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Experimental Investigation on Stone Matrix Asphalt Mixture using Arbocel Fiber

Santosh Kumar[1], Shiva Prasad N[2]

[1]PG Student, Department of Construction Technology Management and Highway Technology,
Dayananda Sagar College of Engineering, Bangalore, Karnataka, India

[2]Assistant Professor, Department of Construction Technology Management and Highway Technology
Dayananda Sagar College of Engineering, Bangalore, Karnataka, India

Abstract: ***As much as a larger portion of the assets in the highways sector are being spent on the restoration and resurfacing of the current asphalts. It is a fact that has to be accepted that conventional bituminous mixtures proves obsolete to the heavy loading conditions and climatic varieties. It is the time that we pick a predominant plan of bituminous mixes. Almost $ 150 billion is being invested in highway and transportation segment from Indian government by the year 2019. As dependable natives, it is our obligation to use this mammoth reserve in the most productive way. The Stone Matrix Asphalt (SMA) mixture is a hot blend asphalt, developed in Germany in the mid-1960. It is a gap graded asphalt mixture which is intended with expanding deformity (rutting) resistance and durability by using the structural premise of stone-on-stone contact. Also which is characterized by high coarse aggregates and fine particles, high binder content and fiber additives as stabilizers. It has low air voids with a higher level of macro texture laid resulting in waterproofing with good drainage surface. The present work focuses on assessing the properties of Stone Matrix Asphalt Mix and also the effect of the addition of fibers. The objectives of the study to obtain a desired gradation as per specification given by IRC: SP: 79: 2008 by using locally available aggregates and other materials, to determine the optimum binder content and optimum fibre content by varying binder content 5.8%, 6%, 6.2%, 6.4% and 6.6% , fibre content 0.30%, 0.35%, and 0.40% by total weight of aggregates. In this study, PMB-40 grade is used as the binder and hydrated lime is used as filler and Arbocel as fiber. From Marshall Stability test results, it is observed that the 0.30% of addition fiber optimum dosage. The drain down test done for optimum fiber content and binder content, in order to assure that binder drain off does not exceed 0.30%. Further the performance evaluation, the mix was evaluated by conducting Indirect Tensile Strength Test, and Rutting characteristics without and with the addition of optimum fiber content. The results showed that the SMA Mix has better resistance with optimum dosage than the conventional SMA.***

Keywords: Stone Matrix Asphalt, Stone-on-Stone, Marshall Stability, Drain-down Potential, Indirect Tensile Strength, Rutting.

1. Introduction

In highways, major distress is due to the rain-induced damages. It is a settled actuality in created nations that the water actuated harms are required to be less in a gap graded mix like stone matrix asphalt than conventional blends. In any case use of SMA in India is extremely restricted because of absence of appropriate determinations. This requires the requirement for careful trial and field experiments in different parts of SMA, in setting of India. Stone Matrix/Mastic Asphalt (SMA) is a hot blend asphalt, developed in Germany in the 1960's. SMA has been referred some time concerns over the years as Stone Mastic, Grit Mastic or Stone Filled black top. It is a gap-graded hot blend black-top which is intended with expand deformity (rutting) resistance and durability by using a structural premise of stone-on-stone contact [1]. The European definition of SMA is "a gap graded asphalt concrete composed of a skeleton of crushed aggregates bound with a mastic mortar". The SMA Mixture mainly composed to have a high coarse aggregate percentages typically 70%-80%, a high binder content minimum 5.8%, and a mineral filler content approximately 8%- 12%. The high coarse aggregate content results in stone-on-stone contact that produces a mixture that is highly resistant to deformation [11].

2. Need for Study

Road transportation is one of the common modes of transport which was used in the pre-notable circumstances. From that point forward many examinations in pavement material were carried out providing safe and comfortable ride to the road users. In the present day scenario it is noticed that vehicular volume, frequency and loading intensity is increased by manifolds the road laid with conventional bituminous mixes is unable to cope up with the above variables resulting in early failure. Many researchers have contributed for the use of waste materials, for improvement in pavement service life. Stone Matrix asphalt mix is suitable for heavy vehicle traffic and offers good resistance for rutting characteristics. Keeping in mind the end goal to build the quality and resistance of SMA mixture Arbocel fibers is added at regular intervals.

