International Journal for Innovative Engineering and Management Research

A Peer Revieved Open Access International Journal

www.ijiemr.org

COPY RIGHT

IJIEMR Transactions, online available on 24 May 2017. Link :

http://www.ijiemr.org/downloads.php?vol=Volume-6&issue=ISSUE-3

TITLE: A Study Of Effects Of Binder Quality And Coconut Fiber On Stone Matrix Asphalt Mixtures

.

Volume 06, Issue 03, Pages: 312 – 324.

Paper Authors

P S P S VANI DEVI , S. ESWAR

Pydah College of engineering, Kakinada, India.

.

USE THIS BARCODE TO ACCESS YOUR ONLINE PAPER

To Secure Your Paper As Per UGC Guidelines We Are Providing A Electronic Bar Code

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

A STUDY OF EFFECTS OF BINDER QUALITY AND COCONUT FIBER ON STONE MATRIX ASPHALT MIXTURES

P S P S VANI DEVI[1]; S. ESWAR[2]
[1]PG Scholar, Pydah College of engineering, Kakinada, India.
[2]Asst professor, Pydah College of engineering, Kakinada, India.
E-Mail: psvanidevi@gmail.com, seswar@pydah.edu.in

Abstract
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 and modified binder CRMB 60, 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. The optimum binder content is determined keeping the suggested air voids content in the mix. Marshall properties such as stability, flow value, unit weight, air voids are used to determine optimum binder content and optimum fiber content for each type of binder for further studies on SMA mixes. Thereafter, the draindown characteristics, both static indirect tensile strength parameters and moisture susceptibility characteristics in terms of tensile strength ratio and retained stability of different SMA mixtures values have been studied for such mixes. 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 draindown, indirect tensile strength of the SMA mixes with conventional bitumen, which would otherwise have not been able to meet the prescribed criteria.

Key Words: stone matrix asphalt, coconut fiber, static indirect tensile test, Marshall Properties, indirect tensile strength, draindown test, moisture susceptibility.

1. INTRODUCTION

1.1 INTRODUCTION

Aggregates bound with bitumen are conventionally used all over the world in construction and maintenance of flexible pavements. The close, well, uniform, or dense graded aggregates bound with normal bitumen normally perform well in heavily trafficked roads if designed and executed properly and hence very common in paving industry. However, it is not always possible to arrange dense graded aggregates available at the site. In such situations a bituminous mix called stone matrix asphalt (SMA) which basically consists of gap graded aggregates, can be attempted.SMA was developed in Germany in the 1960s by Zichner of the Straubag-Bau AG central laboratory, to resist the damage caused by studded tires. As SMA showed excellent resistance to deformation by heavy traffic at high temperatures, its use continued even after the ban of studded tires. SMA is a gap graded mixture containing 70-80% coarse aggregate of total aggregate mass, 6-7% of binder, 8-12% of filler, and about 0.3-0.5% of fiber or modifier. The high amount of coarse aggregate in the mixture forms a skeleton-type structure providing a better stone-on-stone contact between the coarse aggregate particles, which offers high resistance to rutting. Aggregate to aggregate contact is also there in dense graded mixtures but it occurs within the fine aggregate particles as the coarse aggregate floats in the fine aggregate matrix, which don't give the same shear resistance as the coarse aggregate skeleton. Brown and Manglorkar (1993) reported that the traffic loads for SMA are carried by the coarse aggregate particles 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 drainage during production, transportation and laying.

SMA has been proved to be more cost effective than dense graded mixes for high volume roads. Brown (1992) observed that a number of factors influence the performance of SMA mixtures, such as changes in binder source and grade, types of aggregate, environmental conditions, production and construction methods etc. Evaluation of these factors would help to determine the long term performance of SMA and provide information to make changes as needed to suit different environmental conditions. The SMA Technical Working Group of FHWA defined SMA as "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".

