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Comparative Study on Stone Mastic Asphalt Mix for Coir Fiber and Bamboo Fiber

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***Abstract*: As we know that the conventional mix which is used in Construction of bridges and road is dense graded asphalt. But if we are using Stone mastic asphalt maximize rutting resistance and durability in heavy traffic road. Typical SMA composition consists of 70−80% coarse aggregate, 8−12% filler, 6.0−7.0% binder, and 0.3 per cent fiber. The deformation resistant capacity of SMA stems from a coarse stone skeleton providing more stone-on-stone contact than with conventional dense graded asphalt (DGA) mixes. Improved binder durability is a result of higher bitumen content, a thicker bitumen film, and lower air voids content. This high bitumen content also improves flexibility.**

In this study relevant index and engineering properties of bagasse and coir fibers in stone matrix asphalt is done with several laboratories experimentation.

***Keywords*: Bagasse, Coir fiber, SMA (Stone mastic asphalt).**

1. Introduction

The construction of a new road and the strengthening of the bridge are major developments in India in the area of infrastructure development. To build a bridge that spans the course of strength, mastic stability is a task that provides all the materials for a study. Bitumen bitumen is composed of mineral filler and coarse composites, fine aggregates and heavy bitumen mass to form a coarse, low-density, solid or solid under normal temperature conditions, but sufficient liquid when brought to room temperature which should be distributed by float in handicrafts and paver in machinery construction.

Mastic asphalt is a dense compound consisting of coarse aggregate, sand, and fine limestone aggregate, filler and bitumen, which may contain additives (e.g., polymers, waxes). The mixture is designed to be in a non-abrasive content. The content of the binder is so adjusted that the voids are completely filled and that even a small amount of binder can emerge. Mastic asphalt is poured and can be distributed at its operating temperature. It does not require interaction on site. The mastic asphalt base is a widely used material and was specified to place bridges on top. This traditional information is known as water-based durability, however, the large increase in traffic load and application requirements under harsh environmental conditions makes performance better. It is an integrated gap, characterized by high-quality composites, high asphalt content. It provides high erosion resistance and provides sufficient friction at the surface of the subway despite being exposed to repeated loads. It has a high part of the composite compound, a low part of the compound size and a high part of the mineral filler. It is used on a much larger scale in some countries such as sitting on bridges, rotary where the wear and load of the car is over. The main problem with mastic asphalt is the failure of the binder during compaction, transport materials due to the high percentage of content of the

SMA improved durability and durability. It has good fatigue and tensile strength. SMA is probably only used for high school courses on high volume tracks. The materials used for SMA are Gap grad aggregate, modified asphalt binder, fiber filler. Other benefits of SMA include wet weather collisions (due to overcrowding of the coarser), low tire noise (due to overcrowding of the coarser) and cracks showing discomfort. Mineral fillers and additives used to reduce asphalt binder drain-down during construction, increase the amount of asphalt binder used in mixing and improve durability.

2. Literature Review

This *Rosli Hainan et. al.,* studied the Importance of Stone Mastic Asphalt in Construction. The first aim of this study is to provide an updated systematic review of the evaluation of stone mastic asphalt in construction. The second aim is to develop knowledge readers and researchers for advantages and disadvantages of stone mastic asphalt to help focus future research in this area. This paper has reviewed on stone mastic asphalt that addressed these major elements through interviews with a number of respondents and through an investigation of previous researches used SMA. It is concluded that SMA is appropriate asphalt in construction. The use of SMA does not show any systemic safety issues. There are however institutional issues that influence the effective use.

Teja Tallam et. al., studied the assessment of stone mastic asphalt Performance with the inclusion of fiber Material on resilient characteristics. The main objective of this study is to compare the inclusion of polyester fibers in SMA Mix for understanding the behaviour of resilient characteristics. Optimum binder content (OBC) of SMA Mix is arrived 6.5% and the corresponding fiber content (OFC) was arrived as 0.4% when performed through drain down test. Polyester fibers have good drain down characteristics and provide good homogeneous mixture compared with conventional SMA. It is observed from test results that resilient modulus increased with the addition of polyester fibers by 18% and tensile strength ratio by 1.2%. This indicates that fiber inclusion provides better cracking resistance when compared with conventional SMA Mix.