3. Range of Applications

SMA is sufficient and it is suggested for any surface course. It is particularly utilized for all overwhelming movement streets. SMA is a great deal more sparing (Long Life Asphalt Pavements 2007, EAPA) than black-top cement. Since the details were presented in 1984, the utilization of SMA has essentially expanded. The stone network black-top is fitting for [1]:

- Roadways
- Federal Streets
- Rural Streets

- Urban Streets
- Airports

4. Scope and Objectives of Present Study

The extent of present work includes the assurance of different properties of the binder and aggregates utilized for SMA mixture. SMA samples were set up by fluctuating the bitumen substance and fiber content by conducting Marshall Stability Test to decide the ideal bitumen substance and ideal fiber substance. Further the Drain-down Test was led to check for the cover seepage. The laboratory performance of the SMA blends is checked for the Moisture Susceptibility and Rutting Test. The objectives of the present dissertation work is given below:

1) To assess the properties of the aggregates and binder content by conducting the test in the laboratory as per IRC: SP: 79:2008 Specifications for SMA mixture.
2) To determine the optimum binder content and optimum fibre content by varying their percentage by conducting the Marshall Stability Test.
3) To estimate the Drain down Characteristics in Un-compacted Asphalt Mixtures in accordance with ASTM D 6390.
4) To study and compare the property of conventional SMA Mix with Arbocel fiber by performing Moisture Susceptibility and Rutting Test.

5. Material Characterization

5.1Aggregates

Aggregates used are mainly divided into coarse and fine aggregate based on their size. The aggregates selected for the Stone Matrix Asphalt are subjected to various aggregate tests as specified by IRC: SP: 79: 2008 and MoRTH section 500, confirming to the table 500-36. Good durable quality crushed aggregates of different sizes are obtained from R. N. Shetty Quarry, Jigani Bengaluru. The test results on Aggregates as shown in Table 1.

5.2 Binder

The proper selection of binder content **is** an important element supporting the stone skeleton performance. In this study Polymer Modified Bitumen (PMB-40) used. To find the physical properties of the binder content the various test are carried out as per IRC: SP: 53: 2010 and MoRTH 500-36 Section. The binder content PMB-40 is obtained Hindustan Colas Pvt. Limited Mangalore. The test results on PMB-40 as shown in Table 2.

5.3 Hydrated lime

Hydrated lime has been used as the mineral filler in the stone matrix asphalt mixture, with the replacement for stone dust in the percent of 2%. It was procured from Panacea Polychem, Sait industrial town, Bengaluru. The sieve analysis of hydrated lime and test results as shown in Table 3.

5.4 Arbocel fiber

Fibers are used as stabilizer in SMA mixture. It helps to increase the strength and stability also decrease the drain down in SMA Mix. In the present study, the fibre used is ARBOCEL® ZZ 8/1G. It was procured from Strategic Marketing and Research Team, Bangalore. Arbocel is natural cellulose fibre produced from cellulose and it is a powdery to fibrous cellulose additive for use in construction chemicals products. The Characteristics of arbocel fiber as shown in Table 4.

Table 1: Physical Characteristics of Aggregates- Test Results

Sl No	Aggregate Test	Method	Result	Requirement as per IRC:SP:79:2008
1	Aggregate Impact Value (%)	IS : 2386 (Part-IV)	16.81 %	< 18 %
2	Los Angeles Abrasion Value (%)	IS : 2386 (Part-IV)	17.76 %	< 25 %
3	Combined Flakiness and Elongation Index (%)	IS : 2386 (Part-I)	12.70 %	< 30 %
4	Water Absorption	IS : 2386 (Part-III)	0.90 %	< 2 %
5	Specific gravity Coarse Aggregate Fine aggregate	IS : 2386 (Part-III)	2.72 2.64	2.5-2.8

Table 2: Test Results on PMB-40 binder

Sl No	Test	Method	Results	Requirement as per IRC: SP: 53: 2010
1	Penetration at 25°C (mm)	IS – 15462-2004	40	30-50
2	Softening Point (°C)	IS – 15462-2004	64	Min 60
3	Flash Point (°C)	IS – 15462-2004	260	Min 220
4	Specific Gravity	IS – 15462-2004	1.02	>0.99
5	Thin Film Oven Test 1. Loss in mass (%) 2. Increase in softening point (°C) 3. Reduction in penetration (mm)	IS – 15462-2004	0.82 5 32	Max 1 Max 5 Max 35

Table 3: Sieve Analysis of Hydrated lime and Test results

Sl No	IS Sieve Size (mm)	Weight Retained (gms)	% Weight Retained (gms)	Cumulative % Weight Retained	Cumulative Weight % Passing	Cumulative % passing by weight of total aggregate
1	0.6	2	0.5	0.5	99.5	100
2	0.3	10	4.5	5	95	95-100
3	0.075	13	7	12	88	85-100

Table 4: Characteristics of Arbocel Fiber

Sl No	Characteristics	Values from Testing Certificate
1	Physical appearance	Long fibre, Grey
2	Cellulose content	80±5 %
3	Average fibre length	1100 µm
4	Average fibre thickness	45 µm
5	Bulk density	200 g/l – 280 g/l
6	Temperature resistance (°C)	Up to 200°C
7	pH value	7.5±1

6. Experimental Programme

6.1 Aggregate Gradation

The different size of aggregates used to obtain proper blend are 19mm down size, 10mm down size, 6mm down size and stone dust. 4000gm of aggregates were taken for sieve analysis. The aggregate gradation is done by using Rothfuch's Method to find the individual percentages of different sized aggregates to be used confirming to the upper and lower limits specified as per MoRTH table 500-37 and IRC: SP: 79: 2008.

