EVALUATION OF MECHANICAL PROPERTIES OF SMA WITH ADDITION OF COCONUT FIBER

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Abstract: Stone Matrix Asphalt (SMA) is a gap graded mix, characterized by high coarse aggregates, high asphalt contents and polymer or fiber additives as stabilizers. The stabilizing additives composed of cellulose fibers, mineral fibers or polymers are added to SMA mixtures to prevent drain down from the mix. In the present study, an attempt has been made to study the engineering properties of mixtures of stone matrix asphalt made with three types of binders namely conventional bitumen 80/100 and 60/70, with a non-conventional natural fiber, namely coconut fiber. The binders and fibers in different proportions are used for preparation of mixes with a selected aggregate grading. The role of a particular binder and fiber with respect to their concentrations in the mix is studied for various engineering properties. For this, various Marshall Samples of SMA mixtures with and without fibers with varying binder type and its concentration are prepared. It is observed that only 0.3% addition of coconut fiber significantly improves the Marshall properties of SMA mixes. Addition of nominal 0.3% fiber considerably improves the drain down, indirect tensile strength and fatigue characteristics of the SMA mixes with conventional bitumen, which would otherwise have not been able to meet the prescribed criteria.

***Index Terms*–Bitumen, Aggregates, Coconut fibre, Stone Matrix Asphalt (SMA).**

Introduction

Aggregates bound with bitumen are conventionally used in maintenance and construction of flexible pavement. The well graded or dense graded aggregate bound with bitumen substance perform well on vigorously trafficked roads, hence it is very commonly used in paving industry. It is not always possible to obtain the dense graded aggregates at the site. In this scenario the bituminous mix called SMA (stone matrix asphalt) can be used, which consists of gap-graded aggregates.

SMA showed excellent resistance to deformation caused by high temperature. Various studies reveals that use of Stone Matrix Asphalt for surfacing road pavements is expected to significantly increase the durability and rut resistance of the mixes. It is a gap-graded mix having 70-80% of coarse aggregates in total mass of aggregates, 6-7% of binder, 8-12% of filler and about 0.3 to 0.5% of coconut fiber. Due to high content of coarse aggregate there is better stone to stone contact and better interlocking which serves as the structural basis of Stone Matrix Asphalt, since aggregates do not deform as much as asphalt binder under load, this stone to stone contacts greatly reduces rutting. Thus use of high coarse aggregates provide better rut resistance and skid resistance. It is reported that the traffic loads for SMA mixes are carried by the coarse aggregate particles only instead of the fine aggregate asphalt-mortar. The higher binder content makes the mix durable. The fibers or modifier hold the binder in the mixture at high temperature; prevent segregation and bleeding during production, transportation and laying.

Comparatively the SMA is cost effective than the dense graded mixes in high volume roads. The factors that influence the requirement of Stone Mastic Asphalt mixes was observed, such as changes in binder source and grade, types of aggregates, environmental conditions, production and construction methods etc. A gap graded aggregate hot mix asphalt that maximizes the binder content and coarse aggregate fraction and provides a stable stone-on-stone skeleton that is held together by a rich mixture of binder, filler and stabilizing additives.

Materials Used

The details of various materials used in this investigation are listed below.

Coarse-aggregate

Aggregates of sizes 20mm and 12.5mm are used in this project. Aggregates are tested as per IS-code 2386; Part-IV

Crushed aggregate available from local sources has been used. To obtain a reasonably good grading, 48% of the 20mm passing, 52% of 12.5mm passing aggregates are used in this production.

Table 1: Physical Properties of Coarse Aggregate

Sl. No.	Test	Specification as per MORT&H	Obtained Value	Test method
1	Flakiness and elongation index (combined)	MAX 30%	27.43%	IS 2386 PART-1
2	Aggregate impact test	MAX 27%	16.26%	IS-2386 PART-IV
3	Crushing test	MAX 30%	17.4%	IS-2386 PART-IV

4	Los Angeles abrasion test	MAX 40%	23.43%	IS-2386 PART-V
5	Water absorption 20mm down 12.5mm down	MAX 2%	0.3% & 0.76%	IS-2386 PART-III
6	Specific gravity 20mm down 12.5mm down	>2.5	2.72 & 2.86	IS-2386 PART-III

Bitumen

Bitumen used for this project is collected from the hot mix plant near Veniveerapura PPR Contractors Ballari, which is of VG-30 grade. Bitumen is tested as per IS Code-73 and results with MORTH specifications are shown in table below.