2 LITURATURE REVIEW

A detailed review of literatures made on works related to SMA mixes is described in the following paragraphs. Majority of the roads all over the world are made up of flexible pavements. Flexible pavements consist of a bituminous layer on the surface course and sometimes in base course followed by granular layers in base and sub base courses over the subgrade. Asphalt Concrete Pavement or Hot Mix Asphalt pavement are the bound layers of a flexible pavement structure at the surface course. The most common type of flexible pavement surfacing used in India is a premix bituminous material, commonly called outside as Hot Mix Asphalt (HMA). HMA is a mixture of coarse and fine aggregates and asphalt binder. HMA, as the name suggests, is mixed, placed and compacted at higher temperature. HMA is typically applied in layers, with the lower layers supporting the top layer, which is known as surface course or friction course. The aggregates used in the lower layer are to prevent rutting and the aggregates which are used in the top layer are generally selected on the basis of their friction properties and durability. There are several types of HMA mixes. These include conventional Dense Graded Mixes (DGM), Stone Matrix asphalt (SMA) and various Open graded HMA. The HMA mixes differ from each other mainly in maximum aggregate size, aggregate gradation and binder content or type of binder used.

3. EXPERIMENTAL INVESTIGATION

3.1 Tests on Materials Used:

3.1.1 Aggregates:

For preparation of SMA mixes, aggregates as per NCHRP grading as given in Table 3.1, a particular type of binder and fiber in required quantities were mixes as per Marshall Procedure.

Table 3.1 Adopted aggregate gradation (NCHRP)

Size of Aggregate (NSA)	
ze, mm	Passing

3.1.2 Coarse Aggregates:

Coarse aggregates consisted of stone chips collected from a local source, up to 4.75 mm IS sieve size. Standard tests were conducted to determine their physical properties as summarized in Table 3.2.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

Table 3.2 Physical properties of coarse aggregates

	thod	ult
te Impact Value (%)	(P IV)	
te Crushing Value (%)	(P IV)	
els Abrasion Value (%)	(P IV)	
s Index (%)	(P I)	
on Index (%)		
bsorption (%)	(P III)	
Gravity	(P III)	

3.1.3 Fine Aggregates:

Fine aggregates, consisting of stone crusher dusts were collected from a local crusher with fractions passing 4.75 mm and retained on 0.075 mm IS sieve. Its specific gravity was found to be 2.65.



International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

(i) **(ii)** **(iii)**

(iv) **(v)**

Fig3.1: photographs while doing aggregate testing.

3.1.4 Filler:

Portland slag cement (Grade 43) collected from local market passing 0.075 mm IS sieve was used as filler material. Its specific gravity was found to be 3.15.

3.1.5 Binders:

Two conventional binders, namely 80/100 and 60/70 bitumen and a polymer modified binder namely CRMB 60 were used in this investigation to study the effects of binder type on SMA mixes. These binders were collected from the local depot. Normal tests were performed to determine the important physical properties of these binders. The physical properties thus obtained are summarized in Table 3.3.

Table 3.3 Physical properties of binders

		thod	ult

ʒit.	ion at 25□C, 100g, 5 s n	ʒ-1978	
	g Point (R&B), □C	ʒ-1978	
	y (Brookfield) at 160□	) 4402	
t.	ion at 25□C, 100g, 5 s n	ʒ-1978	
	g Point (R&B), □C	ʒ-1978	
	y (Brookfield) at 160□	) 4402	
ʒ0	ion at 25□C, 100g, 5 s n	ʒ-1978	
	g Point (R&B), □C	ʒ-1978	
	y (Brookfield) at 160□	) 4402	

3.1.6 Fibers:

The peelings of ripe coconut were collected locally, dried and neat fibers taken out manually. The lengths of such fibers were normally in the range of 75 to 200 mm and diameter varied from 0.2 to 0.6 mm. The tensile strength of these fibers was tested in a materials testing machine, Tinious Olsen, UK, Model HIOKS. The test was done in tensile mode with 10 KN load cell and the cross head speed was maintained at 0.2 mm/min. The average tensile strength of the fiber thus obtained was found to be 70.58 N/mm^2. The coconut fibers were cleaned and cut in to small pieces of 25-75 mm in length to ensure proper mixing with the aggregates and binder.