Mohammad Altaf Bhat et. al., studied the Effect of Fillers on Bituminous Mixes. To satisfy the design requirements of stability and durability the bituminous mixes should be designed effectively. The ingredients of the mixture include dense grading of coarse aggregates, fine aggregates, fillers and bitumen binder. In this Study an attempt was made to find the effect of filler on the behavior of bituminous mixes. Fillers play an important role in the filling of voids and hence change the physical and chemical properties. Thus their effect is of utter importance. Bitumen in combination with filler forms mastic. This mastic can be seen as a constituent of mixture of asphalt that holds the aggregates together. An important role is played by the fillers that pass through 0.075mm sieve. With the increase in the amount of filler, Marshall Stability of the bitumen mix increases directly. Use of 4-8% filler in asphalt concrete is recommended by the Asphalt Institute. In India, waste concrete dust and brick dust are considered to be cheaper and are available in plenty. In this study an attempt was made to find the effect of fillers on the bitumen mixes. In this study, concrete dust and brick dust was used as filler. The properties of bituminous mixes containing these fillers were studied and compared with each other. For the purpose of comparison Marshall Method of mix design was used. In this study various tests were also conducted on aggregates and bitumen and the results were compared with the specifications. The study revealed that use of concrete dust and brick dust as filler improves the physical characteristics of bitumen. Marshall Stability and flow value of bitumen mix also improved.

3. Material Used

The materials used are as follows.

1) Aggregates
2) Bituminous Binder
3) Mineral Filler
4) Bamboo Fiber & Coir Fiber

A. Aggregate

Aggregate constitutes the granular part in bituminous concrete mixtures which contributes up to 90-95 % of the mixture weight and contributes to most of the load bearing & strength characteristics of the mixture. Hence, the quality and physical properties of the aggregates should be controlled to ensure a good pavement. The properties that aggregates should have to be used in pavement are shown below,

- Aggregates should have minimal plasticity. The presence of clay fines in bituminous mix can result in problems like swelling and adhesion of bitumen to the rock which may cause stripping problems. Clay lumps and friable particles should be limited to utmost 1%.
- Durability or resistance to weathering should be measured by sulphate soundness testing.
- The ratio of dust to asphalt cement, by mass should be a maximum of 1.2 & a minimum of 0.6.
- It is recommended AASHTO T-209 to be used for determining the maximum specific gravity of bituminous concrete mixes.
- Aggregates are of 2 types. i.e.
  a) Coarse Aggregate (CA)
  b) Fine Aggregate (FA)

B. Bitumen

Asphalt binder grade 30 (VG30) is used in this research. The bitumen used should have the following properties.

a) Grade of bitumen used in the pavements should be selected on the basis of climatic conditions and their performance in past.
b) It is recommended that the bitumen should be accepted on certification by the supplier (along with the testing results) and the State project, verification samples. The procedures for acceptance should provide information, on the physical properties of the bitumen in timely manner.

The physical properties of bitumen used which are very important for pavements are shown below. Each State should obtain this information (by central laboratory or supplier tests) and should have specification requirements for each property except specific gravity.

Table 1
Physical Properties of Bitumen

S. No.	Property	Result
1.	Specific Gravity	0.995
2.	Penetration Value	46.23 mm
3.	Ductility Test	104.5 cm
4.	Softening Point	51ºC
5.	Flash Point	267 ºC
6.	Fire Point	345 ºC

C. Mineral Filler

The fillers constitute 8% to 12% of the mixture. In this study we have used 20% hydrated lime and 80% fine aggregates passing through 75µm for good binding properties.