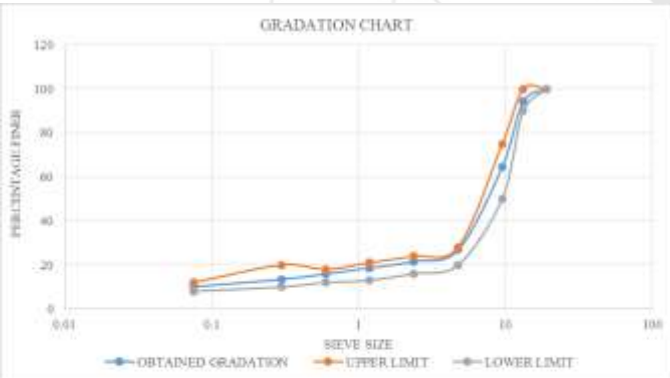

Figure 1: Gradation Chart for SMA Mix

6.2 SMA Mix Design

The mix design is done by using Marshall Stability Test to find the optimum binder content bearing a maximum stability value and also confirming the other Marshall parameters. The design mix shall meet the requirements as per MoRTH table 500-38: SMA Mix requirements.

6.2.1 Specimen Preparation for SMA Mix

The various size of aggregates were mixed in proportion obtained from the gradation and Marshall Samples were prepared at varying binder contents of 5.8%, 6%, 6.2%, 6.4%, and 6.6% at increments of 0.2%. Approximately 1200gms aggregates taken in combination of different sizes and filler heated to a temperature of around 170°C -180°C for the preparation of specimen. The bitumen is heated up to a flowing state of around 125°C. The aggregates and bitumen are well mixed in the mixer at a temperature of around 165°C-185°C. The mix is now transferred to the preheated mould and compacted with 50 blows on each side of specimen at a temperature of around 130°C-150°C. Once the mix is compacted the specimen is allowed to cool down for 24hrs and de-mould the specimen. The de-moulded specimen is kept in water bath for 30 minutes maintained at a 60°C temperature. The specimen is placed in the Marshall Test setup, the load is applied at the constant deformation rate of 51mm per minute and load deformation readings are closely observed. The maximum load reading corresponding deformation of the specimen at failure load are noted. The maximum load value expressed in kg is recorded as the 'Marshall Stability' value of the specimen. The vertical deformation of the test specimen corresponding to the maximum load, expressed in mm units is recorded as the 'Flow Value'. The specimen is removed from the test head and test is repeated on other specimen. Three specimens were casted for each binder content and average value is considered.

6.2.2 SMA mixture (Conventional)

For SMA Conventional mixture to know the optimum binder content and stability by conducting the Marshall Stability test in the laboratory. Varying the percentage of binder content with increment of 0.2% i.e. 5.8%, 6%, 6.2%, 6.4%, 6.6% and addition of filler material 2% in to the mix. The test results are shown in Table 5 and Marshall Parameters are shown in Figure 2. The volumetric property with binder content (%) for conventional mix are within limits as per IRC: SP: 79: 2008 Specifications for Stone Matrix Asphalt.

6.2.3 SMA Mix with addition Fibers

The reason for adding fibers is to reduce the drain down of binder and making the mix homogeneous, which is very well confirmed by the stability results of SMA mixture before and after addition of fibers. Marshall Stability test on SMA with addition of fibers aims to found out the optimum binder content and optimum fiber content bearing the maximum stability. Here also varying the percentages of binder content 5.8%, 6%, 6.2%, 6.4%, and 6.4% with varying the percentages of fibers 0.3%, 0.35%, and 0.4% are added to the mix. The test results of addition fibers are shown in Table 6, 7, and 8 respectively. And Marshall Properties with addition of fibers are shown in Figure 3, 4 and 5 respectively. The OFC (optimum fiber content) and OBC (optimum binder content) are observed to further investigations on SMA mixture.

