EFFECT OF FORTA AND BANANA FIBERS ON SMA MIXES

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***Abstract*— Stone Mastic Asphalt is a stone to stone like structures like skeleton of aggregates, joined mutually via asphalt or mastic which is actually higher binder substance to the normal asphalt, filler plus fiber are added to reduce the drain down of asphalt. In this study Forta fiber and Banana fibers are added to the SMA Mix with 0.3% of total weight of the mix for reducing the drain down of asphalt. From the result it is found that SMA Mix with Forta fiber gives significant higher strength compared to banana fiber. Because the Optimum Binder Content of Forta fiber mix is 6% & the Stability at OBC is 15.119 kN, and for Banana fiber mix the OBC is 6.1% & stability at OBC is 12.7 kN.**

Keywords— **Stone mastic asphalt: Forta & Banana Fiber, Optimum binder content (OBC)**

1. INTRODUCTION

The main problem encountered in flexible pavements is rutting failure of the both bituminous layers, such as binder (intermediate) and wearing course due to heavy wheel loads of the moving vehicles. In mid 1960s the stone mastic asphalt is as well-known as stone matrix asphalt (SMA) was advanced in Germany for the flexible pavements. This gives a stability against the permanent deformation of the pavement layer due to heavy traffic loads. There are generally the sorts of bituminous finishing, categorised by bituminous blend combined with stone aggregates, these are condensed graded blacktop, Open graded SMA pavement. Stone Mastic Asphalt is a stone to stone like structures like skeleton of aggregates, joined mutually via asphalt or mastic which is actually higher binder substance to the normal asphalt, filler plus fiber are added to reduce the drain down of asphalt. For improvement of stability and working of the SMA even higher than the dense and open graded mixes. Higher fraction of asphalt quantity is principal to certify the endurance and strength of SMA. Due to the high rut resisting properties and also noise reducing ability enables this mix in the use of airfield pavements and highways with heavy traffic loads.

Usual SMA Mix configuration comprises of 70-80% coarse aggregate, 8-12% filler, 6-7% bitumen, 0.3% fiber. Presence of additives such as fibers toughen the bonding among the aggregates specified in the binder in addition to in this manner enhancing the stone to stone interaction which result now cumulative the resistance towards crushing due to action of moving wheel loads. This outcomes in the growth of firmer in addition stronger mix through substantial enhancement in strength. Inclusion of additives not the reason of SMA blend to deteriorate when open to dampness. In fact they remain boosting the opposition to dampness vulnerability of the mix.

1.1 Scope of the Project

To determine the various engineering properties of aggregates, binder and additives are done in preliminary studies. To find out the optimum fiber percentage for the better strength and durability of the SMA mixes. To evaluate the better fiber on behalf of the usage in SMA mixes on the basis of Marshal Stability properties such as Stability and flow value.

1.2 Objectives

Evaluating the optimum binder content of SMA Mix with using Forta and Banana fibers, and compare the Marshal & Drain down results for each fiber to evaluate which is best for SMA mix.

2. MATERIALS

The materials used in this project are as follows.

2.1 Bitumen

VG 30 grade bitumen is used.

2.2 Fibers

Forta fiber, Banana fiber.

2.3 Aggregate

20 mm down size Natural Aggregate and Stone dust is used.

3. METHODOLOGY

Samples of the materials are taken and basic test are conducted for aggregate, & bitumen as shown in Fig. 1. The aggregate graduation requirements are shown in Table I according to IRC:SP:79-2008. The predetermined properties of Forta & Banana fibers are used are shown in Table II. At first 5.8% bitumen content taken to prepare SMA Mix is as mentioned in IRC:SP:79-2008. The marshal specimen is prepared by taking aggregate and mineral filler of total weight of 1200gm, in proportion obtained in the Job mix formula. Initially the aggregates with mineral filler are heated to a temperature ranging from 160-170ºC, the fiber is mixed to the heated aggregate and mineral mix. The binder is heated to achieve the temperature of 160ºC. The heated aggregate, fiber and filler blend is added to the hot bitumen and mixed thoroughly till all the bitumen is dispersed to the aggregate blend evenly at a temperature maintaining 160ºC. Once the mixture is uniform it is transferred to compacting mould. The compacting mould is preheated to 16ºC and thoroughly lubricated with oil. Once the mix is placed the compaction is to be done with 50 no of blows on both side. Once the compaction is done
The specimen is removed and it is placed in room to cool at with the temperature same as room temperature. Once the specimen is cooled and it is placed in water for bath for about 30 minutes maintaining a temperature of 60ºC. The binder content is increased with a percentage of 0.2, for optimum Binder Content (OBC).

