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Laboratory Investigation Of Use Of Geo-Synthetic Material in Marshall Mix Design

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***Abstract*— In India there are limited manufacturing facilities for geo-synthetics, which compel us to import a large quantity. The main purpose of this study is to use any such locally available material, which is naturally and abundantly available in our country. Reliance Industry Ltd. has prepared geo-synthetic material like needle punch, spun bond. A Geo-synthetic material when used with asphalt concrete has shown a serviceable life equivalent to that of an overlay. On the Marshall Mix design, OBC was calculated and prepared a Marshall moulds using geo-synthetic material as well as without geo-synthetic material. The Geo-synthetic material was placed as a intra layer in Marshall moulds and stability was found.**

Keywords*— Geo-synthetic material; Marshall Mix design; PMB-40 &70; Asphalt retention; Melting point.

I. INTRODUCTION

A. *Geo-synthetic material*

Definition – "A planar product manufactured from polymeric material used with soil, rock, earth or other geotechnical, engineering related material as an integral part of a man-made product, structure or system." Geo-synthetics are man-made materials used to improve soil conditions. The word is derived from: ***Geo*** = earth or soil + ***Synthetics*** = man-made.

Geo-synthetics are typically made from petrochemical-based polymers ("plastics") that are biologically inert and will not decompose from bacterial or fungal action. While most are essentially chemical inert, some may be damaged by petrochemicals and most have some degree of susceptibility to ultraviolet light (sunlight).

There are a number of different geo-synthetic materials, and with the similarity of many of the names, as well as many similar sounding trade names, it can be confusing without an understanding of the basic categories.

• **geo-textiles**, used for drainage, separation and reinforcement, are in two forms,

- **woven** - cloth-like materials with fibres woven perpendicular to each other.
- **non-woven** - felt-like materials with randomly-oriented fibres.

• **geo-grids** are open mesh-like materials used for stabilization and reinforcement.

• **geo-cells** are cavity-like materials in a web used for stabilization.

• **geo-membranes** are very low permeability liner or fluid containment materials.

These are fabric or cloth-like materials that are classified based on the method used to place the threads or yarns in the fabric: either woven or non-woven. Geotextiles typically come in rolls up to approximately 5.6m (18 ft) wide and 50 to 150m (160 to 500 ft) long.

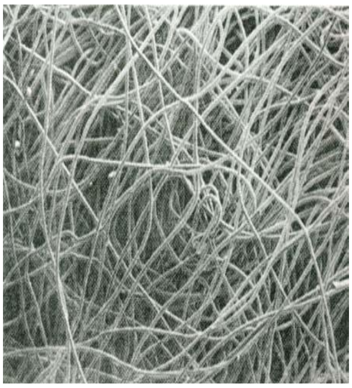
A. *Woven*

These cloth-like fabrics are formed by the uniform and regular interweaving of threads or yarns in two directions as shown in Figure 1, below. These products have a regular visible construction pattern, and where present, have distinct and measurable openings. Woven geotextiles are typically used for soil separation, reinforcement, load distribution, filtration, and drainage. They can have high tensile strength and relative low strain or limited elongation under load (typically up to 15%).

A. Non-Woven

These felt-like fabrics are formed by a random placement of threads in a mat and bonded by heat-bonding, resin-bonding or needle punching, as shown in Figure 2, below. These products do not have any visible thread pattern. Non-woven geotextiles are typically used for soil separation, stabilization, load distribution, and drainage but not for soil reinforcement such as in retaining walls. They have a relatively high strain and stretch considerably under load (about 50%).

A Typical Woven Geotextile



A Typical Non-Woven Geotextile

Pavement structures that are subjected to distress by reflection cracking are: - rigid pavement with flexible overlay, semi-rigid pavement and flexible pavements with or without overlay. Reflection cracking may also occur due to the presence of discontinuities that exist in the underlying layers for a variety of reasons such as road widening, local repairs and local weakness of the sub grade etc.

Once reflection cracks propagate to the surface of the overlay the pavement becomes more susceptible to adverse environmental factors. These factors are predominantly water infiltration and oxidation, which can ultimately lead to the failure of the pavement. In the current economic environment the need to ensure that pavements remain in a serviceable state is of paramount importance.