3.2 Preparation of Mixes:

The mixes were prepared according to the Marshall procedure specified in ASTM D1559. The coarse aggregates, fine aggregates and cement were mixed according to the adopted gradation. Three types of binders as already stated were used in different proportions in the mixes starting from 3% to 7% with an increment of 0.5% of the total mix to obtain the optimum binder requirement and also to determine the effect of binder content and binder type on the mix properties. After some initial trials for preparation of SMA samples with coconut fiber, a proper procedure could be developed. The coconut fibers after being cut in to small pieces (25-75 mm) were added directly to the aggregate sample in three different proportions, 0.3%, 0.5%, and 0.7% of the total mix to assess the optimum fiber requirement for the best possible mix. The mineral aggregates with fibers and binders were heated separately to the prescribed mixing temperature. The temperature of the mineral aggregates was maintained at a temperature 10□C higher than the temperature of the binder. Required quantity of binder was added to the pre heated aggregate-fiber mixture and thorough mixing was done manually till the colour and consistency of the mixture appeared to be uniform. The mixing time was maintained within 2-5 minutes. The mixture was then poured in to pre-heated Marshall moulds and the samples were prepared using a compactive effort of 50 blows on each side as 75 blows compaction is reported to result in significant degradation of aggregates The specimens were kept overnight for cooling to room temperature. Then the samples were extracted and tested at 60□C according to the standard testing procedure

3.3 Tests on Mixes:

Presented below are the different tests conducted on the bituminous mixes with variations of binder type and quantity, and fiber concentration in the mix.

3.3.1 Marshall test:

Marshall Mix design is a standard laboratory method, which is adopted worldwide for determining and reporting the strength and flow characteristics of bituminous paving mixes. In India, it is a very popular method of characterization of bituminous mixes. This test has also been used by many researchers to test SMA mixes.

(i)

(ii)

Fig. 3.3 Marshall test in progress

3.3.2 Draindown test:

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

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 3.2. 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.

Fig. 3.4 Drainage baskets kept in oven at 150°C

Fig. 3.5 Drainage of 80/100 bitumen sample

Fig. 3.6 Drainage of 60/70 bitumen sample

Fig. 3.8 Drainage of CRMB 60 binder sample

3.3.3 Indirect tensile test:

Indirect tensile test is used to determine the indirect tensile strength (ITS) of bituminous mixes. In this test, a compressive load is applied on a cylindrical specimen (Marshall Sample) along a vertical diametrical plane through two curved strips the radius of curvature of which is same as that of the specimen. A uniform tensile stress is developed perpendicular to the direction of applied load and along the same vertical plane causing the specimen to fail by splitting. This test is also otherwise known as splitting test. This test can be carried out both under static and dynamic (repeated) conditions. The static test provides information about the tensile strength, modulus of elasticity and Poisson's ratio of bituminous mixes. The static indirect tensile strength test has been used to evaluate the effect of moisture on bituminous mixtures.

The test temperature was varied from 5˚C to 40˚C at an increment of 5˚C. In this test three Marshall samples were tested at a particular temperature and the tensile strength was reported as the average of the three test results.

Fig. 3.9 Static indirect tensile test in progress

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

(i) Specimen tested at 30□C

(ii)Specimen tested at 10□C

Fig. 3.10 CRMB 60 sample tested in static indirect tensile test

3.4 Moisture susceptibility test:

The presence of moisture in bituminous pavement is a critical factor leading to failure of pavement. Therefore it's very much essential to study the resistance to moisture characteristics of bituminous mixes. There are several methods in which the loss of adhesion of bitumen from aggregates can be studied. However, the following two methods have been used to study the moisture susceptibility characteristics of the SMA mixtures. Both of these tests are used to evaluate the loss of strength of bituminous mixes after being subjected to moisture for a certain period of time.

4. RESULT:

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

In this chapter the results and observations of the tests conducted are presented, analyzed and discussed. It is mentioned earlier that three types of binders, namely 80/100 penetration grade bitumen, 60/70 penetration grade bitumen and CRMB 60 grade binder have been used in the SMA mixes with and without coconut fiber in this investigation.

