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## Use of Wheat Straw Fibre as Stabilizing Additive in Stone Matrix Asphalt Mix

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**ABSTRACT.** Stone Matrix Asphalt (SMA) is a gap graded mix; characterized by higher proportion of coarse aggregate, lower proportion of middle size aggregate and higher proportion of mineral filler. The prime advantage of Stone matrix asphalt (SMA) is its ability to provide more durable surfacing, as well as its high resistance from damage due to heavy axle loads. However, the initial cost for preparation of SMA is more than the other common asphalt mixes. On the other hand, the utilization of waste and by-products in the construction is still limited, especially in developing countries like India. Agricultural wastes i.e. wheat straw is mostly burnt that causes environmental pollution. Utilizing agricultural waste for construction will not only reduce pollution but also reduce the overall construction cost. This paper reports about the experimental investigations carried out on stone matrix asphalt mixes prepared by using wheat straw fibres with VG 30 grade bitumen. Marshall Procedure has been followed to determine the optimum binder and also to study the relative advantages of fibre addition in the SMA mixtures. From the test results it was observed that stone matrix asphalt mix with wheat straw fibre shows better performance than stone matrix asphalt mix without fibre. It was also observed that SMA Mix with wheat straw fibre works out cheaper and abundantly available.

**KEYWORDS:** Stone matrix asphalt, wheat straw fibre, stabilizing additive, Marshall Test, optimum bitumen content, volumetric parameters.

### I. INTRODUCTION

Stone mastic asphalt (SMA) is a discontinuously graded mix with a high coarse aggregate percentage (60-80%), high binder content (5.5-7% by weight), less amount of added fibres (1%) and essentially a high percentage of mineral filler (7-11%) [1]. The SMA mixtures have a rough macro texture, forming small path between the coarse aggregate, which is useful for an efficient surface drainage [2]. The higher binder content is required to make the mix durable. The fibres or modifier are required to hold the binder in the mixture at high temperature; prevent drainage during production, transportation and laying. Many other researchers have reported the advantages of cellulose fibres or polymers in SMA mixes. However, these are either costly or not readily available. The initial cost of SMA is higher than that of the common asphalt mixes in practice. On the other hand, increases of the waste products are posing the consequential threat to mankind. Use of waste for making it further usable is a smart way of reducing it. Thus in this paper a study is carried out to use agricultural waste i.e. wheat straw which is obtained after cutting of wheat fields which is mostly burnt that causes environmental pollution and threat to human health. Various tests on aggregates, filler (cement) like impact test, crushing value and Marshall Test on samples prepared with and without wheat straw as stabilizing additive were conducted. On the basis of the test results, it may be concluded that stability, flow and other volumetric parameters of SMA Mix with wheat straw as fibre is improved as compared to SMA Mix without wheat straw as fibre.

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## II. LITERATURE REVIEW

The present study aimed at the use of wheat straw fibre as stabilizing additive in Stone matrix asphalt for surface course. As cellulose fibres are either costly or not readily available. Various literatures related to SMA have been reviewed and some of them are presented in this chapter.

**Prof S.S. Awanti, A. Habbal, P.N. Hiremath, S. Tadibidi & S.N. Hallale (2016)** reports about the experimental investigations carried out on stone matrix asphalt mixes prepared by using coconut and cellulose fibres with VG 30 grade bitumen. From the test results it was observed that stone matrix asphalt mix with coconut fibre shows better performance than stone matrix asphalt mix with cellulose fibre. It was also seen that SMA Mix with coconut fibre has low cost and easily available.

**Goutham Sarang, B.M.Lekha, G.Krishna & A.U.Ravi Shankar (2016)** in their study they reports about the shredded waste plastics (SWP) are used instead of other additives to prepare SMA mixtures with conventional viscosity graded VG30 Bitumen. And other mixture is made with modified bitumen is used as binder material and then comparison is made. On the basis of the current study, waste plastic in suited dosage can be advocated in SMA, instead of a stabilizing additive.