Table 2: Tests on Bitumen

SI.NO.	Test	Specification as per MORTH	Obtained value	Unit	Test method
1	Penetration	50-70	68	Mm	IS-1203-1925
2	Ductility	Min.75	82	Cm	IS-1208-1978
3	Specific gravity	-	1.01	-	IS-1202-1978
4	Softening point	Min.47	53	°C	IS-1205-1978
5	Flash Fire point	Min.220	290	°C	IS-1209-1978

Filler

For the filler material Fly ash collected from the local market passing 0.075 mm IS sieve was used. It was found to be 2.09 as specific gravity.

Fiber as an additive

From the husk of coconut fruit the coconut fiber is derived which is natural fiber. The neat fibers are taken out manually and dried. The diameter caries from 0.2 to 0.6mm and the length of fibers are normally in the range of 75 to 200mm.

Methodology

About 1200 gm of aggregates and filler is heated to a temperature of 175°C to 190°C. Bitumen is heated to a temperature of 120°C to 165°C with the first trial percentage of bitumen (say 3 or 4% by weight of the mineral aggregates). The heated aggregates and bitumen are mixed thoroughly at a temperature of 154°C to 160°C. Aggregates and bitumen mix is placed in a pre-heated mould and then compacted by a rammer with 75 blows on the either side of the specimen. By varying the binder content by +0.5% repeat the above procedure. Then prepared moulds are loaded in the Marshall test setup to check the stability and flow value. Marshall Stability test is conducted on well compacted cylindrical specimen of diameter 101.6 mm and thickness 63.5 mm. The load is applied perpendicular to the axis of the cylindrical specimen at a constant rate of deformation of 51 mm per minute at the temperature of 60°C. The specimens were tested at different ages for stability of pavements. The graphs are plotted as per readings. The results have been analyzed and useful conclusions have been drawn.

Discussion of the Results

Table 3:Optimum Fiber Content Results

Fiber Content (%)	Air Voids (%)	VMA (%)	Stability (kN)	Flow (mm)	Bulk Density (g/cc)	VFB (%)
0	4.34	19.85	13.65	2.7	2.43	75
0.1	4.94	19.65	14.62	2.96	2.45	74.43

0.2	4.61	19.06	15.45	3.05	2.46	76.50
0.3	3.83	18.6	16.50	3.42	2.47	78.2
0.4	5.12	19.34	14.92	3.25	2.44	73.48

