Draindown Analysis of Bituminous Mix Modified with Natural Fibre

Naveen Kumar R
TRP Engineering College (SRM Group). Trichy, Tamil Nadu, India 621 105
Manimaran S
TRP Engineering College (SRM Group). Trichy, Tamil Nadu, India 621 105
Sureshraja K
TRP Engineering College (SRM Group). Trichy, Tamil Nadu, India 621 105

Abstract—The present study investigates the draindown property of mixtures of stone matrix asphalt made with conventional bitumen 60/70 with a non-conventional natural fibre, namely sisal fibre. By Marshall method Optimum Bitumen Content have been found. Thereafter, the draindown characteristics for modified and unmodified SMA (Stone Mastic Asphalt) mix have been studied. It is observed that only 0.28% addition of sisal fibre significantly improves the Marshall properties of SMA mixes. Addition of nominal 0.28% fibre considerably improves the draindown characteristics of the SMA mixes with conventional bitumen, which would otherwise have not been able to meet the prescribed criteria.

Index Terms— Stone Mastic Asphalt, Sisal Fibre, Draindown test.

I. INTRODUCTION

Asphalt is a viscous material that is derived from crude petroleum. Asphalt that has been specially prepared for use in pavement by controlling its quality and consistency is called asphalt cement. Asphalt cement is ordinarily used in a ‘‘hot mix” pavement composition that also contains coarse and fine aggregate. This composition, also called bitumen concrete, is blended at high temperature, applied to the roadbed, and compacted with rollers to produce a smooth driving surface and is used in paving roads. As SMA is constituent of rich binder, it may lead to draindown problem which exists in transportation of mix, at that stage additives were used as solution, especially natural fibres such as sisal fibres. Sisal fibre is a hard fibre extracted from the leaves of the sisal plant (Agave sisalana). Though native to tropical and sub-tropical North and South America, sisal plant is now widely grown in tropical countries of Africa, the West Indies and the Far East. A sisal plant produces about 200-250 leaves and each leaf contains 1000-1200 fibre bundles. Generally, the strength and stiffness of plant fibres depend on the cellulose content. The structure and properties of natural fibres depend on their source, age, etc. [1]. The absorbing nature of sisal fibre serves act as an additive for SMA and life of the fibre is higher as compared to other natural fibres.

II. MATERIALS AND METHODS

A. Materials

The materials used in the present study includes 60/70 penetration grade bitumen, graded aggregate of nominal size (20mm, 10mm, 4.75mm), dust and processed sisal fibre (Diameter 0.2 to 0.4 mm and length of 6mm)

Marshal Test procedure is used in the investigation for study of behaviour of sisal fibre modified bituminous mix. Gradation of aggregate is one of the important factors for mix, but in this study instead of proportioning of aggregate as conventional method, the adopted grading is middle value of suggested grading in specification prepared by Indian Roads Congress (IRC) (Indian Highways, February 2007).

B. Preparation of Specimen

The SMA mix were prepared with a additive at the rate of 0.1 to 0.5% (by the weight of total mix) with interval of 0.1 %. The length of fibre was kept as 6mm as per specification [8]. The aggregate specimen taken was maintained an absolute grading as for control mix, the aggregate gradation was given. The fibre rate was varied for each bitumen content (Optimum Bitumen Content (OBC) and two other content closest to OBC). Then the sisal fibre was added to heated aggregate in dry method and mixed thoroughly, the mix was maintained at 180^0C. The mix was mixed thoroughly so that balling and clumping would be avoided. The bitumen added mix should not kept more than 5 minutes in stove, because continuous heating of mix leads to loss of consistency of bitumen

and increasing flow which leads to heterogeneity mix. After compaction the mix was kept in room temperature for 24 hours before unmolding.