**Yanping Sheng, Haibin Li, Ping Guo, Guijuan Zhao, Huaxin Chen And Rui Xiong (2017)** reports about effect of fibres on mixture design of stone matrix asphalt. The test results indicated that while percentages of voids and Marshall stability and VMA increased, the bulk specific gravity of SMA mixtures and asphalt saturation decreased with increasing fibre content.

**Tejas, Aniket, Gourav, Swapnil, Vijay (2017)** reports about suitability of coconut shell charcoal as filler in stone matrix asphalt. The result showed that it improved quality and durability of road pavement.

## III. EXPERIMENTAL INVESTIGATION

### 3.1 Material used:

1. Coarse and fine aggregate
2. Cement as filler
3. VG30 Bitumen as binder
4. Wheat straw fibre as stabilizer

### 3.2 Laboratory tests carried out on SMA Components:

Tests like abrasion test, impact value test, aggregate crushing test, flakiness and elongation test, water absorption test were conducted on coarse aggregates, specific gravity test on both fine and coarse aggregate, penetration test and softening test were conducted on VG 30 bitumen and the results are given in Table 3.1

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**Table 4.1: Properties of SMA components**

Test on SMA components	Test methods as per IS procedure	Test result	As per IS Specification
Aggregate crushing value	IS:2386 (PIV)	17.84%	18%
Impact value	IS:2386 (PIV)	10.58 %	18%
Abrasion value	IS:2386 (PIV)	19.44 %	25%
Flakiness Index	IS:2386 (PI)	8.4%	30%
Elongation Index	IS:2386 (PI)	19.9%	30%
Water Absorption	IS:2386 (PIII)	0.85%	2%
Specific gravity of coarse aggregate	IS:2386 (PIII)	2.76	2.6-2.8
Specific gravity of fine aggregates	IS:2386 (PIII)	2.72	2.6-2.8
Penetration value of binder VG30	IS1203-1978	67.495	60-70
Softening point VG30	IS1205-1978	48.5	Min 47

### 3.3 Preparation of test samples:

The mix samples were prepared according to the Marshall procedure, which is widely practiced and popular in India [3]. The coarse aggregates, fine aggregates and cement were mixed according to the adopted gradation and heated to the required temperature. Required quantity of wheat straw fibres after being cut to small pieces approximately 5 mm long, were added directly to the aggregate sample and thoroughly mixed before adding required quantity of binder. The entire mixtures were heated separately to the prescribed mixing temperature, mixed properly and compacted using a compactive effort of 50 blows on each side [4]. Binder concentrations were varied from 4% to 6% while fibre concentrations were selected as 0.3% to assess the optimum binder content.

### 3.4 Testing of test samples:

Marshall Mix design method is a standard laboratory method, which is adopted in India for determining and reporting the strength and flow characteristics of bituminous paving mixes. In the absence of modern equipment's, this method was used to study various Marshall Characteristics such as Marshall Stability, flow value, unit weight, air voids etc., which helps in determining the Optimum Binder Content (OBC) of the SMA mixes.

The details of experiments carried out for this work as described in Paragraph 3.4. Various Marshall parameters such as air void ratio, volume of bitumen, voids in mineral aggregate, voids filled with bitumen etc. is calculated based on result obtained from Marshall test and presented in this section. These parameters are calculated for both types of mix that is with and without fibre and results are compared and presented.

