EFFECT OF COIR FIBER ON STONE MATRIX ASPHALT (SMA) WITH MARBLE WASTE AS FILLER

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Abstract - *Synthetic fibers are available in India only at a very high cost and are used in construction of SMA. It is therefore necessary to find economical alternatives to high cost materials. Hence a low cost natural fiber namely coir fiber is used as additive in this study. Marble powder which is a common waste product from marble industries is dumped into bare lands and water bodies causing environmental concern. Hence, 8% of marble powder was selected as filler for this study. The aggregate and bitumen properties were tested. The percentage of bitumen by weight of aggregates was varied as 5,5.5,6% to determine optimum bitumen content by Marshall Stability Test. Bitumen percentage corresponding to 4% air voids gives the OBC which was found to be 5.84%. Similarly the percentage of fiber by weight of mineral aggregates was varied as 0.2, 0.3, and 0.4% and the optimum fiber content was found to be 0.3%. The addition of coir fiber showed increase in stability of the mix, which was found to be maximum at 0.3% of coir fiber by weight of aggregates.*

***Key Words*: Marshall Stability, Coir fiber, Marble waste, Optimum bitumen content, Optimum fiber content**

1.INTRODUCTION

The cost of materials used for pavement constructions is increasing day by day. Hence it is necessary to use sustainable and lower cost materials.

The marble industry deals with cutting and processing operations for production of tiles. Large amount of marble waste in the form of stones and marble powder is released from marble industry during mining operations. The marble waste so produced is released into empty pits in forestland and water bodies with no proper disposal.

Marble powder which is a waste product available at a low cost from marble industry is hence used as filler for the SMA mix. In addition, the usage of marble wastes in SMA has significant role on recycling waste marble powder with contributions to economy and ecology of the country.

Fibers are additives used in mixes to improve the binding and reduce the drain down of mortar. Most commonly used fibers for construction of SMA include synthetic fibers, which are expensive.

Natural fibers are biodegradable and an economical alternative to synthetic fibers. Hence coir fiber which is abundantly and cheaply available in Kerala is used as an additive for the SMA mix, in this study.

The main objective of this paper is to study the effect of coir fiber on Marshall properties like stability and flow of SMA mix. Marshall test was carried out to determine the optimum bitumen content and optimum fiber content.

2. LITERATURE REVIEW

Stone Matrix Asphalt (SMA) is a gap graded mixture which was first developed in Germany. Its use in various countries has been increasing due to better durability and resistance to rut and wear. Due to greater amount of coarse aggregates there is better interlocking and stone to stone contact.

George Mohan [2016] conducted a study on 'Effect of Marble Waste and Coir Fiber Content on the Indirect Tensile Strength of Bituminous Concrete Mixtures'. Marble dust and coir fiber were used and Marshall stability test was conducted to determine the optimum bitumen content for neat bituminous concrete mixes. The indirect tensile strength was found to increase by addition of marble dust up to 8%, and on further addition, the strength decreases. Upto 0.5% the strength goes on increasing and then decreases.

Bindu C [2015] conducted a study on' Shear Strength Characteristics of Coir Fiber Stabilized Stone Matrix Asphalt Mixtures'. The triaxial shear strength test was conducted on SMA mixes to study the effect of additive, coir fiber on the strength properties by varying the percentages of fiber. SMA without fiber was taken as the control mixture. At fiber content of 0.3%, higher values of cohesion and shear strength were observed. It is observed that the shape change of the stress-strain curves is more gradual for stabilized mixtures with increase in fiber content and brittle type failure does not seem to occur as in the case of control mixture.

In this investigation, coir fiber is used as a stabilizing agent in SMA and Marshall stability is conducted. The stability of SMA mixes with and without coir fiber are compared.

3. MATERIALS

3.1 Aggregates

Aggregate of sizes 20mm and 10mm down obtained from a local quarry at Ernakulum, Kerala was used in this study.

The aggregates were proportioned and its properties were tested and are listed in Table -1.

Table -1: Properties of Aggregates

Sl No	Test	Result	Specification
1	Aggregate Crushing Test	29.34%	10-30%(satisfactory for road surfacing IRC)
2	Aggregate Impact Test	29.9%	<30%(suitable for wearing course-IRC)
3	Specific Gravity	2.8	2.6-2.8 (MoRTH)
4	Water Absorption	0.5%	Not greater than 0.6%

3.2 Filler

Filler stiffens the binder. Marble powder which is a waste product from marble industry was used as filler. 8% of marble powder by weight of aggregates was adopted as filler for the SMA mix.

3.3 Additive

Coir fiber which is a natural fiber was used as an additive. The coir fiber length adopted was 8mm as per MoRTH.

3.4 Binder

Bitumen acts as a binding agent to aggregates. VG-30 bitumen was used as the binder. The properties of bitumen are tested and listed in Table -2.