Table 5: Marshall Properties for Conventional SMA Mix

% of Bitumen	G_t	G_m	V_v %	VMA %	VFB %	V_b %	Flow Value (mm)	Stability Value (kg)
5.8	2.40	2.28	5.00	17.96	72.10	12.96	2.2	1489.52
6	2.40	2.29	4.58	18.05	74.60	13.47	2.8	1548.86
6.2	2.40	2.30	4.17	18.15	77.0	13.98	3.2	1764.87
6.4	2.38	2.29	3.78	18.15	79.16	14.37	3.6	1591.32
6.6	2.38	2.29	3.76	18.60	79.66	14.82	3.8	1443.08

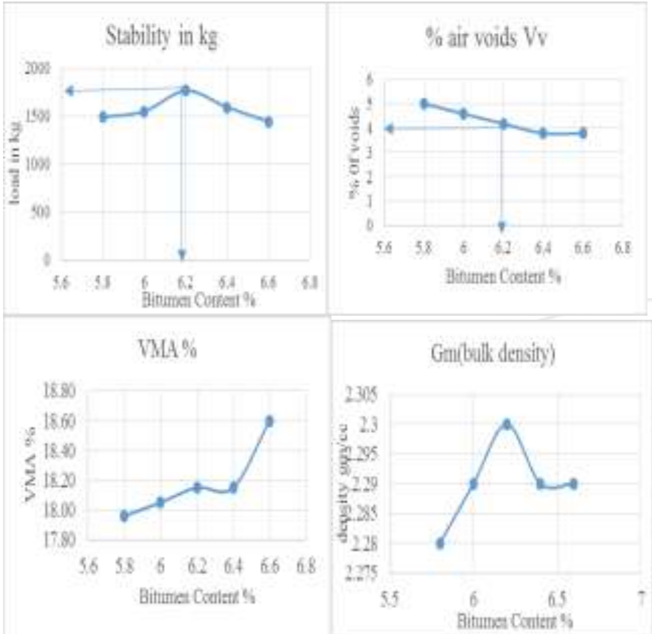

Figure 2: Graphical Representation of Bitumen Content v/s Marshall Parameters

Table 6: Marshall Properties for SMA Mix with 0.30% Fiber

% of Bitumen	G_t	G_m	V_v %	VMA %	VFB %	V_b %	Flow Value (mm)	Stability Value (mm)
5.8	2.41	2.29	4.79	17.72	72.95	12.93	4.2	1457
6	2.41	2.30	4.55	17.96	74.27	13.41	4.8	1526
6.2	2.41	2.32	4.12	18.11	77.25	13.99	5.2	1984
6.4	2.40	2.31	3.98	18.35	78.29	14.36	5.4	1753
6.6	2.38	2.29	3.95	18.63	78.67	14.67	5.6	1350

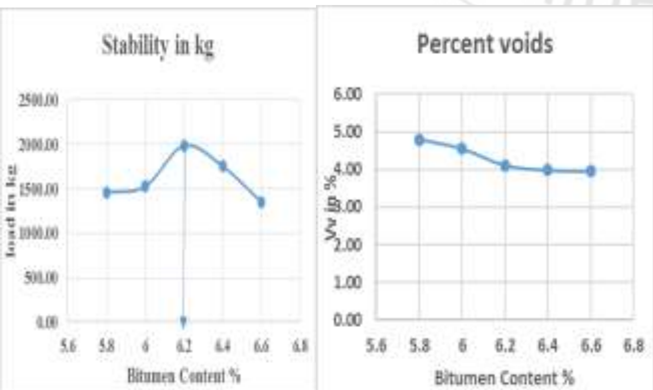

Figure 3: Graphical Representation of Bitumen Content v/s Marshall Parameters with 0.30% fiber

Table 7: Marshall Properties for SMA Mix with 0.35% fiber

% of Bitumen	G_t	G_m	V_v %	VMA %	VFB %	V_b %	Flow Value (mm)	Stability Value (mm)
5.8	2.41	2.29	4.72	17.66	73.27	12.94	4.2	1383
6	2.41	2.30	4.33	17.78	75.55	13.44	4.8	1427
6.2	2.41	2.32	4.05	18.06	77.56	14.00	5.2	1776
6.4	2.40	2.31	3.92	18.28	78.66	14.38	5.5	1630
6.6	2.38	2.29	3.62	18.35	80.26	14.75	5.6	1350

Table 8: Marshall Properties for SMA Mix with 0.40% fiber

% of Bitumen	G_t	G_m	V_v %	VMA %	VFB %	V_b %	Flow Value (mm)	Stability Value (mm)
5.8	2.41	2.29	4.79	17.72	72.97	12.93	4.2	1137
6	2.41	2.30	4.37	17.81	75.45	13.43	5	1255
6.2	2.42	2.32	4.05	18.09	77.39	13.99	5.2	1417
6.4	2.41	2.31	3.72	18.13	79.49	14.40	5.4	1290
6.6	2.38	2.30	3.44	18.20	81.08	14.75	5.6	1284