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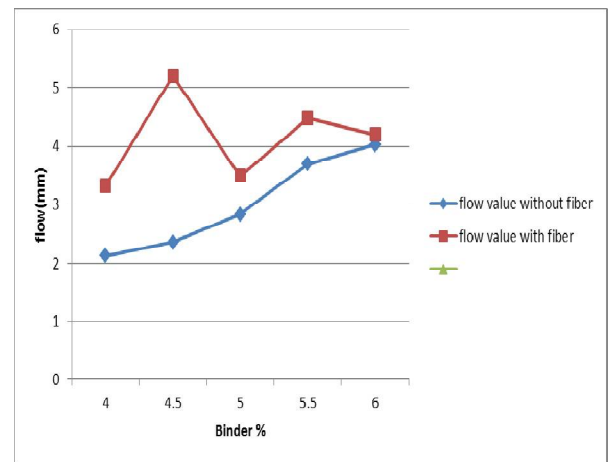
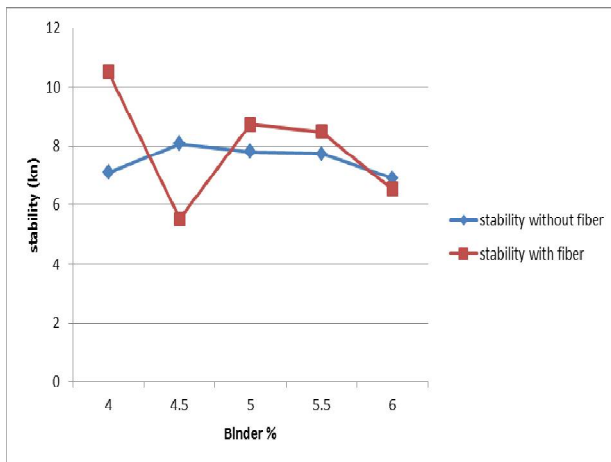


Figure 4.1: Stability v/s bitumen content % Figure 4.2 : Flow values v/s bitumen content %

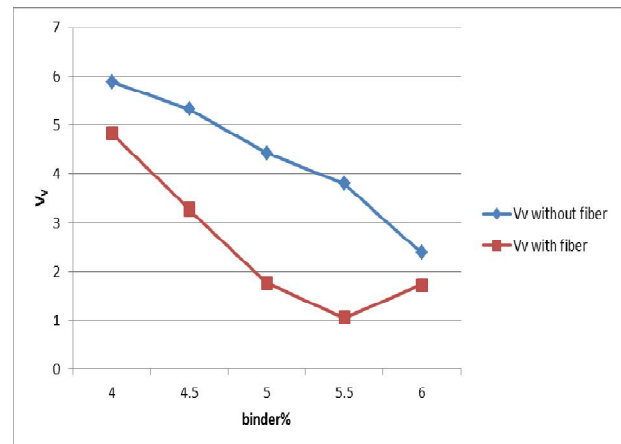
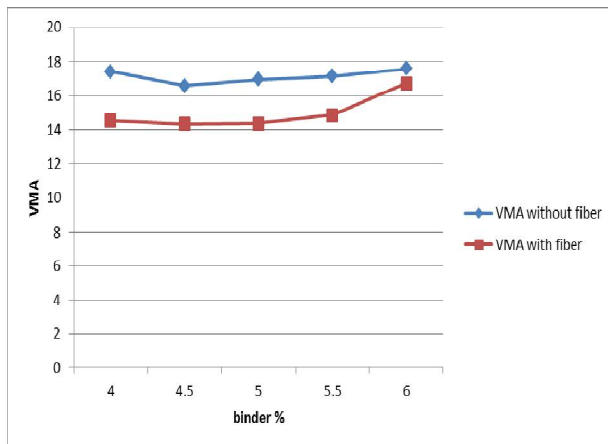


Figure 4.3: VMA v/s Bitumen content % Figure 4.4: Vv v/s Bitumen content %

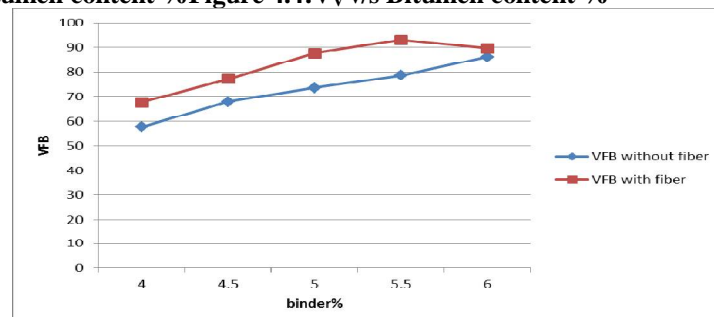


Figure 4.5: VFB v/s Bitumen content %

## 4.1 Optimum bitumen content

For SMA mixes due to its high coarse aggregate percentage hence, we following the MORTH and IRC SP79, 2008 specifications to find the optimum binder content which decides the OBC value based on 4 % air voids. Here we obtained the OBC with respect to 4% air voids, and the optimum binder was obtained as 5.1 % without fibre and 4.11% with fibre. Other mix parameter such as stability, flow values,  $V_v$ , VMB, VFB were also calculated for the obtained optimum bitumen content for both type of mix as given in Table 4.2 and 4.3.