- Figure 1 illustrates the stress pattern generated by a wheel load moving on an overlay placed over a cracked pavement. The development of crack in the overlay can be considered in the following three phases – Initiation of the crack , propagation of the crack and failure of overlay when the cracks reaches the surface . The main factors that can cause reflection cracking are traffic, temperature variations, and moisture variations in the sub grade. ***Brooker,*** said that external parameters involved in thermal reflective cracking are,
- Road base transverse crack spacing
- Road base thermal coefficient of expansion
- Monthly daily temperature range (top of road base)
- Monthly mean temperature in surfacing

  The first three of these parameters combine to determine daily cyclic crack opening movements in the road base that may cause thermal reflection cracking of the top surface.

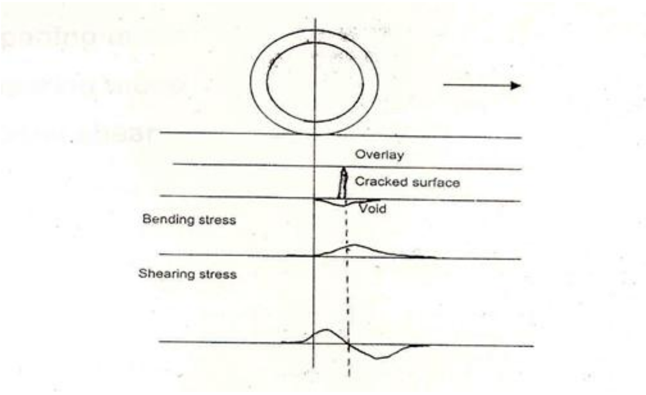


Fig.1 Stress development in pavement under wheel load

Traffic loads traveling over a crack existing in the lower base layer produce three successive stress pulses, two in the shearing mode and one in the opening mode when the load is over the crack. Temperature and moisture changes in the underlying layers make the layers expand or contract generating mode 1 opening of the crack.

II. DESIGN OF AGGREGATE MIX

A. *Physical properties of Aggregates & Bitumen*

The various properties of course aggregates and Bitumen are as shown in table I & table II respectively.

TABLE I. PHYSICAL PROPERTIES OF AGGREGATE (AS PER MORTH)

SR. No.	Name of the property	Value in %
1	Aggregate Impact Value	14
2	Flakiness Elongation Index	20
3	Water absorption	1.1
4	Soundness test	4 % (Loss of weight)
5	Loss Angeles abrasion test	19 %

The specific gravity of coarse aggregate 20mm, 13.2mm, stone dust and lime are 2.67, 2.67, 2.69 and 2.80 respectively.

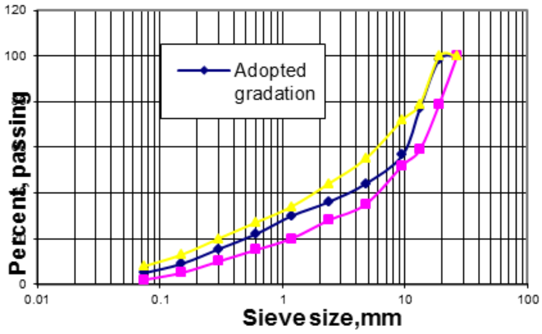
TABLE II. PROPERTIES OF THE BINDER USED FOR THE MIX (AS PER MORTH AND SP: 53: 2002)

S. No	Sample of bitumen	Specific Gravity	Softening point ˚C	Ductility (at 27˚C) cm	Penetration 25˚C/100gm/5 sec.
1	60/70	1.02	47.7	74	63
2	PMB 40	1.03	67	>100	42
3	PMB 70	1.03	82	>100	25

Specific gravity of bitumen has been taken as 1.02

B. *Gradation of aggregate*

For the different sizes of aggregates, individual aggregates gradation has been done. To get the specified gradation of BC mix, aggregates of different sizes were blended with different proportion and many trials were made. The final gradation is shown through the graph.



