Utilization of Coir fibre in Bituminous Concrete Mixes

Bindu C. S* and Beena K. S**

The addition of coir fibers to asphalt mixtures enhances material strength while adding ductility. Because of their excellent mechanical properties, coir fibers might offer an excellent potential for asphalt modification. A multitude of fiber and fiber materials were introduced and are continuously being introduced in the market as new applications such as polyester fiber, asbestos fiber, glass fiber, polypropylene fiber, Carbon fiber, Cellulose fiber

Abstract

The conventional bitumen is no longer able to meet the required performance level especially in road paving. The worldwide demand of bitumen is significantly increasing. Bitumen is a costly and scarce commodity in India. Very high bitumen content is needed in bituminous concrete wearing courses and is very expensive. It has been possible to improve the performance of bituminous mix used in the surfacing course of road pavements with the help of various types of additives to bitumen such as polymers and fibres. Some limited studies have been reported on the use of fibres. This paper presents the details of the laboratory investigations carried out to determine the feasibility of the use of the natural fibre, coir, which is abundant in Kerala, in bituminous dense graded mix with 60/70 penetration grade bitumen. Marshall Stability test was conducted over 100 samples with varying % bitumen by weight of mineral aggregate from 3% to 6% with 1% increments for 0%, 0.05%, 0.25%, 0.1 % and 0.5% fibre by weight of mix. The percentage increase in retained stability as compared to conventional mix (without fibre) was found to be 13.50% at 0.3 % fibre content. The optimum fibre content is found to be 0.3%. The test results indicated that the coir fibre reduces the bitumen requirement of the mix.

1. Introduction

Scientists and Engineers are constantly trying to improve the performance of asphalt pavements. Modification of the bituminous binder is one approach taken to improve pavement performance. Denning (1993) reported that asphalt concrete which employ modified binders are more resistant to rutting during elevated seasonal temperatures. Goodrich (1998) reported that modifier improves the properties are improved elastic properties of asphalt mixtures. Some of the improvements in the properties are improved elastic properties to withstand severe loading conditions, increase in resistance to deformation, smoother riding surface, increased stability of the mix, high retained strength after exposure to moisture, improved skid resistance over the life of the pavement, better resistance to aging caused by atmosphere, improved resistance to aging caused by atmosphere, improved resistance to low temperature cracking, higher softening point etc.

It seems that the addition of coir fibers to asphalt mixtures enhances material strength while adding

*Reader in Civil Engineering, ** Professor in Civil Engineering
School of Engg, Cochin University of Science and Technology, Kochi, 682 022

ductility. Because of their excellent mechanical properties, coir fibers might offer an excellent potential for asphalt modification. The concept of using fibres to improve the behavior of materials is not new. The modern developments of fibre reinforcement started in the early 1960s. A multitude of fiber and fiber materials were introduced and are continuously being introduced in the market as new applications such as polyester fiber, asbestos fiber, glass fiber, polypropylene fiber, Carbon fiber, Cellulose fiber (Serfandss and Samons 1996)

Attempts of using jute fibers in pavement also have been reported in the literature (Pawan Kumar et.al). Cotton fibers and asbestos fibers were used but these were degradable and were not suitable as long term reinforcement (Bushing, 1968). Metal wires have also been proposed but they were susceptible to rusting with the penetration of water. Asbestos was also used until it was determined as a health hazard (] Kietzman, 1960, Marais, 1979)

This study investigates on the characteristics of coir fiber reinforced Bituminous Concrete (BC), which may have the benefit of improving the performance of road pavement.

2. Experimental Programme

To verify the advantages of the addition of coir fibres to bituminous mixes, a series of laboratory testing program was carried out in the Civil Engineering Division of Cochin University of Science & Technology, Kerala, India. Samples with percentage bitumen varying from 3% to 6 % (by weight of mineral aggregate) and percentage fibre varying from 0%, 0.05%, 0.25%, 0.1 % and 0.5% (by weight of mix) were tested in the Marshall Stability equipment. The testing data were used to select the optimum combination of bitumen and fibre content to prepare coir fibre reinforced Bituminous Concrete mix. The average value of bitumen contents corresponding to maximum stability, maximum density and 4% air voids is taken as the optimum bitumen content.

