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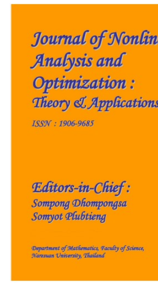

CHARACTERISATION OF FIBRE REINFORCED BITUMINOUS MIXES

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Abstract:
The proposed work presents the studies on stability [1], flow and volumetric properties of fibre Reinforced [2] bituminous concrete in comparison with the properties of conventional bituminous concrete. Marshall's stability tests were conducted to determine the optimum binder content. By varying the amount of 10mm polypropylene fibers [3] (4%, 6%, 8% and 10% by weight of bitumen), optimum fiber content was obtained. The results indicate that the addition of Coir [4] fibers increase the stability but decreases the flow value.
Keywords: Fiber reinforced, Coir fibers, Fiber Reinforced Bituminous Concrete, Marshall's test.

1. INTRODUCTION
A good roadway infrastructure is an essential component of a strong and stable economy. BituminousConcrete (BC) [5], a mixture of bitumen and aggregate is a widely employed material for pavement construction. As the modern highway transportation has high speed, high traffic [6], traffic [7] density, heavy load and channelized traffic [8],bituminous concrete pavements in urban [9], [10] and rural areas are subjected to various types of distress such as fatigue cracking, rutting andravelling. Use of modified binders with additives like crumb rubber, natural rubber, polymers [11], etc., is gainingpopularity as means of controlling pavement distresses.The merits and demerits of fibre reinforcement in bituminous concrete have been studied extensivelyover the past few years.A comprehensive study shows that coir, polypropylene, polyester and glassfibres are the most commonly used fibres in Fibre Reinforced Bituminous Concrete (FRBC).Coir fibres, however, are preferred due to their low-cost and good consistency with bituminous pavement. Thesefibres have been found to reduce crack intensities and reflective cracking in pavements [12]. Coir fibre modifiedmixtures [13] are also slightly stiffer and show improved fatigue life. The use of Coir fibres increases the MarshallStability value while it decreases the flow value.This paper aims at studying the effect of coir fibres as reinforcement in bituminouspavements. The optimum binder content wasdetermined for the selected aggregate grade [14] and thencommercially available coir fibres ofgraded [15] length were added to the obtained optimum binder content.Different percentages of

coir fibres (4%, 6%, 8% and 10% by weight of bituminous binder) were added todifferent samples. Marshall's stability tests were conducted on these specimens and MarshallStability value andflow value were found out. From the obtained data, optimum fibre content was determined.

2. MATERIALS USED

A. *Binder*

Bitumen acts as a binding agent to the aggregates, fines and stabilizers in bituminous mixtures. Binder provides durability to the mix. The characteristics of bitumen which affects the bituminous mixture behaviour are temperature susceptibility, visco-elasticity and aging. The behaviour [16] of bitumen depends on temperature [17] as well as on the time of loading [18]. It is stiffer at lower temperature and under shorter loading period. Bitumen must be treated as a visco-elastic material as it exhibits both viscous as well as elastic [19] properties at the normal pavement temperature. Though at low temperature it behaves like an elastic material and at high temperatures [20] its behaviour is like a viscous fluid.

B. *Stabilizing agents*

Stabilizing additives are used in the mixture to prevent mortar drain down and to provide better binding. Fibres commonly used now-a days are polypropylene, polyester, mineral and cellulose. The main stabilizing additives used in mixes can be classified in to different groups they are Fibres (Cellulose Fibres, Mineral Fibres, Chemical Fibres), Geo Polymers [21], Plastics (Polymer Powders or Pellets). Natural Fibres are also used, they are classified as Stem Fibre (jute, banana etc.), Leaf Fibre (sisal, pineapple), Fruit Fibre (cotton, coir, oil palm). Coir fibre produced from coconut husk, is a natural fibre which is cheaply and abundantly available in Kerala. It is having excellent physical and chemical properties as stabilizing additives in BC and SMA [22] mixtures and as an additive in the present study. The addition of coir fibre to asphalt mixtures enhances material strength [23] while adding ductility. Other advantages of using coir fibre include high strength [24], biodegradability, excellent absorbing and environmental friendliness. Because of their excellent properties coir fibre offer an excellent potential for asphalt modification. This study investigates on the characteristics of coir fibre reinforced bituminous mixes, which may have the benefit of improving the performance of road [25] pavement. The Coir fibre generally used are of 10-16 microns in diameter with 1.4 g/cc of Density and Swelling of 5% in water.

C. *Mineral Filler*

Mineral fillers have a significant impact on the properties of SMA [26] mixtures. Mineral fillers increase the stiffness of the asphalt mortar matrix. Mineral fillers also affect workability, moisture resistance, and aging characteristics of HMA mixtures. Generally, filler plays an important role in properties of bituminous mixture particularly in terms of air voids and voids in mineral aggregate. Different types of mineral fillers are used in the SMA mixes such as stone dust, ordinary Portland cement (OPC), slag cement, crystals [27], fly Ash [28], hydrated lime etc.