C. *Preparation of Marshall Sample*

Marshall samples of 4 inch. Diameter were prepared using gradation of aggregates as per table 4.7 and 60/70 Grade bitumen as per MS-2 specifications. The samples were prepared at different Binder contents. These samples were tested in the lab for stability and flow values. The test results have been shown in table III and graphically in fig.2. The binder content at maximum stability, at maximum bulk density, 4.5 % air voids, at 70 % VFB & at flow value of 3 is determined. The optimum binder content is the average of all the 5 binder content values.

TABLE III. RESULTS OF MIX DESIGN BY MARSHALL METHOD WITH NEAT BITUMEN

%ASPHALT	STABILITY (Kg)	FLOW (mm)	CDM (%)	VIM (%)	VMA (%)	VFB (%)
3.5	912	2.96	2.41	5.858	13.84	57.67
4	1065	3.06	2.43	4.428	13.58	67.39
4.5	1043	3.25	2.43	3.576	13.84	74.16
5	972	3.62	2.42	3.145	14.47	78.26
5.5	907	4.1	2.40	3.614	15.86	77.22

Average value of OBC is 4.45 % by weight of Aggregate.

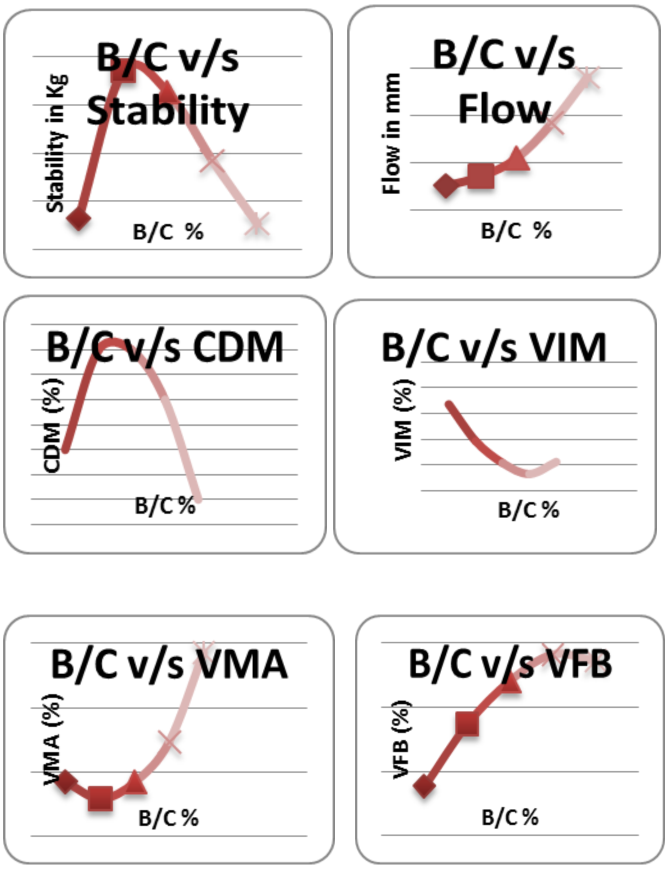


Fig.2. Marshall stability Parameter curves

III. IDENTIFICATIONS OF GEO-SYNTHETIC MATERIAL

Four different types geo-synthetic samples were purchased from the market for use. These were commonly available gunny bags which were used to pack sugar, rice, wheat, needle punch ,span bund, etc. various tests were carried out on these geo-synthetics as per ASTM specifications. Asphalt retention has been done as per ASTM D 6140-97; for Thickness ASTM D 5199-91 has been referred. The results are shown in table IV.

TABLE IV. GEO-SYNTHETICS STUDIED FOR RESEARCH WORK

Fabric Type	**Thickness (mm)**	**Asphalt Retention (kg/Sq.m)**	**Melting Point °C**	**Status**	**Mass per Area gm/m²**
Sample No 1 N.W.S.B	0.7	-	135	Rejected	-
Sample No 2 W.N.P.	1.0	-	135	Rejected	-
Sample No 3 N.W.S.B	0.6	-	130	Rejected	-
Sample No 4 N.W.S.B	0.6	-	140	Rejected	-
Sample No 5 N.W.S.B	0.7	0.7	>150	Adopted	138
Sample No 6 W.N.P.	1.0	1.6	>150	Adopted	145
Sample No 7 W.N.P.	1.3	2.3	>150	Adopted	146
Sample No 8 W.N.P.	1.8	3.0	>150	Adopted	152

N.W.S.B. – Non Woven Span Bund.