Table -2: Properties of Binder

Sl No	Test	Result	Specification
1	Softening Point	47.9°C	35-50 (°C) as per IRC
2	Ductility	82 cm	>70cm as per IRC
3	Penetration	68	60-80 for VG-30
4	Specific Gravity	0.998	0.97-1.02 (pure bitumen)

4. METHODOLOGY

4.1 Preparation of Specimen

The aggregates were proportioned (total aggregate contribute to 1200gm). These aggregates were heated to a temperature of 150°C - 170°C and the bitumen heated to 160°C, was added as 5.0, 5.5 and 6.0 percent by weight of aggregates and this was thoroughly mixed at a temperature of 160°C. The mix was then placed in a preheated mould of 6.3cm height and 10 cm diameter with a base plate. The top surface was then levelled and the mix was compacted by a rammer of 4.54 kg weight and 45.7 cm height of fall with 50 blows on either side at a temperature of 150°C. After 24 hours these specimens were removed using specimen extractor. For each bitumen content, 3 specimens were prepared. For Marshall mix with coir fiber, the fiber was mixed and heated with aggregates and bitumen at 160°C. The % of fiber was varied as 0.2,0.3,0.4% of weight of aggregates.

4.2 Marshall Stability and Flow Test

The specimens to be tested were kept immersed under water in a water-bath maintained at 60˚C for 30 to 40 minutes. One of the specimen was then taken out and placed in the Marshall test-head. The test head with the specimen was placed in position in the loading machine and the base-plate of the loading machine was raised until top of the test head came in contact with bottom of the proving ring. The deformation measuring dial gauge or the flow meter was then placed and adjusted to read zero. The load was applied through Marshall test setup maintaining a constant deformation rate of 51 mm per minute. The maximum load at failure and the corresponding flow readings were noted.

5. RESULTS AND DISCUSSIONS

5.1 Optimum Bitumen Content (OBC)

The Marshall test was conducted on the SMA mix without coir fiber and properties namely % air void, stability and flow value were determined. These results are listed in Table -3.

Table -3: Properties of SMA mix

Bitumen content (%)	Air void Va (%)	Stability Value(kN)	Flow (mm)
5	11.078	11.34	3.43
5.5	4.129	14.29	3.60
6	3.936	10.52	4.06

To obtain optimum bitumen content for SMA mix, the % bitumen vs % air void (Va) graph was plotted and bitumen % corresponding to 4% air voids was interpolated from the graph (Chart -1). This % bitumen gives the OBC which was found to be 5.84%.

Air voids is the total volume of air pockets present between coated aggregate particles. The air voids present in mixture is important and related to durability and permeability of the mix.

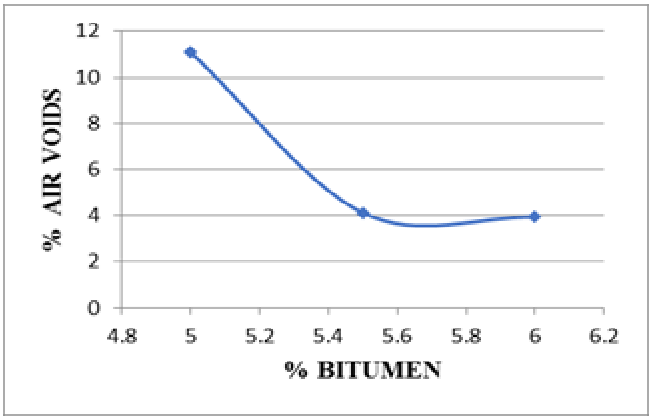

Chart -1: % Bitumen vs % air void graph

From Chart -2 it was observed that the stability value increases with increase in bitumen % up to 14.29 kN and is then found to decrease with further increase in bitumen %. This is because with further increase in bitumen %, the initial strong aggregate-bitumen bond, becomes weak due to load transmission through hydrostatic pressure.

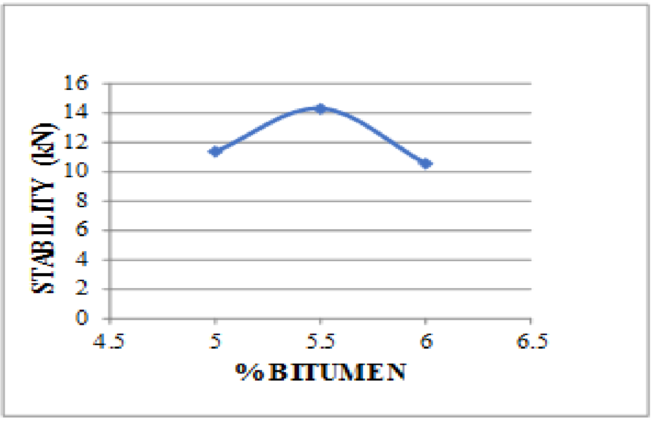

Chart -2: % Bitumen vs Marshall Stability graph

Flow refers to deformation at maximum load when failure occurs. From Chart -3, it was observed that the rate of increase of flow value was slow initially, but later it increases with increase in bitumen %.