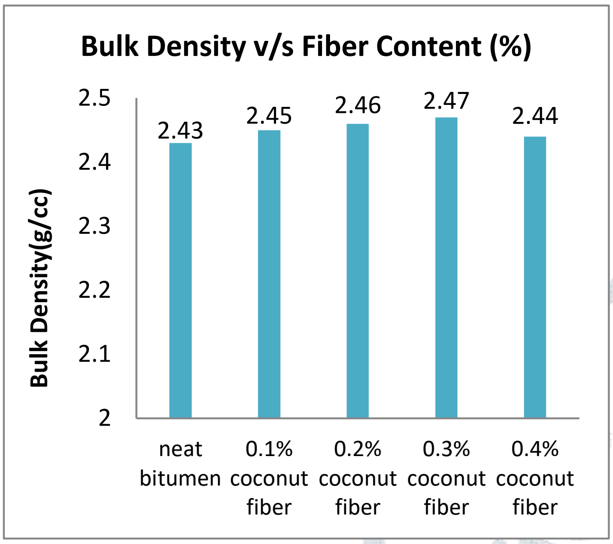


Fig 1: Bulk Density vs Fiber Content

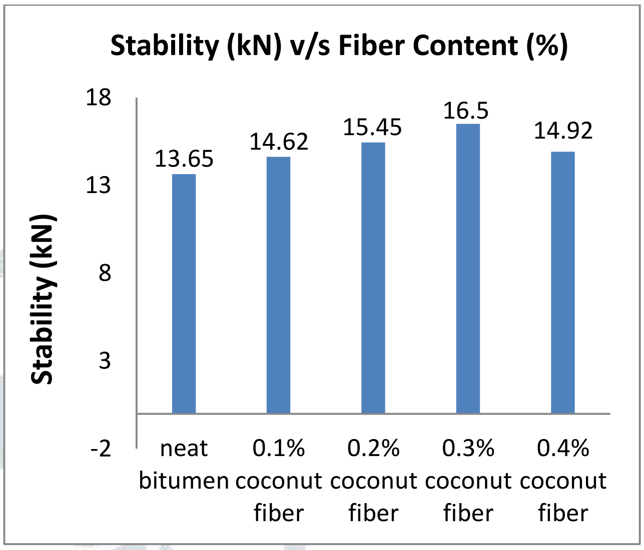
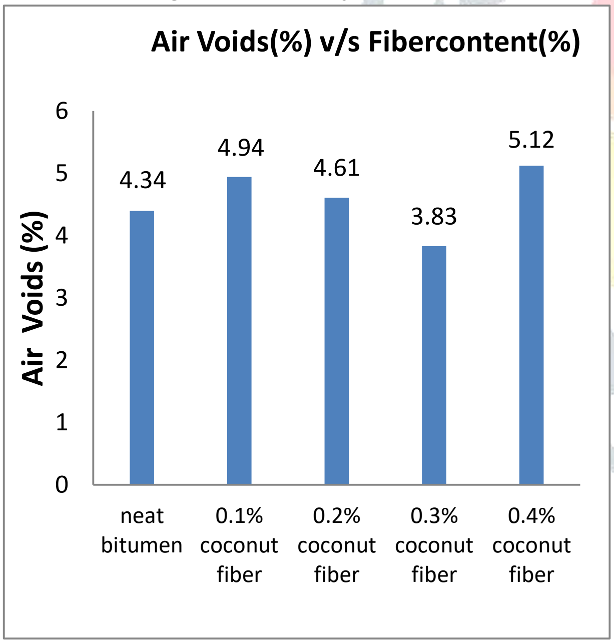