TABLE I
AGGREGATE GRADATION AS PER IRC:SP:79-2008

SMA designation	**13mm SMA**
Course	Wearing course
Nominal aggregate size	13mm
Nominal layer thickness	40-50mm
IS sieve (mm)	Cumulative % by weight of total aggregate
26.50	-
19.00	100
13.20	90-100
9.50	50-75
4.75	20-28
2.36	16-24
1.18	13-21
0.60	12-18
0.30	10-20
0.075	8-12

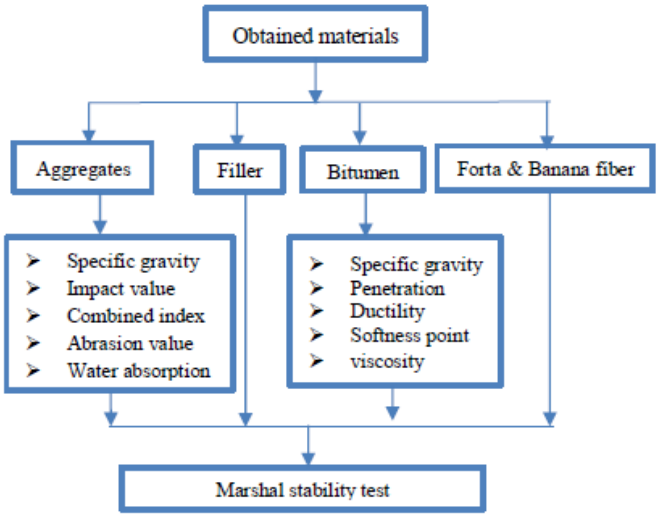

Fig. 1: Methodology flow chart

TABLE II
PHYSICAL PROPERTIES OF FIBERS USED

Properties	Forta fiber	Banana fiber
Diameter(mm)	100-450	100
Density(g/cm3)	1.4	1.35
Length	19mm	15mm
Specific gravity	0.91-1.44	0.9
Colour	yellow	white

4. TESTS CONDUCTED

Test basic tests are conducted on Bitumen and aggregate and the results are tabulated in the Table III & IV. The Marshal properties of SMA Mix with 0.3% for both fibers are shown in the Table V & VI. The Marshal properties corresponds to the Optimum Binder Content (OBC) is shown in Table VII. The various Marshal properties such as Stability, Flow value, Density, Vv, VFB, and VMB varying with respect to the Binder content are plotted in the graph shown in Figs. 2 to Fig. 13.

4.1 Basic test results of Bitumen

TABLE III
Bitumen Test Result

Test	Values Obtained	Specification	Standard Test Method
Specific Gravity	1.003	0.97-1.02	IS 1202
Penetration Test	65	60-70	IS 1203
Softening Point	58	45-55	IS 1206
Flash Point	185ºC	Min 220ºC	IS 1448
Viscosity Test	368	Min 350	IS 1206
Ductility Test	81cm	Min 75mm	IS 1208

4.2 Basic test results of Natural Aggregate

TABLE IV
NATURAL AGGREGATE TEST RESULT

Test	Values Obtained	Specification	Standard Test Method
Specific gravity	2.6	2.4 to 2.8	IRC:SP: 79-2008
Water absorption	0.25%	Max 2%	IRC:SP: 79-2008
Impact test	14.50%	Max 18%	IRC:SP: 79-2008
Crushing value	23.36%	Max 30%	IRC:SP: 79-2008
LOS Abrasion test	21.14%	Max 25%	IRC:SP: 79-2008
Combine Flakiness and Elongation Index	24.77%	Max 30%	IRC:SP: 79-2008

4.3 Test results of SMA with 0.3% Forta fiber

TABLE V
Marshal properties

Bitumen (%)	5.4	5.6	5.8	6.0	6.2
Stability (kN)	12.30	12.925	1375	15.119	12.01
Vv (%)	5.120	4.8	4.315	4.014	3.87
Vb (%)	10.925	12.343	13.65	13.967	10.92
Density (g/cc)	2.176	2.41	2.6	3.21	3.9
Flow (mm)	2.12	2.41	2.78	3.2	3.79
VMA (%)	16.135	17.143	17.87	17.98	18.72
VFB (%)	69.71	70.20	74.13	75.12	76.17