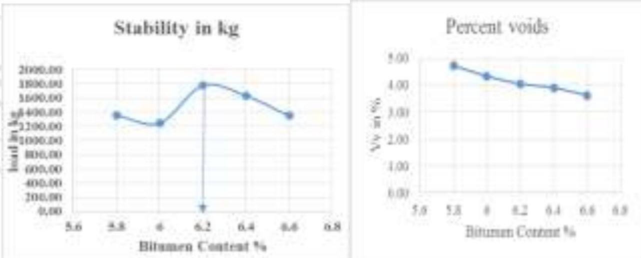

Figure 5: Graphical Representation of Bitumen Content v/s Marshall Parameters with 0.40% fiber

6.3 Binder Drain down Test

Drain-down of binder is one of the most common features observed in gap-graded bituminous mixes such as Stone Matrix Asphalt and hence the effect of binder content on drain down characteristics of un-compacted fresh mix is an important parameter to address. This test was done in order to assure that binder drain off does not exceed 0.3%. In this test two mix samples were prepared, one without fibre and another mix sample with 0.3% fibre for optimum binder content.

Table 9: Drain down Potential Test Results

Fibre (%)	Bitumen content (%)	Empty wire basket (A) gm	Wire basket + Sample (B) gm	Empty catch plate (C) gm	Catch plate + Drained Material (D) gm	Drain down potential (%) = $\frac{D-C}{B-A}*100$
0%	6.2	718.89	1780.36	105.22	107.80	0.24
0.3%	6.2	718.89	1780.56	105.22	105.61	0.03

6.4 Static Indirect Tensile Strength Test

One of the initial concerns regarding the durability of Stone Matrix Asphalt pavement is its resistance to freeze-thaw damage. So it is necessary to check the resistance of compacted Stone Matrix Asphalt mixtures to moisture-induced damage and to investigate the effects of saturation and accelerated water conditioning under freezing and thawing cycles. This test includes both indirect tensile strength and tensile strength ratio of SMA Mix. Here 6 samples were prepared for both conventional SMA Mix and with addition of 0.3% fibre. The number blows will be 34 for each side of the specimen. ITS of specimen is determined at 25°C using formula. The test results for both conventional SMA Mix and addition of fibre are shown in Table 4.10and 4.11 respectively.

Indirect Tensile Strength is calculated using following formula

$$ITS = \frac{2000P}{\Pi dt} \qquad \textit{Equation (2)}$$

P = load at which the specimen fails, N
d= diameter of specimen, mm
t= thickness of specimen, mm

$$TSR = \frac{T_{wet}}{T_{dry}} * 100 \qquad \textit{Equation (3)}$$

T_{wet} = average ITS of wet specimens
T_{dry} = average ITS of dry specimens
From Table 10 and 11, The Tensile Strength Ratio for Conventional SMA mixture is 87.14% and with addition of optimum binder content 0.30% is 92.85%.

Table 10: ITS Test Results for Conventional SMA Mix

S.no	Height of Specimen (cm)	Diameter of Specimen (cm)	Maximum Load (N)	Tensile Strength (kPa)	Avg Tensile Strength (kPa)
	Avg h, cm	Avg d, cm			
Unconditioned Specimens					
1	6.98	10.16	3418	30679.39	30628.68
2	6.97	10.16	3240	29123.42	
3	6.95	10.17	3562	32083.22	
Conditioned Specimens					
1	6.95	10.16	3087	27814.66	26688.89
2	6.98	10.15	2892	26254.00	
3	6.98	10.15	2850	25998.00	

Table 11: ITS Test Results for SMA Mix with OBC (0.30%)

S.no	Height of Specimen (cm)	Diameter of Specimen (cm)	Maximum Load (N)	Tensile Strength (kPa)	Avg Tensile Strength (kPa)
	Avg h, cm	Avg d, cm			
Unconditioned Specimens					
1	6.97	10.19	4080	36595.43	35658.10
2	6.93	10.16	3978	35968.43	
3	6.95	10.13	3876	34409.90	
Conditioned Specimens					
1	6.98	10.18	3876	34727.19	33109.87
2	6.95	10.19	3570	32097.79	
3	6.96	10.18	3621	32504.63	

6.5 Immersion Wheel Tracking Test

This test will be one of major surface distortion factor is rutting. It is characterized by the longitudinal depression along the wheel path, creating a channel. The rutting behavior of SMA Mixtures prepared in the study was passed by wheel tracking test. The dimension of the mould 6*100*10 cm. the thickness of specimen can be varied based on the specification of different courses. The total weight of the mix taken for the 40mm and 50mm thickness of rutting specimen is calculated as follows:-

