A Review on Fiber Modified Stone Matrix Asphalt

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Abstract - *Stone matrix asphalt (SMA) is a gap graded mix and contains a high concentration of coarse aggregate. They are held together by a rich matrix of mineral filler, fiber or polymer as stabilizers in a thick asphalt film. The durability is provided by rich mortar binder. Due to high content of coarse aggregate there is better stone to stone contact and better interlocking which serves as the structural basis of SMA. Drain down is an important problem associated with SMA Mix. To prevent drain down of the mix, Cellulose fibers, mineral fibers or polymers are used as stabilizing agent. These structural characteristics makes SMA to maximize deformation resistance or rutting, provides durability and longer service life for the pavements. The Marshall method of mix design can be used for preparing the samples. The Marshall properties and volumetric properties are used to find the optimum bitumen content and optimum fiber content for the SMA Mix.*

***Key Words*: Stone Matrix Asphalt, Cellulose Fibers, Marshall Properties, Volumetric Properties, Optimum Bitumen Content, Optimum Fiber Content**

1. INTRODUCTION

Use of SMA for surfacing road pavements is expected to significantly increase the durability and rut-resistance. SMA is a gap graded mixture containing 70-80% coarse aggregate of total aggregate mass, 5-7% of binder, 8-12% of filler, and about 0.3-0.5% of fiber or modifier. Thus use of high concentration of coarse aggregate provides better rut resistance and provides skid resistance. Due to high content of bitumen it fills the voids between the aggregates effectively and binds them together, thus contributing to its durability from premature cracking. A potential problem associated with SMA is drainage and bleeding. Bleeding is caused due to difficulty in obtaining the required compaction. Therefore stabilizing additives such as cellulose fibers, mineral fibers or polymers are used to stiffen the matrix thereby reducing the drain down and bleeding significantly. The different types of stabilizing agents commonly used in SMA are generally expensive hence there exist a need to obtain an alternative, lower-cost stabilizers that will essentially serve the same objective, in a similar way as obtained by using other commonly used stabilizing additives.

2. Advantages of SMA

SMA provides a textured, durable, and rut resistant wearing course. They are have a High stability against permanent deformation (rutting) and high wearing resistance. They exhibit slow aging and durability to premature cracking of the asphalt. They are have longer service-life, reduced noise and higher macro-texture than dense-graded pavements. At intersections and other high traffic stress situations SMA can be effectively used.

The higher cost of SMA is due to the addition of mineral filler, fibers, modified binders, and possible higher asphalt contents.

3. Materials in SMA

3.1 Mineral Aggregates

The structure and quality of aggregates in SMA is an important factor to make the mixture resistant to rutting. Therefore, the stability of the aggregate structure is crucial in order to ensure the proper design of a mixture. Aggregates are selected should satisfy the following qualities;

a) Aggregates should be cubic shaped and rough textured to resist rutting and movements
b) Sufficient Hardness to resist fracture under heavy traffic loads
c) High resistance to polishing
d) High resistance to abrasion

Aggregate gradation is selected from the MoRTH specifications.

Table -1: Aggregate gradation

SMA Designation	19mm SMA
Course where used	Binder (intermediate) course
Nominal aggregate size	19mm
Layer thickness	45-75mm
IS Sieve (mm)	Cumulative % by weight of total aggregate passing
26.5	100
19	90-100
13.2	45-70
9.5	25-60
4.75	20-28
2.36	16-24
1.18	13-21
0.600	12-18
0.300	10-20
0.075	8-12

3.2 Mineral Filler

The quality of SMA mixes affected by mineral filler hence it is occupied by a good portion in SMA. Therefore it is essential to study the effect of fillers in SMA. Various types mineral fillers that are being used in SMA are rock dust, slag dust, hydrated lime, fly ash etc. They provide stiffness to the asphalt matrix, thus preventing the rutting and also help in lowering the drain down.

3.3 Bitumen

SMA contains very high content of bitumen when compared to conventional mixes. It is used to bind the aggregates, fillers and stabilizing additives. Different studies on SMA have been conducted by using different bitumen grades. Modified bitumen can also be used in SMA for better results. Optimum bitumen content for the SMA is calculated corresponding to the 4% air voids as per IRC specifications.

3.4 Stabilizing Additives

Fibers are used as stabilizing additives in SMA. There is a significant chance of drain down of the binder matrix due to the gap graded structure. Hence fibers are used as stabilizers which not only prevent the drain down but also add to the rut resistance. The commonly used fibers are cellulose fibers, mineral fibers, polymers and plastics etc. Various studies are conducted by using different fibers like natural fibers such as coir fiber, sisal, banana fibers and synthetic fibers like jute fibers.