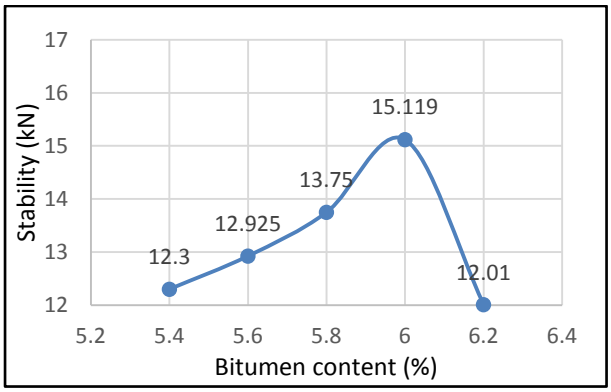

Fig. 2: Stability of SMA mix with 0.3% Forta fiber

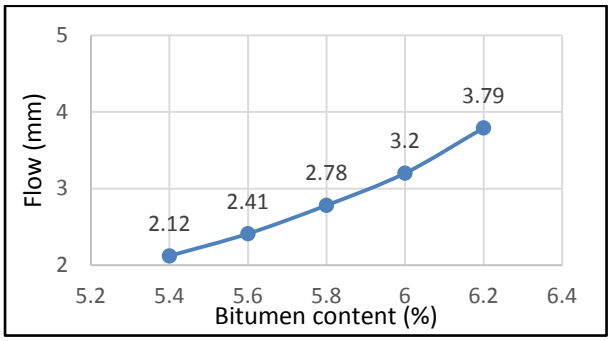

Fig. 3: Flow of SMA mix with 0.3% Forta fiber

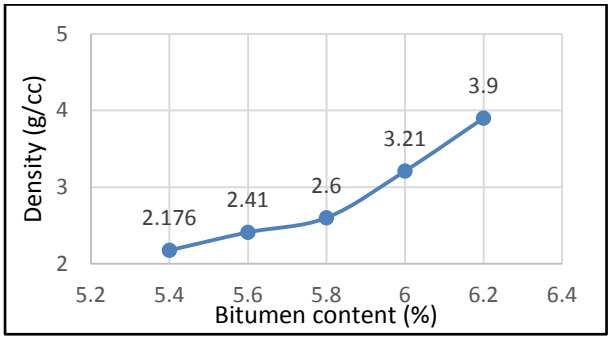

Fig. 4: Density of SMA mix with 0.3% Forta fiber

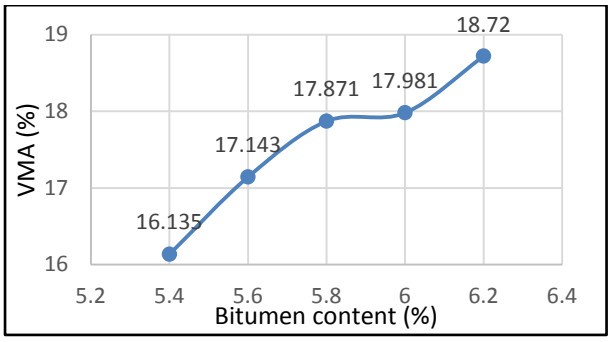

Fig. 5: VMA of SMA mix with 0.3% Forta fiber

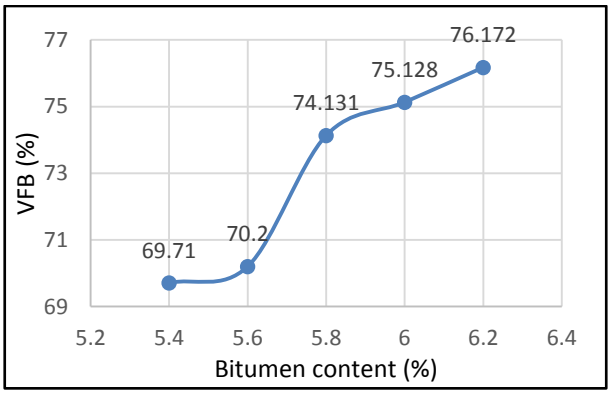

Fig. 6: VFB of SMA mix with 0.3% Forta fiber

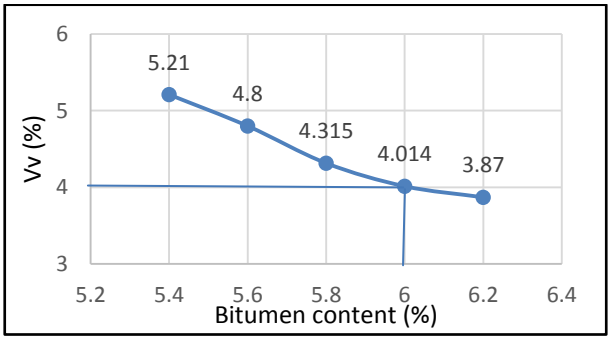

Fig. 7: Vv of SMA mix with 0.3% Forta fiber

4.4 Test results of SMA with 0.3% Banana fiber

TABLE VI

Marshal properties

Bitumen (%)	5.4	5.6	5.8	6.0	6.2
Stability (kN)	10.12	11.92	12.19	12.7	12.20
Vv (%)	5.29	4.92	4.42	4.12	3.96
Vb (%)	12.381	12.616	13.199	13.79	14.14
Density (g/cc)	2.214	2.316	2.327	2.33	2.34
Flow (mm)	2.5	3.36	4.01	4.36	4.91
VMA (%)	17.671	17.536	17.619	17.91	18.10
VFB (%)	70.06	71.91	74.91	78.26	82.69