1) For 40mm thickness specimen
   a) Mould dimension = 6*100*4 cm
   b) V= Volume = 2400 cm³
   c) ρ = Density of mix = 2.32 g/cc (refer
   d) M = $V \times \rho$ = 2400 × 2.32 = 5568 gms
2) For 50mm thickness specimen
   a) Mould dimension = 6*100*5 cm
   b) V= Volume = 3000 cm³
   c) ρ = Density of mix = 2.32 g/cc
   d) M = $V \times \rho$ = 3000 × 2.32 = 6960 gms
3) Optimum binder content = 6.2%
4) Optimum fiber content = 0.30%

The test results of rutting for 40mm thickness specimens for both conventional and with OFC are shown in Table 4.12. The graphical representation of Rut depth v/s Number of Passes for 40mm thickness specimen as shown in figure 6.
The test results of rutting for 50mm thickness specimens for both conventional and OFC are shown in Table 4.13. The graphical representation of Rut depth v/s Number of Passes for 50mm thickness specimen as shown in figure 7.

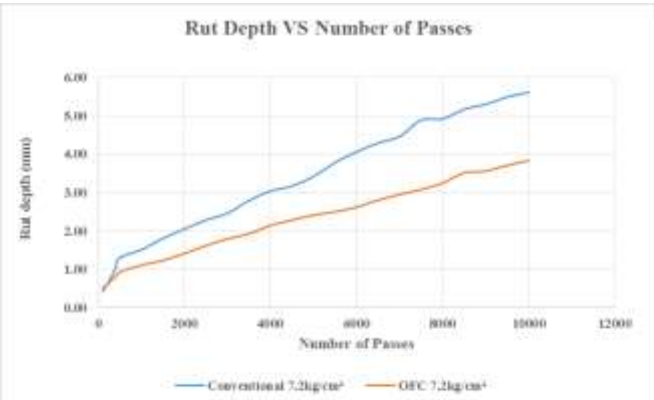

Figure 6: Rutting Characteristics for SMA Mix 40mm Thickness

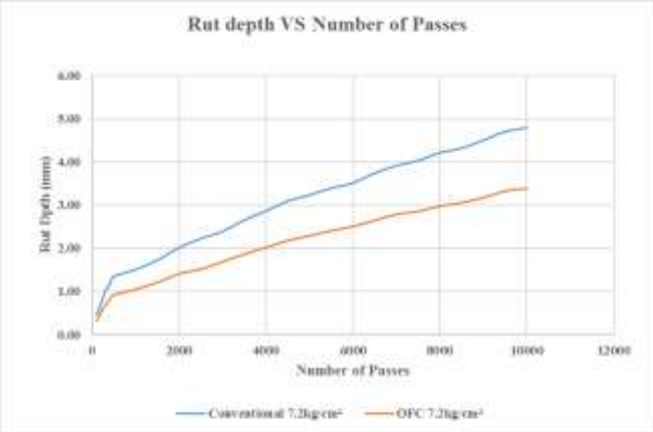

Figure 6: Rutting Characteristics for SMA Mix 50mm Thickness

Table 12: Rutting Characteristics for SMA Mix 40mm Thickness

Mix Type	Conventional	OFC
Tyre Pressure	7.2kg/cm²	7.2kg/cm²
Number of Passes	Rut depth 40mm thickness	
100	0.42	0.52
200	0.60	0.60
300	0.79	0.71
400	1.02	0.80
500	1.30	0.93
1000	1.51	1.11
1500	1.80	1.23
2000	2.05	1.41
2500	2.28	1.62
3000	2.46	1.79
3500	2.79	1.93
4000	3.04	2.14
4500	3.17	2.28
5000	3.42	2.41
5500	3.78	2.50
6000	4.06	2.62
6500	4.29	2.80
7000	4.46	2.95
7500	4.89	3.08
8000	4.92	3.25
8500	5.17	3.51
9000	5.30	3.56
9500	5.49	3.71
10000	5.61	3.83

Table 12: Rutting Characteristics for SMA Mix 40mm Thickness

Mix Type	Conventional	OFC
Tyre Pressure	7.2kg/cm²	7.2kg/cm²
Number of Passes	Rut depth 50mm thickness	
100	0.45	0.31
200	0.71	0.51
300	1.01	0.68
400	1.16	0.81
500	1.34	0.92
1000	1.50	1.05
1500	1.72	1.21
2000	2.01	1.41
2500	2.22	1.52
3000	2.39	1.69
3500	2.65	1.87

4000	2.86	2.02
4500	3.09	2.18
5000	3.23	2.29
5500	3.39	2.41
6000	3.51	2.51
6500	3.74	2.65
7000	3.91	2.79
7500	4.03	2.86
8000	4.21	2.98
8500	4.32	3.06
9000	4.50	3.18
9500	4.70	3.33
10000	4.79	3.39

7. Results and Discussion

7.1 Discussion on Conventional SMA Mixtures

For the Conventional SMA Mixtures Marshall stability test conducted for the obtained gradation as per MoRTH guidelines. The optimum binder content obtained for conventional SMA Mix is 6.2% bearing a maximum stability 1764 Kg and the maximum air void percentage will be 4.17%. The flow value in the range 2 to 4mm. these test results will be used for the further investigations of SMA fixtures.