Table 2
Specific Gravity of Filler Materials

S. No.	Filler	Specific Gravity
1.	Hydrated Lime	2.25
2.	Fine Aggregates	2.70

D. Coir Fibers and Bamboo

In this study two types of fibers were used Bamboo and Coir Fiber. 0.3% by weight of aggregate has been added to minimize the drain down effects.

Table 3
Specific Gravity of Fibers

S. No.	Fibre	Specific Gravity
1.	Bamboo	0.685
2.	Coir	0.684

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4. Methodology

It involves mainly three processes.

a) Preparation of samples
b) Void analysis
c) Testing

Before these processes, the specific gravity of polythene was calculated as per the guidelines provided in ASTM D792-08.

A. Sample Preparation

The specifications of the Marshall sampling mould and hammer are given in table

Table 4
Dimensions of Marshall Sampling mould and hammer

Apparatus	Value	Working Tolerance
Mould		
Average internal diameter, (mm)	101.20	± 0.5
Hammer		
Mass, (kg)	4.535	± 0.02
Drop Height, (mm)	457	± 1.0
Foot diameter, (mm)	98.5	± 0.5


Fig. 1. Marshall sampling mould

B. Mixing Procedure

Mixing ingredients is done as follows: STP 204-8).

1) Necessary quantity of composite composite, fine composite & mineral composites.
2) These are stored in the oven at a temperature of 1600C for 2 hours, because a mixture of compounds will be put into the mix, so pre-heating is necessary.
3) Bitumen was heated again until it melted before mixing.
4) The required amount of polythene was weighed and stored in a container.
5) Aggregates were heated in a burner for a few minutes to maintain the temperature mentioned above.
6) Boiled polythene was added to the aggregates and mixed for two minutes.
7) Thereafter, bitumen (60 gm), i.e.5% was added to the mixture and the whole mixture was stirred evenly and evenly. This was done for 15 to 20 minutes until they were thoroughly mixed which appeared to be the same color throughout the mixture.
8) After that the mixture is transferred to the casting mould.
9) It was then compiled by Marshall Hammer.
10) Seventy-five no. beats are given on each side of the sample
11) Then the mouldy samples are stored separately and marked.


Fig. 2. Marshall samples

Table 5
Amounts of raw materials

Polythene %	Wt. of Fibre(gm)	Wt. of Aggregate (gm)
MIX 1	3.6	1152
MIX 1	3.6	1152
MIX 1	3.6	1152
MIX 2	3.6	1140
MIX 2	3.6	1140
MIX 2	3.6	1140
MIX 3	3.6	1134
MIX 3	3.6	1134
MIX 3	3.6	1134
MIX 4	3.6	1128
MIX 4	3.6	1128
MIX 4	3.6	1128
MIX 5	3.6	1116
MIX 5	3.6	1116
MIX 5	3.6	1116

Table 6
Gradation table with Fibre

Sieve Size (mm)	% Retained	4%	5%	5.5%	6%	7%
13.2	5	57.42	56.82	56.52	56.22	55.62
9.5	32	367.49	363.65	361.72	359.80	355.97
4.75	39	447.88	443.196	440.86	438.52	433.84
2.36	4	45.94	45.45	45.22	44.98	44.50
1.18	3	34.45	34.09	33.91	33.73	33.37
0.6	2	22.97	22.72	22.60	22.49	22.25
0.3	0	0	0	0	0	0
0.75	5	57.42	56.82	56.52	56.22	55.62
Filler	10	114.84	113.64	113.04	112.44	111.24
Binder		48	60	66	72	84
Fibre		3.6	3.6	3.6	3.6	3.6

C. Void analysis

The samples were weighed in air and also immersed in water so that water replaces the air present in the voids of specimens. But some amount of water will be absorbed by the aggregates which give flawed results. Therefore, the samples were coated with paraffin wax so that it seals the mix completely and checks the absorption of liquid into it.

