	ASTM D-5199	2 mm
2	Melt flow index	ASTMD-1238 (Cond. E)	< 1 .0
3	Sheet Density	ASTM D- 1505/792	> 0.94
Tensile properties (Each Direction)			
4	Strength at yield	ASTM D-638	≥29 N/mm
5	Strength at break	Type IV	≥53 N/mm
6	Elongation at yield	Specimen at	≥12 %
7	Elongation at break	50mm/min	≥700 %
8	Tear Resistance	ASTM D-1004	249 N
9	Puncture resistance	ASTM D-4833	640 N
10	Carbon black content	ASTM D-1603	2-3 %
11	Carbon black Dispersion	ASTM-D3015/5596	Satisfactory
12	Dimensional Stability	ASTM D-1204	± 2 %
13	Oxidation induction time	ASTM D-3895	>100 min.
14	ESCR	ASTM D-1693	>2000 Hrs.
15	Low Temperature Brittleness	ASTM D -746	<-70 ° C

Table 3. Gradation as per ministry of road transport and highways (MORTH)

Sr. No.	IS Sieve opening (mm)	Standard Values MORTH 500-13 (100%)
1	53	100
2	45	95-100
3	26.5	-
4	22.5	60-80
5	11.2	40-60
6	4.75	25-40
7	2.36	15-30
8	0.6	8-22
9	0.075	0-5

Table 4: Details of soil aggregate system with their designation

Sr. No.	Details of Test Programme	Designation
1	Soil Sample 1	SS1
2	Soil Sample 2	SS2
3	Soil Aggregate System	SA
4	Soil Aggregate with woven coir mat at interface	SAWC
5	Soil Aggregate with woven jute mat at interface	SAWJ
6	Soil Aggregate with non-woven Geomembrane at interface	SANWG

Table 5. CBR of the soil aggregate system with and without geosynthetic material

Sr. No.	Description	Penetration (mm)	Soaked	Unsoaked	Soaked	Unsoaked
			SA with SS1		SA with SS2	
1	SA	2.5	2.232	4.31	0.967	1.48
		5	2.967	4.71	1.047	1.58
2	SAWC	2.5	5.35	7.81	3.64	5.35
		5	6.101	8.97	5.02	7.29
3	SAWJ	2.5	8.705	13.02	5.95	8.92
		5	9.97	14.98	8.18	12.25
4	SANWG	2.5	34.59	52.0	22.32	36.45
		5	40.17	59.02	32.24	48.85

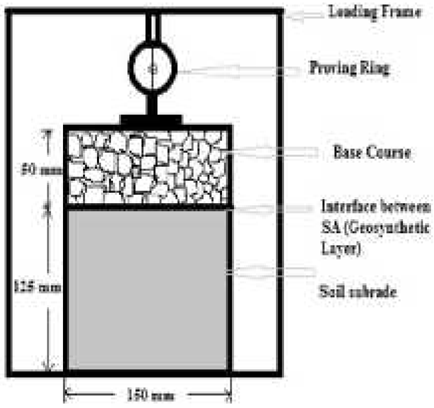

Fig.2 Soil Aggregate System

3 Result and Discussion

The CBR value of SA system was observed 2.967% and 1.047% for soaked condition and 4.71% and 1.58% for unsoaked condition with use of SS1 and SS2 in the SA system respectively. From the Fig. 3, clearly seen that the performance of the SA system is increasing in order due to SAWC, SAWJ and SANWG system. The fig.3, fig.4 and Table 5 represent the results of the CBR Value for both soaked and un-soaked condition with SS1 and SS2. In the present study coir and jute mat is woven geotextile which have void space inside it, so water can be easily pass from base course to soil subgrade. The coir and jute mate are woven type of geotextile material while the geomembrane is non-woven type of geosynthetic material which offers high resistance to loading coming from the aggregate layer in the CBR mould and it also serve the function of moisture barrier. It resist the flow of water from base course to soil subgrade. The thickness of the geomembrane (2 mm), composition and non-woven type of geosynthetic material is made up of high density polyethylene, therefore the CBR value of SANWG system is quite high compared to SAWC and SAWJ system. Fig.5 represent the comparison of CBR value of SA system with and without reinforcement in soaked and unsoaked condition.