D. *Mineral Aggregates*

The aggregates [29] used to manufacture bituminous mixes [30] can be obtained from different natural sources such as glacial deposits or mines. The aggregates can be further processed and finished to achieve good performance characteristics. Industrial by products such as steel slag, blast furnace slags etc are sometimes used as a component along with other aggregates to enhance the performance characteristics of the mix. Reclaimed bituminous pavement is also an important source of aggregate for bituminous mixes. Aggregates play a very important role in providing strength to asphalt mixtures as they contribute a greater part in the matrix. SMA contains 70-80 percent coarse aggregate of the total Stone content. The higher proportion of the coarse aggregate in the mixture forms a skeleton-type structure providing a better stone-to-stone contact between the coarse aggregate [31] particles resulting in good shear [32] strength and high resistance to rutting as compare to BC. These aggregates pose highly cubic shape and rough texture to resist rutting and movements, hardness which can resist fracturing under heavy traffic [33] loads [34], high resistance to polishing, high resistance to abrasion.

3. METHODOLOGY

The experimental [35],[36] methodology consists of the following four essentialphases: -

Phase 1: Material collection

- Aggregate: [37]Granite coarse and fine aggregate were collected from quarry.
- Binder: VG30
- Fibre: Coir fibre

Phase 2: Material Characterization

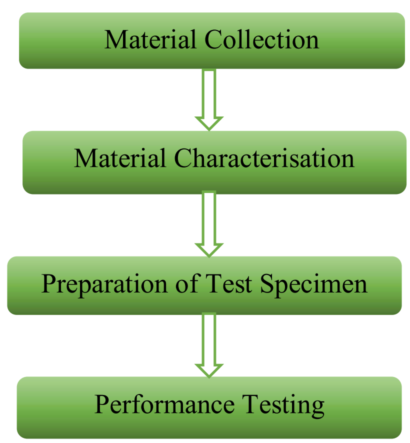
- Standard tests such as crushing value, Impact value, Los Angeles Abrasion value, Specific gravity and Combined Elongation and Flakiness tests to characterize the aggregates.
- Standard tests such as Penetration, softening point, Specific gravity, Ductility tests to characterize the bitumen.

Phase 3: Preparation of test Specimen

- Standard Marshall Specimen.
- Bituminous concrete grade II.
- Stone mastic asphalt

Phase 4: Performance testing

- Marshall Test to assess strength of different bituminous mixes.
- Indirect Tensile Strength of conditioned and unconditioned specimens to evaluate the rutting potential and moisture susceptibility.
- Drain down test to determine the efficiency of the additives as stabilizers to prevent the drain down of the binder
- Repeated load test on the specimen with rest period to estimate the fatigue life.



4. EXPERIMENTATION

Experiments have been carried out on aggregates, bitumen and also on their mixers. The following readings were noted down.

For Aggregate (IS 2386: Part III):

Test Name	Result	Specification	
		BC	SMA

Impact Test	8.30%	24% Max	18
Aggregate Crushing Value	22.0%	30% Max	NA
Abrasion Test	44.80%	30% Max	25% Max
Specific Gravity	2.7%	2.52-3% Max	NA
Water Absorption	0.40%	2% Max	2% Max

For Bitumen (IS 1203: 1978):

Property	**Result**	**Specification**
Penetration 25°C	69	50-70
Softening Point	51°C	47 min
Ductility 25°C, cm	>75	Min 75

For Specimen (Concrete [38] + Coir Fibre):
We have considered Grade [39]-II aggregates and after the completion of Flakiness test, we mixed these aggregates with cement and selected Coir Fibre in specific Water-Cement Ratio and coir fibre according to wight proportion. By mixing all these components, we formed a 150 X 150 X 150 mm Cube and let it settle in a water tank for curing [40] about 28 days and then Compression [41] test was conducted.

Specimen	**Curing Time**	**Compression Value**
Pure Concrete Casted Cube	28 Days	25 N/mm2
Coir fiber + concrete Casted cube	28 Days	35 N/mm2

For Marshall Specimen
The thickness of the compacted specimens is likely to vary depending on the factors such as weight of aggregates, its specific gravity and due to variation in the bitumen content in the specimens.
Marshall Stability test results BC with 15mm length and 0.5% coir fibre (VG30)