Table 8
Correction Factors

Volume of Specimen (cm^3)	Average thickness of Specimen (mm)	Correction Factors
445-455	55.50	1.26
456-469	57.30	1.19
470-481	58.68	1.14
482-494	60.35	1.09
495-507	61.91	1.04
508-521	63.48	1
522-534	65.20	0.96
535-545	66.60	0.93
546-558	68.40	0.89
559-572	69.70	0.83

Table 7
Gradation table without Fibre

Sieve Size (mm)	% Retained	4%	5%	5.5%	6%	7%
13.2	5	57.6	57	56.7	56.40	55.8
9.5	32	368.64	364.80	362.88	360.96	357.12
4.75	39	449.28	444.60	442.26	439.92	435.24
2.36	4	46.08	45.60	45.36	45.12	44.64
1.18	3	34.56	34.20	34.02	33.84	33.48
0.6	2	23.04	22.80	22.68	22.56	22.32
0.3	0	0	0	0	0	0
0.75	5	57.6	57	56.7	56.40	55.80
Filler	10	115.20	114	113.40	112.80	111.60
Binder		48	60	66	72	84

Table 9
Calculation of Parameters without fibres

Sample No's	Bitumen Content (%)	Wt before paraffin coating (gm)	Wt after paraffin coating (gm)	Wt in water (gm)	Ht (mm)	Wt of Aggregate Mix(gm)	Flow (mm)	Load Taken (KN)
1	4	1194	1212	709	64.30	1152	3.22	296
2	4	1185	1197	697	64.55	1152	2.52	256
3	4	1187	1202	703	65.10	1152	3.11	287
1	5	1179	1197	707	62.57	1140	4.20	351
2	5	1196	1198	701	63.15	1140	4.68	322
3	5	1185	1207	716	63.18	1140	3.58	292
1	5.5	1181	1192	747	57.20	1134	3.84	221
2	5.5	1177	1186	756	57.12	1134	4.29	279
3	5.5	1182	1190	758	61.10	1134	4.89	329
1	6	1201	1204	740	58.42	1128	4.64	272
2	6	1193	1201	754	57.35	1128	4.47	328
3	6	1184	1192	750	58.49	1128	5.43	254
1	7	1180	1209	705	61.20	1116	5.52	448
2	7	1182	1211	707	60.23	1116	5.67	476
3	7	1188	1214	712	60.45	1116	4.78	482

Table 10
Calculation of Parameters with bamboo fibres

Sample No's	Bitumen Content (%)	Wt before paraffin coating (gm)	Wt after paraffin coating (gm)	Wt in water (gm)	Ht (mm)	Wt of Aggregate Mix(gm)	Flow (mm)	Load Taken (KN)
1	4	1185	1195	710	65.30	1152	3.63	357
2	4	1182	1187	708	63.25	1152	4.15	374
3	4	1180	1187	704	62.50	1152	3.10	428
1	5	1198	1206	715	57.20	1140	4.89	402
2	5	1195	1204	711	58.30	1140	5.24	332
3	5	1188	1197	713	57.40	1140	3.88	394
1	5.5	1175	1186	746	57.40	1134	4.45	477
2	5.5	1175	1185	742	57.40	1134	4.35	482
3	5.5	1196	1206	755	57.60	1134	5.18	420
1	6	1195	1205	759	59.50	1128	4.18	413
2	6	1201	1210	741	58.40	1128	5.45	387
3	6	1204	1215	750	60.60	1128	4.48	337
1	7	1180	1190	750	57.45	1116	5.18	373
2	7	1182	1189	754	57.20	1116	4.94	368
3	7	1178	1184	746	63.40	1116	5.67	322