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**Table 4.2: Marshall Properties at OBC without fibre**

Stability KN	Flow mm	VMA	V <sub>v</sub>	VFB
7.96	3.5	17%	4%	70.54 %

**Table 4.3: Marshall Properties at OBC with wheat straw fibre**

Stability( KN)	Flow (mm)	VMA	V <sub>v</sub>	VFB
7.98	4.5	14.8%	4%	70.2%

## IV. INTERPRETATION OF RESULTS

- In this project we have prepared different SMA samples using varying bitumen content of 4%, 4.5%, 5%, 5.5%, 6%. It was done to analyze the effect of increasing bitumen content on the stability value. The Optimum binder content for this mix is found in this project work. From the study of graphs it is found that the stability value without fiber increases initially with increase in bitumen content but then decreases gradually. This can be recognized to the fact that with initial increase in bitumen content, the aggregate bitumen bond gradually gets stronger, but with further increase in the bitumen content, the applied load is transmitted as hydrostatic pressure, keeping the fraction across the contact points of aggregates immobilized. This makes the mix weak against plastic deformation and the stability value falls. The same principle applies to mix with fibers, but this mix shows higher stability value at the same binder content than the mix without fibers. It is found that the fibers in the mixes act as stabilizers that not only fills up the voids in the sample but also reduces the drain down, thus holding up the binder in the mix. The homogeneity to the mix provided by addition of fibers. Here in our research it was found that the stability results are higher for samples with fibers except for 4.5%, 6% which may be due to improper mixing.
- Flow is the deformation undergone by the specimen at the maximum load where failure occurs. The flow value increases with the increase in the bitumen content both the mixes with and without fibers. The increase is slow initially, but later the rate increases with the increase in the bitumen content. The flow value of mixes with wheat straw fibers is more than that without fibers initially, this may be on the basis that, at lower percent of bitumen content the fibers fill up the voids efficiently adding to the homogeneity and it provides the stability necessary to oppose any deformation under load the homogeneity is lost with decrease in the bitumen content, that leads to the binder property dominates which makes the fibers to form lumps dropping stability and growing deformation under load.
- According to previous studies the VMA value, for a given aggregate should hypothetically stay constant. In our study it is observed that, at low percent bitumen content, VMA gradually decreases with the increase in bitumen content, then remains constant over a range, and finally increases at high bitumen content. The early fall in VMA value is due to the reason of re-orientation of the aggregates in the presence of bitumen. At very high bitumen content, due to a thicker bitumen film, the aggregates slightly moves apart resulting in an increase in VMA.
- The Air Voids (V<sub>v</sub>) values falls with rise in the bitumen content as with increase in bitumen content the air voids gets filled up progressively. The V<sub>v</sub> of mix with fiber is much less than that without fiber. This is because the fiber already filled up some portion of air voids (V<sub>v</sub>) which further decreases as the bitumen fills up the air voids with rise in bitumen content.
- The Voids Filled Bitumen (VFB) is mainly expressed as a part of VMA. The VFB of a mix generally rises with the raise in the bitumen content. Here in our result too, we can clearly observe that VFB increases, since increase in bitumen content causes more and more bitumen to fill the voids present in the mix as well as that inside the aggregates causing the overall increase in the bitumen inside the voids or VFB.

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## V. CONCLUSION

Through this study we found out that Stone matrix asphalt with wheat straw fibre gives better result in terms of flow, stability etc. as compared to stone matrix asphalt without fibre that too at lower optimum bitumen content. The usage of wheat straw as stabilizing agent will also lower down drain down and reduces overall construction cost. The problem of air pollution due to burning of wheat fields will also be controlled and farmers will also be benefitted and ecofriendly.

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