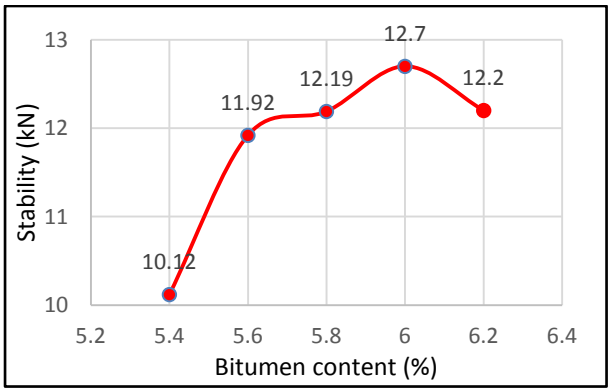

Fig. 8: Stability of SMA mix with 0.3% Forta fiber

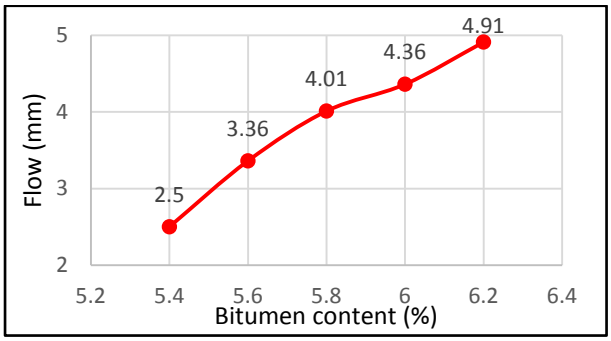

Fig. 9: Flow of SMA mix with 0.3% Forta fiber

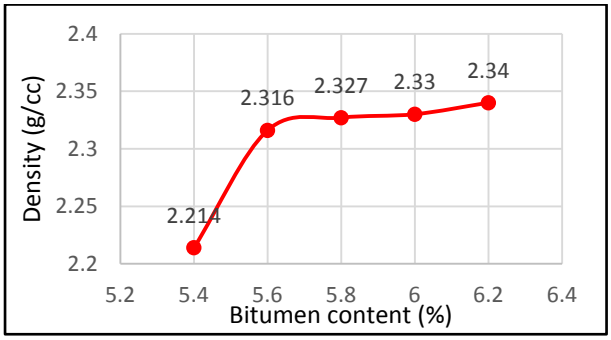

Fig. 10: Density of SMA mix with 0.3% Forta fiber

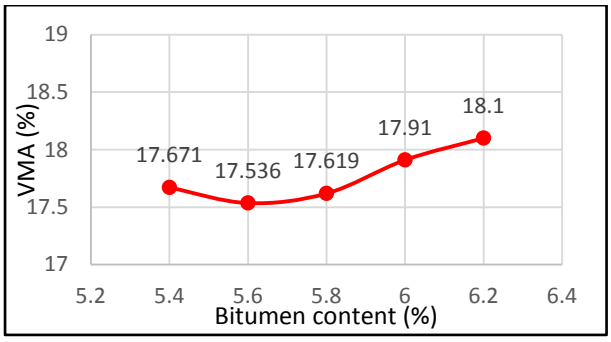

Fig. 11: VMA of SMA mix with 0.3% Forta fiber

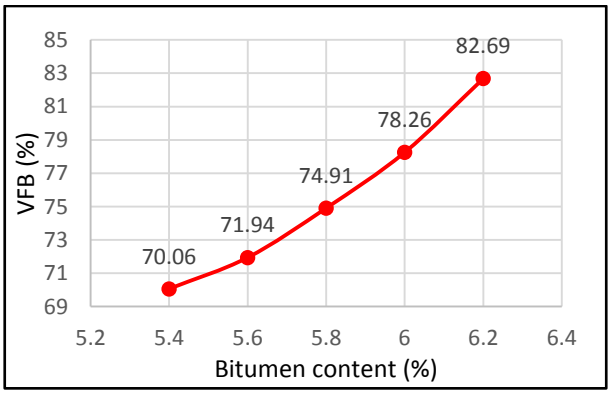

Fig. 12: VFB of SMA mix with 0.3% Forta fiber

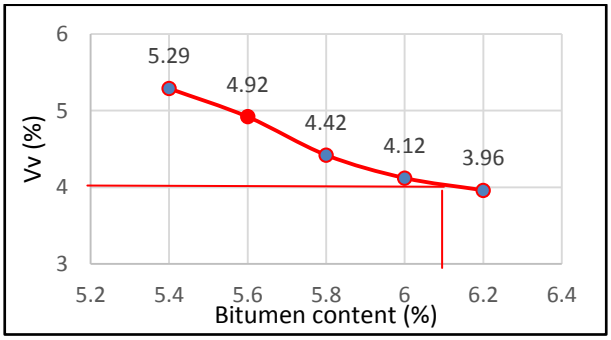

Fig. 13: Vv of SMA mix with 0.3% Forta fiber

4.5 Comparative Marshal Test results of SMA with 0.3% Forta fiber 7& 0.3% of Banana fiber

TABLE VII

Marshal properties of SMA Mix at OBC

Properties	**Specification As Per IRC:SP:2008**	**Forta Fiber**	**Banana Fiber**
OBC (%)	5.8 min	6	6.1
Air voids (%)	3-5	4	4
Stability (kN)	Min 9	15.119	12.7
Flow (mm)	2-5	3.2	4.91
Bulk density (g/cc)	-	3.21	2.34

VMA (%)	17min	17.981	17.91
VFB (%)	-	75.128	78.26

4.6 The drain down characteristics of SMA Mix

Table VIII
Drain down results of SMA Mix at OBC

SMA Mix	**Percentage of Binder drain down**	**Specification as per IRC:SP:79:2008**
With 0.3% of Forta fiber	0.29	Max 0.3%
With 0.3% of Banana fiber	0.28	Max 0.3%

5. Results & Discussion

From Table V the Marshal Test results of Forta Fiber are plotted in graph from Figs. 2 to 7. In Fig. 3 the stability value increases gradually and reach a peak point after that it decreases the peak stability value is taken as maximum stability value and the corresponding binder content is taken as Optimum Binder Content for Forta Fiber SMA mix the maximum stability and flow value is obtained at 6% binder content, which is Optimum Binder Content (OBC) and the stability value at OBC is 15.119 kN, and