Table 12
Calculation of Parameters with Coir fibres

Sample No's	Bitumen Content (%)	Wt before paraffin coating (gm)	Wt after paraffin coating (gm)	Wt in water (gm)	Ht (mm)	Wt of Aggregate Mix (gm)	Flow (mm)	Load Taken (KN)
1	4	1143	1173	678	56.50	1152	2.89	264
2	4	1188	1218	685	57.40	1152	2.85	258
3	4	1152	1182	684	56.30	1152	2.76	273
1	5	1182	1199	673	57.50	1140	3.16	272
2	5	1187	1207	687	58.40	1140	3.24	258
3	5	1192	1210	689	57.50	1140	3.35	254
1	5.5	1201	1214	684	57.40	1134	3.65	278
2	5.5	1180	1191	690	56.70	1134	3.84	303
3	5.5	1186	1195	691	57.50	1134	3.79	301
1	6	1195	1204	695	58.50	1128	4.15	239
2	6	1184	1193	691	57.40	1128	4.36	228
3	6	1188	1198	695	58.70	1128	4.65	242
1	7	1170	1205	668	58.40	1116	4.57	203
2	7	1191	1199	682	56.50	1116	4.62	209
3	7	1187	1198	680	58.50	1116	4.74	219

D. Marshall testing

The Marshall test was done as procedure outlined in ASTM D6927 – 06.

Marshall Stability Value:

It is defined as the maximum load at which the specimen fails under the application of the vertical load. It is the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute (2 inches/minute). Generally, the load was increased until it reached the maximum & then when the load just began to reduce, the loading was stopped and the maximum load was recorded by the proving ring.

Marshall Flow Value:

It is defined as the deformation undergone by the specimen at the maximum load where the failure occurs. During the loading, an attached dial gauge measures the specimen's plastic flow as a result of the loading. The flow value was recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load was recorded.

5. Results

Three samples had been tested for each percentage of the bamboo and coir fibre. The average of the three values had been taken for the analysis. All the average values have been mentioned below in the table 13.

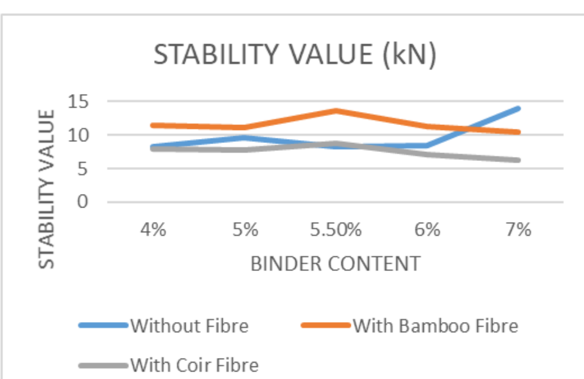

Fig. 3. Variation of stability value

Table 13
Stability vs. Binder Content

Binder (%)	Avg. stability without fiber (KN)	Avg. stability with bamboo fiber (KN)	Avg. stability with coir fiber (KN)
4	8.306108	11.47411	7.870508
5	9.55351	11.16721	7.761608
5.5	8.207108	13.65211	8.731809
6	8.454608	11.25631	7.019107
7	13.91941	10.52371	6.246906

Table 14
Flow Value vs. Binder Content

Binder content (%)	Avg. flow value without fiber (mm)	Avg. flow value with bamboo fiber (mm)	Avg. flow value with coir fiber (mm)
4	2.95	3.626667	2.833333
5	4.153333	4.67	3.25
5.5	4.34	4.66	3.76
6	4.846667	4.703333	4.386667
7	5.323333	5.263333	4.643333

Table 15
VA vs. Binder Content

Binder content (%)	Avg VA without fiber (%)	Avg VA value with bamboo fiber (%)	Avg VA value with coir fiber (%)
4	8.483651	17.12409	21.5904
5	5.050386	16.47994	10.4983
5.5	6.603031	9.062657	19.80487
6	8.24437	10.24419	19.56045
7	5.993435	5.808745	20.09567