Table.1. Physical properties of aggregates

Test Description	Specification	Results
Combined Flakiness and Elongation index (%)	IS 2386(Pt I – 1963)	18
Water absorption (%)	IS 2386(Pt III – 1963)	0.5
Specific Gravity	IS 2386(Pt IV – 1963)	2.65
Impact Value (%)	IS 2386(Pt IV – 1963)	16

2.1 Material selection:

The physical properties of aggregate and bitumen are determined in the laboratory and that of coir fibre is obtained from the supplier. Aggregates procured from a local quarry at Kochi, Kerala were used in the present study and the test results are tabulated as shown in (Table.1). Gradation adopted for the Bituminous Concrete mixture design was as specified by the Ministry of Road Transport & Highways (MoRTH, 2001) specifications and is presented in Table.2.

Table 2. Gradations of Aggregates for SMA

Sieve size (mm)	% Passing by weight	Specified value
12.5	100	80 – 100
10	90	70 - 90
4.75	75	50 – 70
2.36	32	35 – 50
0.6	18	18 – 29
0.3	13	13 – 23
0.15	5	8 – 16

Bitumen of 60/70 penetration grade obtained from Kochi Refineries Limited, Kochi, was used in this study. The Physical properties of Bitumen were tested and the results are given in Table.3.

Table.3. Physical properties of Bitumen

Test Description	Results
Penetration (100 gm, 5 secs, 25°c) (0.01 mm)	64
Ductility at 27°c (cm)	72
Specific Gravity	1.00
Softening Point (°c) (Ring & ball method)	50
Flash Point (°c)	240
Fire Point (°c)	270
Viscosity at 60 °c (Poise)	1200

The physical properties of coir is presented in Table.4 as provided by the supplier. The coir fibre was dipped in bitumen and placed in a thermostatically controlled oven maintained at 135°C for half an hour for allowing the absorption of bitumen. The fibre were then removed from the oven for sometime and again placed in an oven at 135°C for another half an hour to allow the release of extra asphalt from the coir. Before adding the fibre to the heated aggregates, it was cut into small pieces of 10 mm length (maximum) to get a uniform distribution of fibre in the matrix.

Table. 4. Properties of coir fibre

Property	Value
Avg. Fibre length	6 mm max.
Thickness	0.090 mm
Moisture content	<10% (by weight)
Ash-content(Non-volatiles)	19% (by weight)

2.2 Laboratory Mix Design and Analysis

The bituminous mix was designed using Marshall Method of mix design. Marshall Stability test was conducted to determine the optimum binder content of Stone Mastic Asphaltic mix over 100 samples of 100 mm dia and 63.5 mm height with varying % bitumen from 3% to 6% with 1% increments for 0%, 0.05%, 0.25%, 0.1 % and 0.5% fibre by applying 75 blows on each face as per ASTM procedure (ASTM D1559, 2004)

The procedure adopted for the preparation of Marshall specimen was the same as used in the conventional dense graded mixtures with the change that coated fibres are added in heated aggregate prior to mixing them with heated asphalt. The mixing and compaction temperatures were kept at 165° c and 150° c respectively (Brown *et al*) The average value of bitumen contents corresponding to maximum stability, maximum density and 4% air voids is taken as the optimum bitumen content.

Design parameters at OBC for various fibre contents are given in Table: 5 and the graphs showing the various volumetric properties corresponding to each binder content with various fibre content are shown in figures 1 to 6.

2.3 Moisture Sensitivity test

In order to find the difference in the stability loss of Bituminous Concrete mixtures, six samples from each mixture were immersed in the water bath at 60° C. The Marshall Stability values for three samples from each mixture were obtained after 35 min of water immersion. In addition, the Marshall Stability values after 24 h water immersion were also obtained. The results are shown in Table 6.

3. Results and Discussion

3.1 Marshall Properties

Fig. 1 indicate that with an increase in bitumen content the Marshall Stability value of SMA increases first and then decreases. This is because, bitumen holds the aggregates in position, and the load is taken by the aggregate mass through the contact points. If all the voids are filled by bitumen, then the load is rather transmitted by hydrostatic pressure through bitumen, and strength of the mix therefore reduces. That is why stability of the mix starts reducing when bitumen content is increased further beyond certain value. This is true when a coir fibre reinforced BC is used.