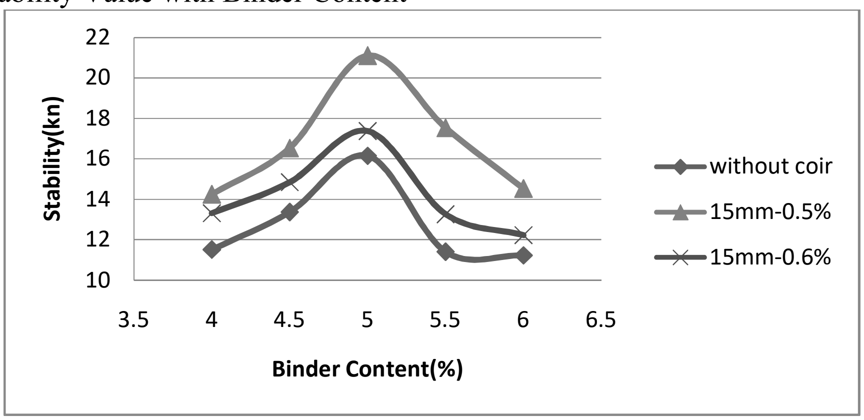
Binder Content (%)	**Unit Weight (g/cc)**	**Voids in Mineral Aggregate (%)**	**Voids Filled with Bitumen (%)**	**% Air Voids**	**Stability Value (kN)**	**Flow Rate (mm)**
4.0	2.4	15.2	61.7	5.9	12.1	4.3

4.5	2.4	15.4	70.2	4.6	13.6	4.8

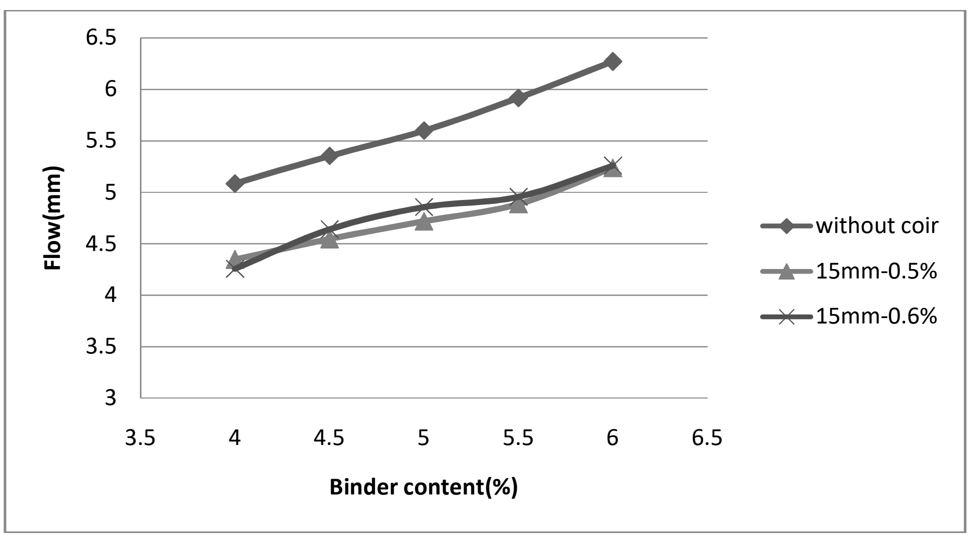
Marshall Stability test results BC with 15mm length and 0.6% coir fibre (VG30)

Binder Content (%)	Unit Weight (g/cc)	Voids in Mineral Aggregate (%)	Voids Filled with Bitumen (%)	% Air Voids	Stability Value (kN)	Flow Rate (mm)
4.0	2.4	15.6	60.9	6.4	14.2	4.3
4.5	2.4	15.7	68.4	4.8	16.5	4.7

Variation in Stability Value with Binder Content



Variation in Flow Value with Binder Content



5.CONCLUSION

The potential of coir fibre as an additive in SMA has been studied in this paper. The percentage fibre content in SMA is varied from 0.5 to 0.6% with increments of 0.1 % for different series of tests. Analyzing the results, following conclusions has been drawn:

1)The addition of 0.5% fibre is found to be the optimum fibre content in SMA.

2)The Marshall Stability value of SMA with optimum fibre content was found to be 13.60 KN, which is higher than the prescribed value of 6.20 KN.

3)The flow value of SMA with 0.5% fiber and 15mm length fibre was found to be 4.8 mm whereas the flow value for conventional mix is 5.96 mm.

4)The drain down test results indicated that coir fibre can retard the drain down of the binder and the 15mm length and 0.5% fibre gives the good results compared to conventional mix.

5)The indirect tensile strength indicates that 15 mm and 0.5% of coir fibre mixes was found to be higher by 2.56% than conventional mix.

6)The Tensile Strength Ratio indicates 15 mm and 0.5% of coir fibre mixes was found to be higher by 4% than conventional mix.

7) Repeated load test on coir fibre reinforced bituminous mixes has proved that performance of mix under fatigue is better for both BC and SMA mixes compared to conventional mixes.

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