III. TESTING OF SPECIMENS

The prepared sample is tested after 24 hours of casting for stability and flow value. Initially the samples prepared without fibre were tested in order to obtain the OBC for control mix. After finding OBC, the sisal fibres modified mix were tested to get reviewed OBC and Optimum Fibre Content (OFC).

Maximum stability value obtained for control mix is 11.575KN from bitumen content 6.21%, which is fixed as OBC.

TABLE I: SMA REQUIREMENTS

Mix Design Parameters	Requirement
Air void Content	4 %
Bitumen Content	5.8 % min
VMA	17 % min
Drain down	0.3 %

The flow value for respective bitumen content is 3.09mm. After this bitumen content the stability value decreases. The characteristics of sisal fibre modified mix are presented in table (2) and comparisons were made with control mix.

TABLE II: COMPARISON OF RESULTS

Mix Design Parameters	Unmodified	Modified	Specification
Marshall Stability value	11.575 KN	14.82 KN	
Flow Value	3.09 mm	3.6 mm	2-4 mm
Air void Content	3.70 %	3.92 %	4%
Bitumen Content	6.21 %	6.18 %	5.8 % min

A. Drain-down Analysis of SMA

There are several methods to evaluate the draindown characteristics of SMA mixtures. The draindown method suggested by MORTH (2001) was adopted in this study. The drainage baskets fabricated locally according to the specifications given by MORTH (2001) is shown in Figure 6.

The loose uncompacted mixes were then transferred to the drainage baskets and kept in a pre-heated oven maintained at 150^0C for three hours. Pre-weighed plates were kept below the drainage baskets to collect the drained out binder drippings. From the draindown test the binder drainage has been calculated from the equation 1.

$$d = \frac{W2-W1}{1200+X} \qquad (1)$$

either where;

W1 = initial mass of the plate

W2 = final mass of the plate and drained binder

X = initial mass of fibers in the mix

Figures 2 and 3 shows the drained out bitumen mix samples after being kept in oven for three hours. SMA mixes are rich in binder, which provides durability to the mix. A major problem that has been observed with SMA mixes is draindown of the binder resulting in bleeding and formation of fat spots. Therefore the draindown characteristics of the SMA mixes prepared at their OBC and OFC were verified using specifications [5]. In this part, the results of the draindown tests are discussed

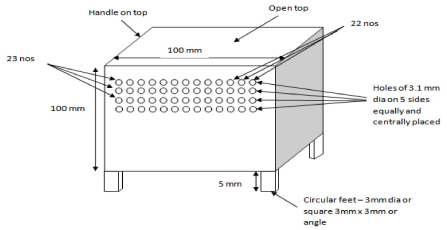

Fig. 1. Schematic representation of 100 mm x 100 mm x 100 mm cubical drainage basket

The draindown tests carried out on mixes without fiber and estimated by using equation 3. It can be observed from the results that for SMA mixes with 60/70 bitumen the draindown is 0.009%. The test carried out on mixes with sisal fibre prepared at their OBC and OFC. It is observed from the result that SMA mixes prepared at reviewed OBC and OFC has very less draindown of 0.001 %. Therefore addition of the fiber improved the draindown characteristics of SMA mixtures.

Fig. 2. Drainage of bitumen from mix -without fibre

Fig. 3. Drainage of bitumen from mix -with fibre at OBC and OFC

IV. CONCLUSION

Based on the results and discussions of experimental investigations carried out on different SMA mixes the following conclusions are drawn. SMA mixes value of optimum binder content is quite high that makes it very costly. So we can say here that use of sisal fibre would result into sufficient cost effective and money saving measure. Here maximum stability value for unmodified mix is 11.575 KN, while stability value for modified mix at OBC and OFC is 14.82 KN. Sisal fibre increased the percentage air voids by 6% which is a necessary parameter for pavement in hotter region. It prevents bleeding of bitumen from pavement by holding within it. It is observed that SMA mixes prepared at OBC and OFC has very less draindown of 0.001 % compared to 0.009% for the SMA without fibre.

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