The proper quantity of bitumen needed to coat the fibres depends on the absorption and the surface area of the fibres and is hence affected by percentage fibre content. The maximum percentage reduction in binder content compared to conventional mix is 5.3% at a fibre content of 0.5% as shown in Fig. 1. This indicates an appreciable saving in bitumen by adding fibres in the mix.

Considering Marshall Stability values the addition of fibre in SMA increases the stability value upto 0.5% (Table 6). On further increasing the fibre content to 0.1%, it is observed that the stability value decreases slightly. This is because when the fiber content exceeds 0.5%., the degree of homogeneity of dispersion of the fibres within the mix is very poor. Due high content in the percentage increase in stability value has been found to be 15% as compared to the mix without fibre.

The flow value decreases with an increase of fiber content in the mix (Fig. 3) but within the limits of 2 to 4 mm. Since the clumping and the meshing of the fibre makes the mix more rigid and thereby lowering the flow value.

There is a decrease in the percentage of voids in the mineral aggregate with increase in percentage of fibre content (Table 5), but the values are within the specified limits mum. A similar variation is observed for VFB also.

3.2 Moisture Damage

Retained stability increases with the increase in fibre content upto 0.5

Table 5. Design Parameters at Various fibre Contents

Properties	0% fibre	0.05 % fibre	0.25% fibre	0.5% fibre	0.1% fibre	Specified Value
Stability(kg)	511.04	477.52	390.44	351.12	305.68	340(min)
Density(g/cc)	2.27	2.28	2.32	2.33	2.35	-
Flow(mm)	3.9	3.7	3.5	3.2	3.0	2 to 4
VMA (%)	80.95	79.67	77.82	76.47	75.92	75 to 85