4. LITERATURE REVIEW

Ratnasamy Muniandy and Bujang.B.K.Huat [1] conducted a study on the fatigue performance of stone matrix asphalt with cellulose oil palm fiber. Generally, it is thought that gap graded mixes are weak in fatigue resistance. In this study, cellulose fibers were pre-blended in PG64-22 binder with fiber proportions of 0.2%, 0.4%, 0.6%, 0.8% and 1.0% by weight of aggregates. The fiber-modified binder showed improved properties. The cellulose oil palm fiber improved the fatigue performance of SMA design mix which increased to maximum at a fiber content of about 0.6%. The tensile stress and stiffness are also get improved in the same manner.

H.Behbahani et.al (2009) [2] concluded the test results like Marshall Stability, Flow parameters and Indirect Tensile Strength showed that variation of fiber type and content Can lead to considerable changes in rutting performance of SMA. Samples with 3% cellulose have shown the highest value of indirect Tensile Strength and least permanent deformation.

K.B.Raghuram and Venkaiah Chowdary (2013) studied on different fibers such as coir fibers, Jute fibers and glass fibers. Fibers of length 10mm was used in this study. It specifies that the addition rate of cellulose fibers as minimum 0.3%. The tests such as stability, flow value showed the increase in compressive strength and decrease in drain down characteristics.

M.Satyavathi, B.Someswara Rao, and G.Venkata Rao[5] found the feasibility of fibers as stabilizing additives and the flow values and stability values were analyzed by performing Marshall Stability test. From the test results, it was concluded that coir fiber and pineapple fiber reduces the drain down and increases the stability.

Bradley et.al. (2004) [6] researched on utilization of waste fibers in stone matrix asphalt mixtures. To improve the strength and stability of mixture they used carpet, tire and polyester fibers and other materials compared to cellulose fiber. The SMA Mix containing waste fibers when compared to the SMA mix which contains cellulose or mineral fiber, no difference was found in the moisture susceptibility and permanent deformation.

Raghuram et al. (2006)) [4] studied the usage low cost fibers for preparing SMA samples. The result was observed that SMA mixes with the polymers as stabilizers shows good performance in terms of drain-down characteristics, resistance to moisture, damage and the permanent deformation characteristics. Hence it was concluded that these mixes have suitability for road paving subjected to heavy traffic and in wet weather conditions.

T. Subramani (2012) [7] used coir fiber as the stabilizing agent in SMA mix and the results concluded that fiber reinforcement in bituminous mixes will lead to an economic mix with lower binder content. There was a significant increase in the Marshall Stability value about 13% on addition of coir fiber. This will help to achieve stronger pavement sections.

Punith V.S, Sridhar.R, Bose Sunil, Kumar K.K, Veeraragavan A (2004) [8] did a comparative study of SMA with asphalt concrete mix using reclaimed polythene in the form of LDPE carry bags as stabilizing agent (3 mm size and 0.4%). The test results indicate that SMA mixture properties are getting enhanced by the addition of reclaimed polythene as stabilizer. It also shows better rut resistance, resistance to moisture damage, rutting, creep and aging.

Kumar Pawan, Chandra Satish and Bose Sunil (2007) [9] studied the use of an indigenous fiber instead of the traditionally used fibers in SMA Mix by taking low viscosity binder coated jute fiber. On comparison of results, optimum fiber percentage was found as 0.3%of the mixture.

Bindu C.S, Beena K.S(2015)[10] tried to study the influence of additives like coir, sisal, banana fibres(natural fibres), on the compressive strength of SMA mixtures. After preliminary investigation compressive strength tests are conducted to study the resistance to crushing to withstand the stresses due to traffic loads. At 0.3% fiber content all stabilized mixtures show the maximum value of compressive strength. Higher compressive strength exhibited by coir fiber and which indicates its higher crushing resistance.

5. CONCLUSION

A number of studies are there to evaluate the performance characteristics of SMA mixtures with different fibers as stabilizing additives. The fibers are helpful in enhancing the stone to stone contact of aggregates and strengthening the bonding between them. When fibers are added it will have a great effect on reducing binder drain down. The study on the SMA can be extended to a wider area by using various locally available fibers. Pineapple fiber which is rich in cellulose content can be used as stabilizing additive in SMA for future studies.

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