W.N.P. – Woven Needal Punch.

Sample No. 1 to 4 is rejected due to their low melting point.

Many other tests were performed to check the durability of the geo-synthetics, such as the tensile strength, asphalt retention. The results are shown in subsequent tables. The standard value of asphalt retention test should 0.6 kg/sq.m, tensile strength 36 kg & melting point 165°C. The standard value of Mass per area is 140 gm/Sq.m.

A. *Asphalt retention*

Asphalt retention is a amount of bitumen required to coat the geo-synthetics . This test is carried out on a 20cm by 10 cm sample of geo-synthetics. Four samples were taken in machine direction and four were taken in cross machine direction. The bitumen is first heated up to a temperature of 135 deg and then maintained at the same temperature for half an hour, now immerse the already weighed geo-synthetics samples in the bitumen for half an hour and keep it in oven. After half an hour remove the jute samples from the bitumen and hang them on a hanger arrangement for half an hour at 135 deg after half an hour change the sides of jute so as the uniform removal of excess bitumen can take place. Weigh the coated samples and find the average wt. of bitumen retained. If bitumen retained is around 0.6kg/m2 then it can be considered as fine. If excess bitumen is retained it can lead to bleeding.

B. Marshall test

Test results of Marshall Sample with geo-synthetic material in-between for stability. Marshall Samples were made with geo-synthetic material as an intra-layer; the geo-synthetic material is first coated with asphalt. The Marshall mould is first filled with half the mix and then compacted with 3 to 5 blows then the coated fabric is placed on the half compacted mix. Above this rest of the mix is placed and then on other side 75 blows were given. The table no. V, VI, VII, VIII shows the stability & flow parameter of Marshall Mix Design test.

TABLE V. STABILITY VALUE OF MARSHALL SAMPLES WITH GEO-SYNTHETIC SAMPLE NO.5 AS INTRA-LAYER

Sr. No	Density (g/cc)	Stability (kg)	Flow (mm)
51	2.31	1255	4.3
52	2.29	1292	4.1
51 a (PMB 40)	2.30	1086	4.2
51 b (PMB 70)	2.30	1329	4.1

TABLE VI. STABILITY VALUE OF MARSHALL SAMPLES WITH GEO-SYNTHETIC SAMPLE NO.6 AS INTRA-LAYER

SR. No	Density (g/cc)	Stability (kg)	Flow (mm)
61	2.30	1139	4.1
62	2.31	1397	4.4
61 a (PMB 40)	2.31	1107	4.0
61 b (PMB 70)	2.33	1276	4.2

TABLE VII. STABILITY VALUE OF MARSHALL SAMPLES WITH GEO-SYNTHETIC SAMPLE NO.AS INTRA-LAYER

SR. No	Density (g/cc)	Stability (kg)	Flow (mm)
71	2.29	1207	4.2
72	2.30	1167	4.0
71 a (PMB40)	2.29	1273	4.0
71 b (PMB70)	2.30	1202	4.2

TABLE VIII. STABILITY VALUE OF MARSHALL SAMPLES WITH GEO-SYNTHETIC SAMPLE NO.8 AS INTRA-LAYER

S. No	Density (g/cc)	Stability (kg)	Flow (mm)
81	2.31	1307	4.5
82	2.31	1298	4.1
81 a (PMB 40)	2.30	1188	4.3
81 b (PMB 70)	2.29	1397	4.1

IV. CONCLUSION

From the result it can be seen that among the all 8 samples only 4 samples (i.e. sample no. 5, 6, 7, 8) were satisfying the temperature requirement of mix.

Result shows that conventional mix has stability value 1046 kg while after addition of Geo-synthetic material sample 5,6,7,8 shows stability values higher than conventional mix stability value. But flow value for conventional mix with addition of Geo-synthetic is little more than the prescribe limit as per Marshall Design. For all sample addition of Geo synthetic with PMB (40) shows high stability value than conventional mix but lower than convention mix with Geo-synthetic. Use of Geo synthetic with PMB 70 shows high stability value for all sample compare to PMB 40 with Geo – synthetic.

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