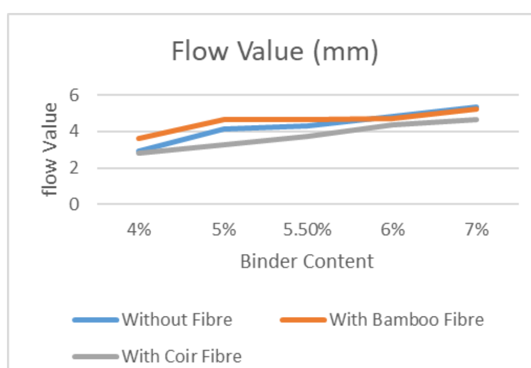

Fig. 4. Variation of Flow value

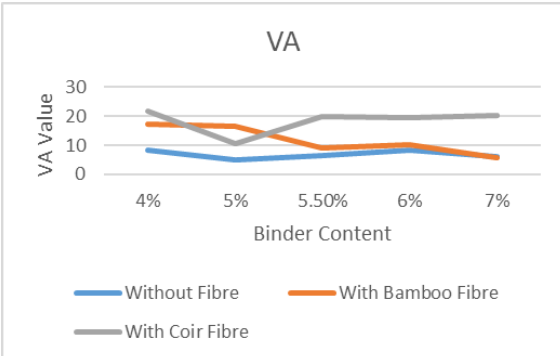

Fig. 5. Variation of VA Value

Table 16
VMA vs. Binder Content

Binder content (%)	Avg. VMA without fiber (%)	Avg. VMA value with bamboo fiber (%)	Avg. VMA value with coir fiber (%)
4	15.93997	24.33296	28.44004
5	15.77148	26.99652	20.58381
5.5	27.31855	20.77835	32.10566
6	22.99815	24.32751	31.05744
7	20.8426	20.80766	33.80044

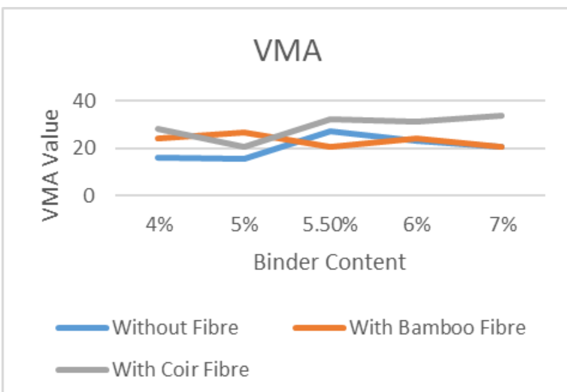

Fig. 6. Variation of VMA Value

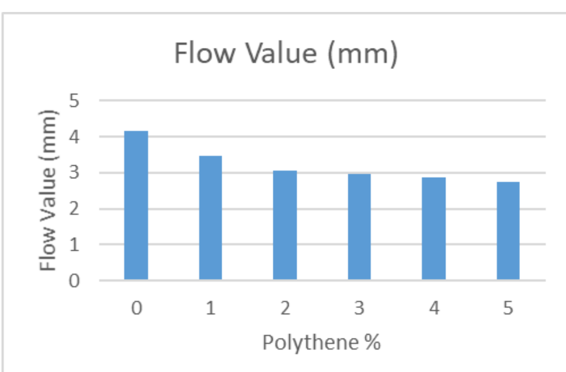

Fig. 7. Flow value with different proportions of polythene

6. Conclusion

Stability value first increases with increase in binder content then at a certain point it decreases gradually. Firstly, it increases because bond between binder and aggregates becomes stronger and it decreases because applied load is transmitted as hydrostatic pressure making fractions across constant point immobilized. This makes the mixture weak against plastic deformation and stability falls. From the graph the average stability value of coir fiber is highest followed by bamboo fiber and without fiber SMA mix.

Flow value increases with the increase in binder content because at lower binder content the mixes provide more stability as its homogeneity is not much disturbed but it is lost when binder content is increased. From the graph coir fiber has the least flow value (2.80mm) followed by bamboo fiber and mix without fiber mix.

OBC is found to be 5.5%. It is found where maximum stability occurs.

VA decreases with the increase in binder content because air voids are filled progressively. At 7% binder content the VA value of coir fiber is much more than bamboo and without fiber mix due to improper mixing.

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