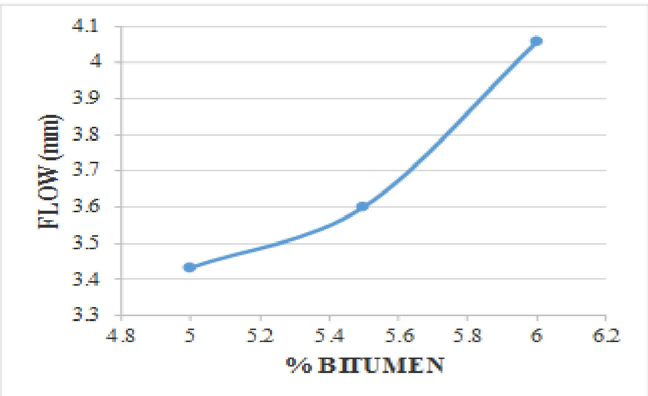

Chart -3: % Bitumen vs Flow graph

5.2 Optimum Fiber Content

The coir fiber % was varied as 0.2, 0.3 and 0.4% by weight of mineral aggregates. The stability and flow value were determined. These results are listed in Table -4. The SMA mix which was prepared without coir fiber was taken as the control mixture.

Table -4: Properties of SMA mix with fiber

Coir Fiber (%)	Stability Value (kN)	Flow Value (mm)
0	11.73	3.91
0.2	16.90	3.83
0.3	18.90	3.55
0.4	16.82	3.42

Graphs were plotted with Marshall stability and flow value against fiber content. The optimum coir fiber is the fiber content corresponding to maximum stability.

From the % fiber vs stability graph (Chart -4), it was observed that with addition of coir fiber, the stability of the mix increase up to 0.3% fiber, due to better interlocking of aggregates. Beyond 0.3%, the stability decreases as the excess fiber occupies the space to be occupied by bitumen and reduces interlocking. The optimum coir fiber was found to be 0.3%. On addition of coir fiber the resistance and stiffness of SMA mix increases. The % increase in stability with respect to control mixture was found to be 61.12%.

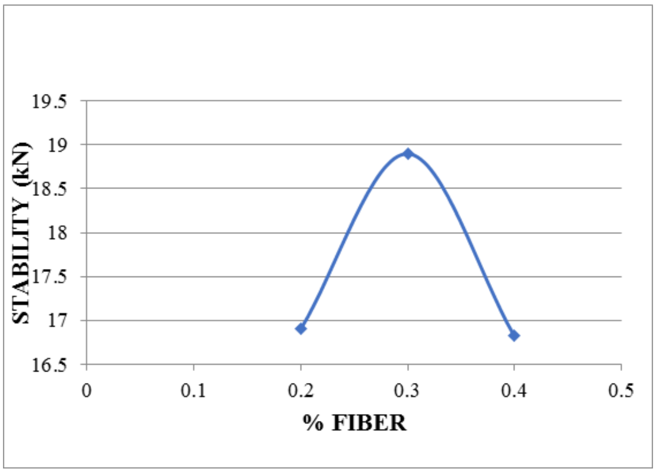

Chart -4: % Fiber vs Stability graph

Chart -5 shows the effect of coir fiber on the flow value of the SMA mix. The decrease in flow value is due to the stiffness of the fiber, which makes the mix more resistant to deformation.

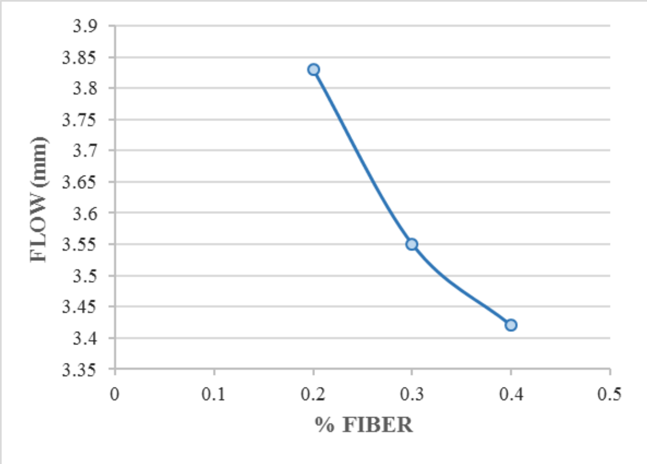

Chart -5: % Fiber vs Flow graph

5. CONCLUSIONS

In this investigation, the effect of coir fiber on SMA mix, with marble waste as filler was studied. Marshall Stability test was conducted on SMA mixes and the optimum bitumen content was found to be 5.84% from the % air void graph. With increase in bitumen%, the stability was found to increase initially up to 5.5% and then gradually decreases with further increase in bitumen%. SMA mixes were prepared with 0.2, 0.3 and 0.4% coir fiber by weight of aggregates and Marshall test was carried out. It was found that with the addition of coir fiber, the stability of the mix increases up to 0.3% fiber, by 61.12% with respect to the control mixture, and beyond 0.3%, the stability of the mix was found to decrease. The optimum coir fiber is the fiber content corresponding to maximum stability and was found to be 0.3%. The addition of coir fiber results in a decrease in flow value. This is because the mix becomes less flexible, due to stiffness of fibers in the mixture. Hence marble waste and coir fiber are economical alternatives for SMA construction and can be effectively used to improve stability of SMA mix.

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