4.1 Marshall Stability:

The binder content in the mix was varied from 3% to 7% by weight. It can be observed from the below figures that, with increase in binder content the stability value increases up-to a certain binder content then decreases as per the normal trend for a bituminous mix. It is observed that the stability value in general increases with the hardness (in terms of penetration value) of the binder.

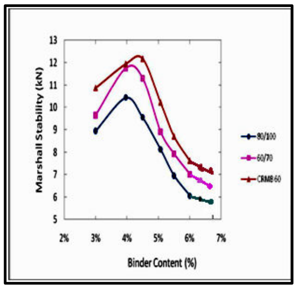
Table 4.1 Maximum Marshall Stability values and their corresponding binder content

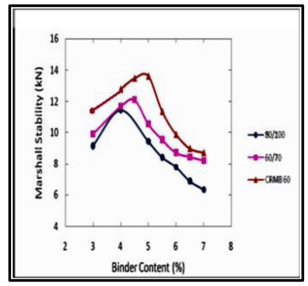
ntent				
ype	ability (kN	ontent (%	ability (kN	ontent (
Bit.				
t.				
60				
ntent				
ype	ability (kN	ontent (%	ability (kN	ontent (
Bit.				

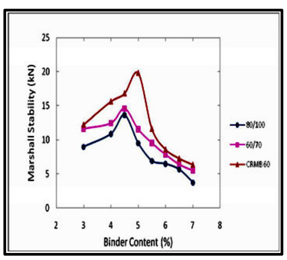
International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

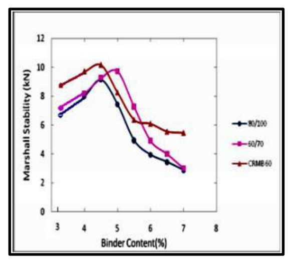
t.				
60				

The results of the above Marshall tests have been represented in Figures 4.1 (i) to (iii).





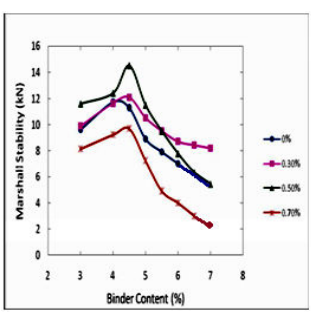


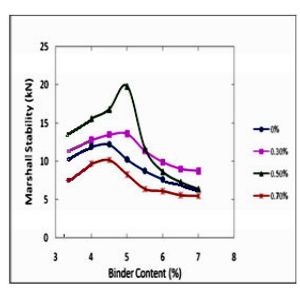


(i) 0% Fiber (ii) 0.3% Fiber

(iii)0.5%fiber (iv)0.7%fiber

Fig. 4.1 Variation of Marshall Stability value with binder content for different binder





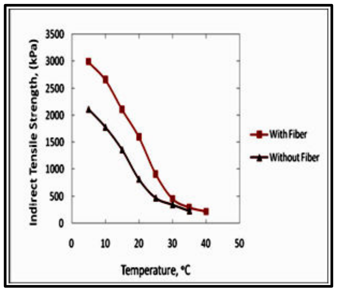
(i)60/80 Binder **(ii)CRMB Binder**

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

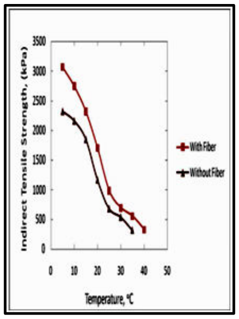
Fig. 4.2 Variation of Marshall Stability value with binder content for different fiber concentrations in the mix

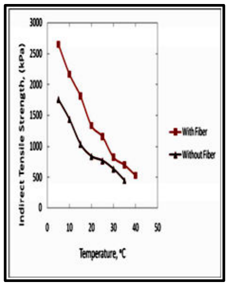
4.2 Draindown Characteristics:

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.



(i) 80/100 Bitumen





(ii) 60/70 Bitumen (iii) CRMB 60 Binder

Fig. 4.3 Variation of ITS with temperature for mixes with different binders