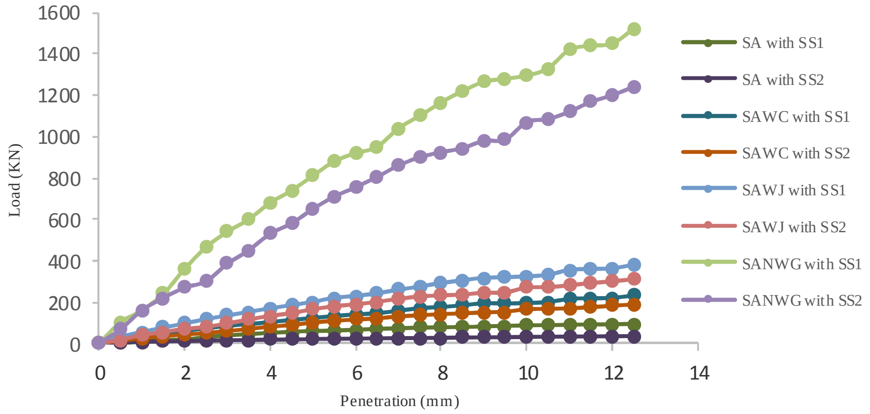

Fig.3 Load vs Penetration relation for soaked condition of soil aggregate system

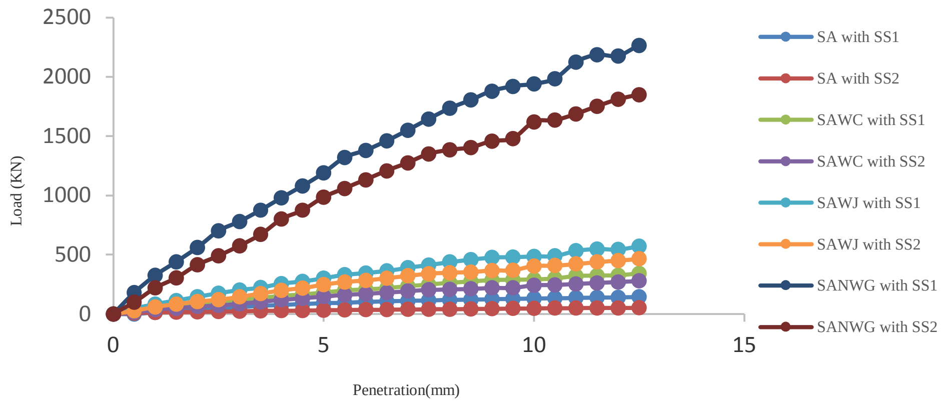

Fig.4 Load vs Penetration relation for unsoaked condition of soil aggregate system

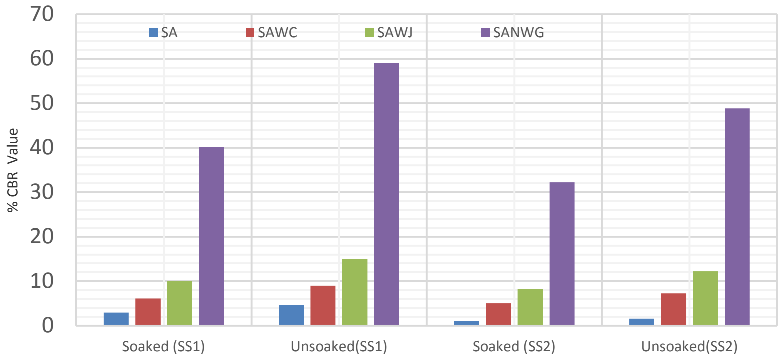

Fig.5 CBR Value comparison of different SA System

4 Conclusion

The performance of SA, SAWC, SAWJ and SANWG was evaluated through CBR test in soaked and unsoaked conditions. The unsoaked CBR value has increased from 4.71% of SA system to 59.02% of SANWG system with SS1 and 1.58% of SA system to 48.85% of SANWG system with SS2. Similarly the soaked CBR value has increased from 2.967% of SA system to 40.17% of SANWG system with SS1 and 1.047% of SA system to 32.24% of SANWG system with SS2. The increment in the CBR value test was achieved for different system in a following order like SA, SAWC, SAWJ, and SANWG. The coir and jute fibre have potential to be used in the rural road because of its biodegradable nature. However their performance can be improved by applying appropriate chemical treatment so the age of performance can be increased. While geomembrane has potential to be used as a moisture barrier in case of urban roads and which can enhance the performance of the pavement as well as it can increase the design period of the pavement.

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