7.2 Discussion on SMA Mixtures with Addition of Fibres

Here the Marshall Stability test conducted on SMA Mixture with addition of fibres varying from 0.30%, 0.35%, and 0.40%. The stability value obtained 1984kg for the 0.30% of fibre, 1776kg for 0.35% fibre, and 1417kg for 00%.The addition of 0.30% fibre will gives the maximum stability and increase in fibre content stability value will be decreases. The flow value increment with increment in the bitumen content and the optimum binder content observed as 6.2%. The air voids percentage will be decreases with increase in fibre content. As compared to conventional SMA Mix Stability value increases with addition of 0.30% of fibres.

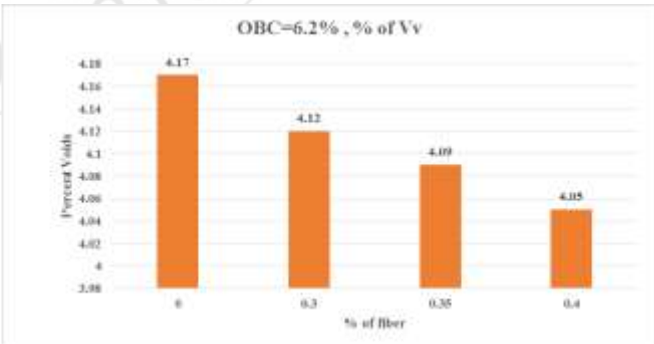

Figure 8: Graphical Representation for fiber content v/s Air Voids percentage for OBC

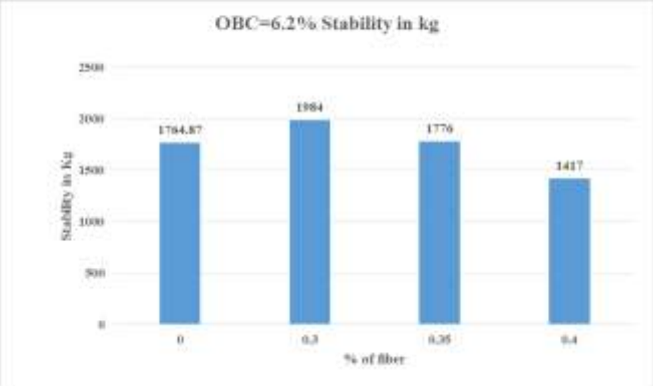

Figure 9: Graphical Representation for fiber content v/s Marshall Stability for OBC

The graphical representation of fiber content v/s percentage air-voids and Marshall Stability for optimum binder content is show in Figure 8 and Figure 9 respectively. From the graphs it is clear that increase in fiber content reduces the percentage air-voids of the compacted mix and with addition of 0.30% fiber increases the stability. Due to increase in the fiber content which pretty much confirmed that the mix is getting dry, hence an optimum dosage of 0.30% was considered after analyzing all the test results.

7.3 Drain down Potential

The drain down potential obtained 0.24% for conventional SMA Mixture and the 0.03% for addition of 0.3% fibres. The maximum permissible drain down for loose mix at 180°C should not exceed 0.30 percent of the total mixture mass. Hence the addition of fibre will be decrease the binder drain down. These test results are within the limits given as per MoRTH and IRC: SP: 79: 2008 Specifications for stone matrix asphalt.

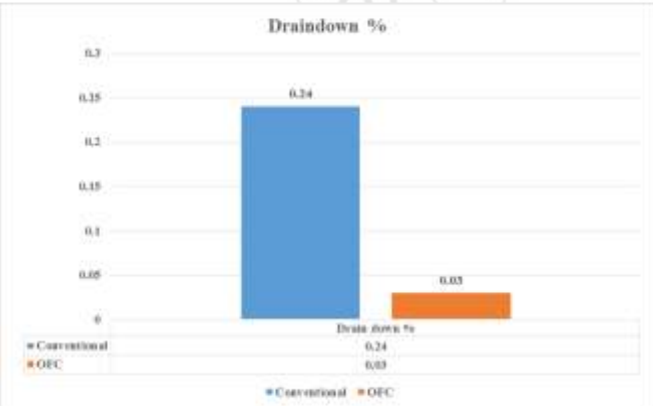

Figure 10: Graphical Representation for Drain down potential results

7.4 Static Indirect Tensile Strength Test

To determine the moisture susceptibility of SMA mixture the indirect tensile strength test and tensile strength ratio were calculated. For conventional SMA Mixture the TSR will be 87.14% and with addition of optimum fibre content 0.30% the TSR will be 92.85%. The TSR will be maximum as compare to the conventional SMA Mix. Also the test results are within the limits minimum 85% as specified in MoRTH table 500-37 and IRC: SP: 79: 2008.