flow value is 4.36mm which is n desirable limit. And the drain down test is conducted at OBC with SMA mix of 0.3% Forta fiber and the results obtained is 0.29% & tabulated in Table VIII. The same procedure is adopted for Banana Fiber the Marshal properties are tabulated in Table VI and graphs plotted from Figs. 8 to 13. From this the OBC obtained is 6.1% and the bitumen stability value is 12.7 kN, and the flow value is 0.2%. The comparison of both results are shown in Table VIII.

6. Conclusions

By conducting Marshal Stability Test and drain down test and considering the results the overall performance of the SMA Mix compared between Forta and Banana fiber the SMA Mix with 0.3% Forta fiber shows the better performance compared to SMA with 0.3% Banana fiber. Forta fiber requires smaller binder content (6.0%) in order to achieve the sufficient strength compared to Banana fiber (6.1%). This is because Forta fiber is stronger than steel and thinner than air. The Forta fiber shows the significant higher strength, stability & flow value compared to Banana fiber from results. So the thickness of the pavement is reduced.

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Completion of a task is never a one man effort. It is often the result of valuable contribution of number of individuals in a direct or indirect manner, which helps in shaping and achieving an objective. It is my pleasant duty to thank all those who have been helpful in various ways towards successful completion of this project. The credit of the successful completion of the project should go to the person who rendered their source of knowledge, timely suggestions and instructions towards us.

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