Table 6 Retained Stability at various % of fibre

% Fibre	0	0.1	0.2	0.3	0.4
Retained Stability (%)	79.4	84.1	90.8	92.9	89.5

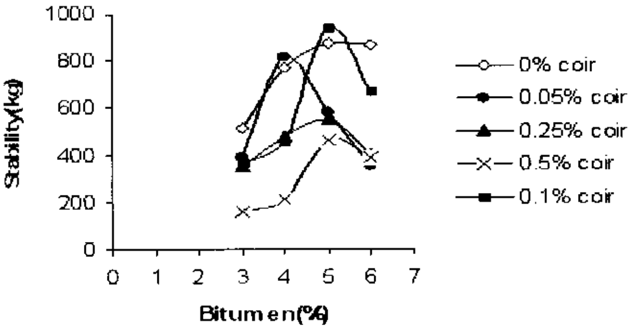

Fig. 1. Stability vs. % Bitumen

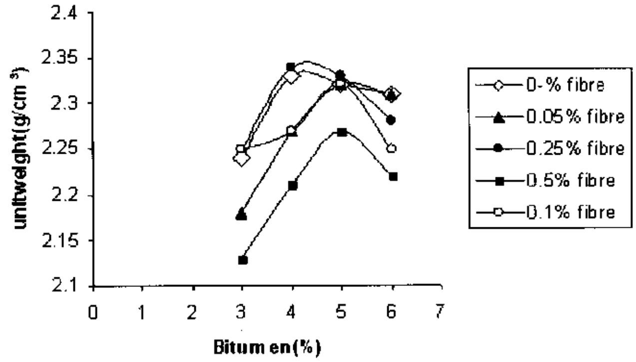

Fig. 2 Unitweight vs. % Bitumen

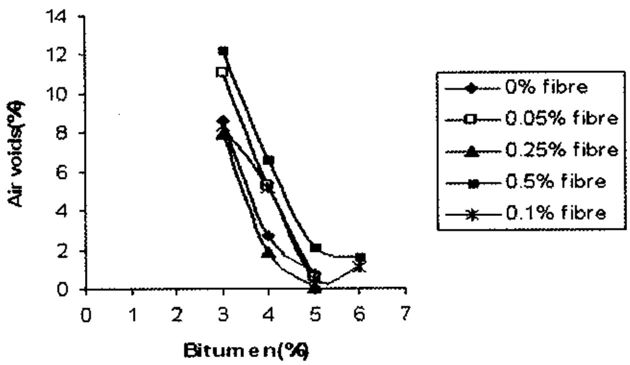

Fig. 3. Air voids vs. % Bitumen

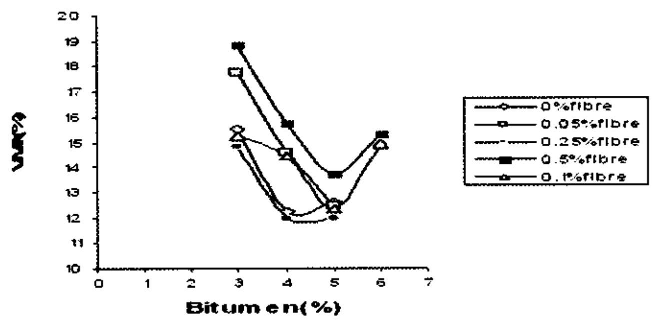

Fig. 4 VMA vs. % Bitumen

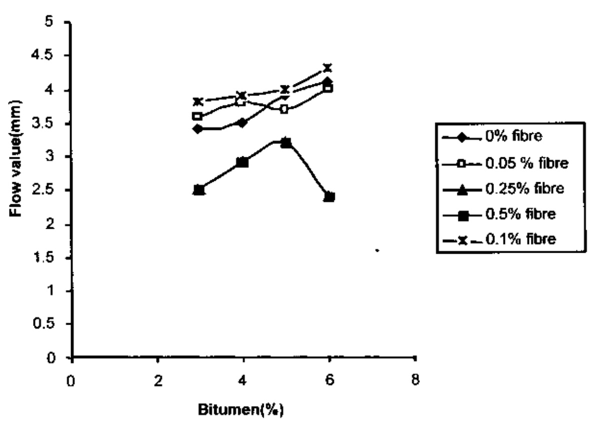

Fig. 5. Flow value vs. % Bitumen

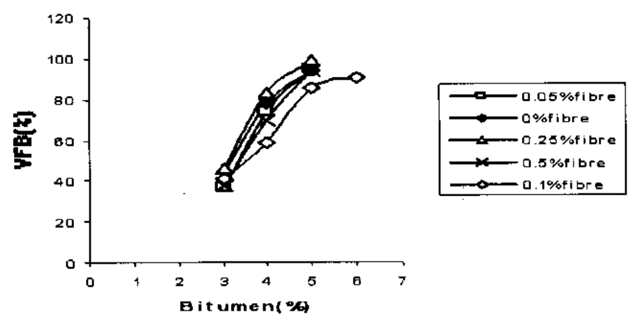

Figure: 6 VFB vs. % Bitumen

%. On further addition of fibre, the value is found to be decreasing (Table 6). The retained stability in fibre reinforced BC is about 93%whereas in conventional mix, it is 79 %. This shows that the mix with 0.3 % fibre content is least affected by water.

4. Conclusion

The feasibility of adding fibre as an additive in Bituminous concrete is studied and the following conclusions are drawn.

- 0.3% fibre is the optimum fibre content in SMA.
- The reduction in binder content compared to conventional mix is 5% giving an appreciable saving in bitumen by adding fibres.
- The Marshall Stability value of SMA with optimum fibre content was found to be 1160 kg, which is higher than prescribed value of

620 kg as per NCHRP report 425 and the percentage increase in stability value has been found to be 15% as compared to the conventional mix.

- The flow value of SMA with 0.3% fibre was found to be 3.69 mm which is in the range of prescribed value (2-4 mm) whereas the flow value for conventional mix is 4.19 mm.
- Retained Stability of SMA increases with increase in fiber content upto 0.3 % and the percentage increase as compared to conventional mix is 17%.

Adding of coir fibre would improve the characteristics of BC. The role of fibre is to increase the stability value while reducing the optimum bitumen content of the Bituminous Asphalt mix. On the whole, the results showed that the Natural fibre, coir which is a cheaper and an ecofriendly alternative to synthetic fibre can be effectively used as a stabilizing additive in Bituminous Concrete.

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The Midget Palm

A six month old coconut seedling having only six roots and six embryonic leaves is observed with six spadices. The tree is grown in the Coconut nursery of Hitech Coconut Corporation Nagercoil, Tamil Nadu. Similar observations were recorded earlier in 1976, 1992 and 1985. This is a result of spontaneous and sudden mutation of cluster of genes located on a particular chromosome. Once the particular chromosome and the gene sector is identified, it would be easy for the future breeders, to develop coconut palm with shorter generation period.

(News Courtesy: Dr. Henry Louis, Chairman, Centre for Innovation and Transfer of Technology, Nagercoil-2)