Fig 2: Stability vs Fiber Content



. Fig 3: Air voids vs Fiber Content

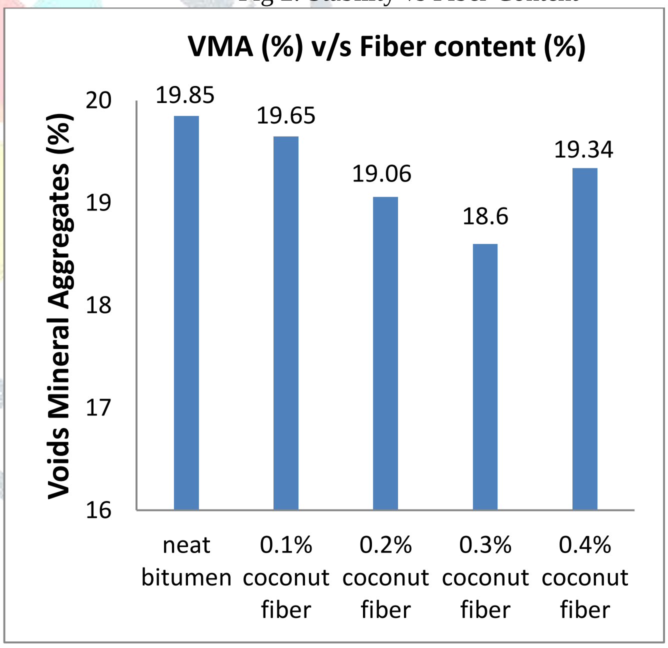


Fig 4: VMA vs Fiber Content

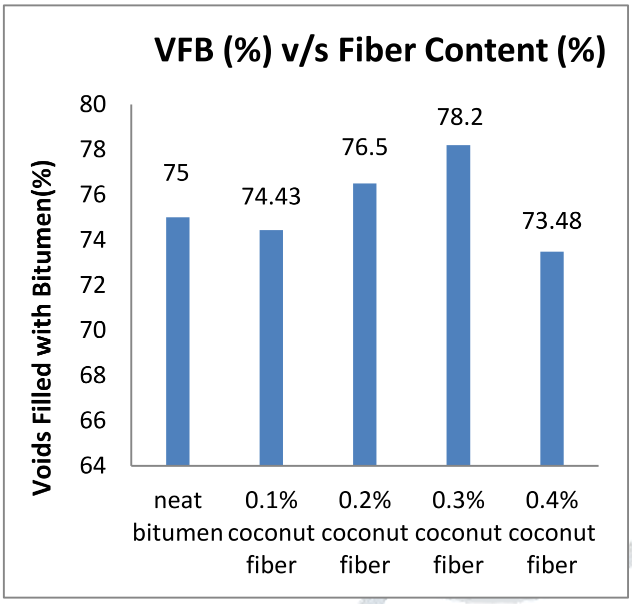


Fig 5: VFB vs Fiber Content

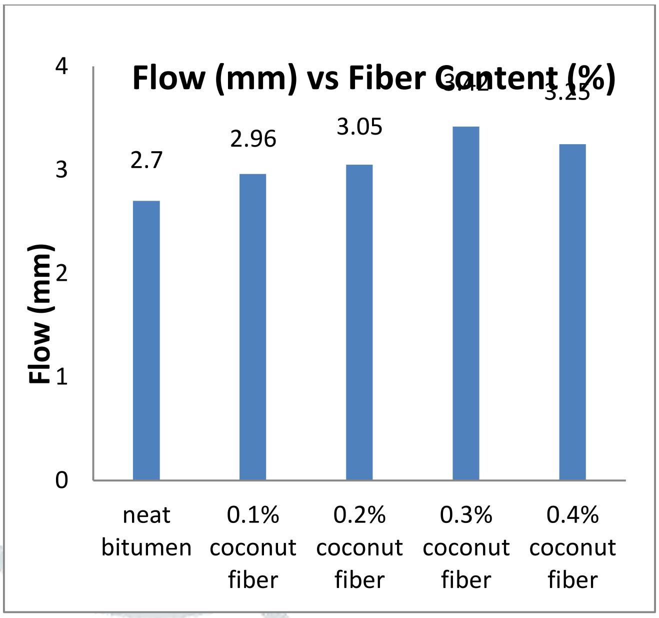


Fig 6: Flow vs Fiber Content

As the fiber content increases, decrease in air voids and VMA but increase in the stability, flow Bulk density and VFB up to 3% of fiber content beyond that it will starts reduce in all.

CONCLUSIONS

- Properties of SMA were improved with the increase in the percentage of coconut fibers. The optimum improvement in the properties is found on 0.3% of coconut fiber.
- With reference to the codal provisions, for Optimum Fiber Content (0.3%) the tensile strength ratio value was 87.06%, which is more than 85% as specified for a SMA mixes.
- When tested for the uncompacted SMA mixes the coconut fiber acts as a better drain down resistance material.
- For heavy traffic conditions, SMA with coconut fiber can be used as wearing surface.
- It is concluded that, the fibre reinforced bituminous concrete pavement will sustain on various climatic condition in India.

References

1. IRC:SP 79 (2008). TENATIVE SPECIFICATIONS FOR STONEMATRIX ASPHALT IRC, New Delhi, Indi
2. Bindhu C.S, Beena K.S "Influence Of Additives On the Drain Down Characteristics of Stone Matrix Asphalt Mixtures" International Journal of Research in Engineering and Technology Eissn:2319-1163.
3. Awanti S.S," Laboratory Evaluation of SMA mixes prepared with SBS modified and neat bitumen "ELSEVIER 2nd conference of Transportation Research Group of India (2^{nd} CTRG).
4. Ashish Talati, Vaishakhi Talati (2014) "Study of Stone Matrix Asphalt for the Flexible Pavement" IJEDR, Volume 2, Issue 1.
5. Vivek B.R and Sowmya N.J 2015 "Utilization of Fiber as a Strength Modifier in SMA".
6. R Taha (2013) "Effect of mineral filler type and particle size on SMA pavements".
7. Umadevi Rongali et.al (2012) studied "Laboratory performance as SMA containing composite of fly ash and plastic waste".
8. Bradely et al. (2004) "Studied utilization of waste fibers in stone matrix asphalt mixtures".
9. Brown E.R. and Manglorkar H. (1993), "Evaluation of Laboratory Properties of SMA mixtures", *Auburn University, Alabama.*

10. Mogawer W.S. and Stuart K.D. (1996), “Effect of Mineral Fillers on Properties of Stone Matrix Asphalt Mixtures”, *TRR 1530, National Research Council, TRB, USA, pp 86- 94*
11. Ravi Shankar A.U., Vishwanath N. and Koushik K. (2009), “Performance Studies of Stone Matrix Asphalt using Waste Plastics as Modifier (Dry Process)”, *Highway Research Board, IRC, Vol 2, pp 63-75*