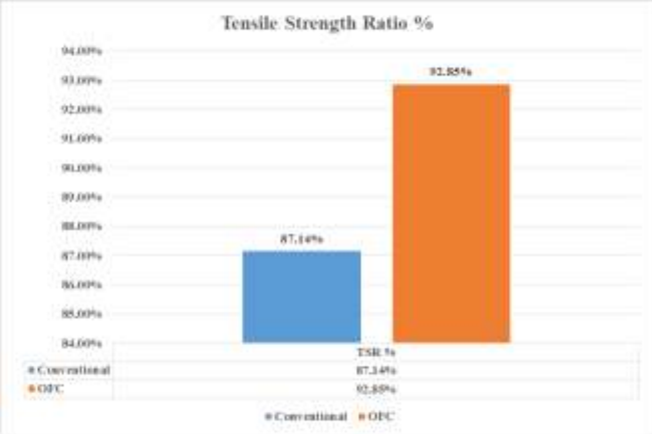

Figure 11: Graphical representation for TSR results

7.5 Rutting Characteristics

This test conducted on both conventional SMA Mix and SMA Mix with addition of optimum fibre content 0.30%. From the test results its shows conventional SMA mixture has more rut depth as compared to the SMA Mix with optimum fibre content in both 40mm and 50mm thickness. As load on the specimen increased there was observation that the specimens with lower weight has less rut depth as compared to the specimens with higher weights.

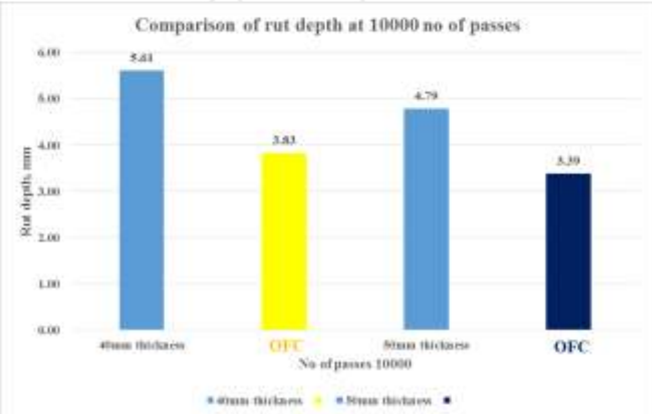

Figure 12: Comparison of rut depth at 10000 passes

8. Conclusions

The followings are the conclusions based on test results:

1) The aggregates and binder content test results are well in conference with specifications as per IRC: SP: 79: 2008.
2) It is observed that Marshall Stability value will be more with addition of 0.30% fibre to the mixture as compared to conventional SMA Mixtures. The stability value will be decreases when increase in fibre content so that the 0.30% of fibre was considered after analysing the test results. The flow value increases with increment in the bitumen substance as compared to conventional SMA Mix.
3) The voids in mineral aggregates (VMA) was found to be minimum 17% in case of SMA Mixtures. For both

conventional and with addition of fibres SMA Mix satisfy the requirement of VMA.

4) The air voids percentage was observed that 4.17% for Conventional SMA and with addition of fibre the air voids percentage will be reduced. The air void percentage will be 4.12% for optimum fibre content. Hence the mix has good amount of aggregate coated with binder.
5) The drain down potential of test specimens was observed 0.24% for conventional SMA Mix and 0.03% with addition fibre content 0.30%. These results are within the limit 0.30% as specified in IRC: SP; 79: 2008.
6) Moisture Susceptibility Test results shows that the SMA Mix with addition of optimum fibre content can withstand larger tensile stress prior to cracking. The tensile strength ratio was found to be greater than 85% as specified in IRC. The TSR value will be more for SMA Mix with addition fibre as compared to conventional SMA Mixtures.
7) Rutting test results observed that the Conventional SMA Mix shows more rut depth as compared to the SMA Mix with addition of 0.30% fibre in both cases of 40mm and 50mm thickness specimens. The rutting test was determined for 10000 number of passes and test results of 40mm thickness specimens for 7.2 Kg/cm² tire pressure shows rut depth 5.61mm and 3.83mm and the 50mm thickness specimens shows rut depth 4.79mm and 3.39mm. From above values it can be concluded that SMA Mix with addition of fibre were more rut resistance when compared to Conventional SMA Mix.
8) From above results it shows that SMA Mix with addition of fibre gives the better results as compared to the Conventional SMA mix.
9) Hence through the lab studies it was found that the SMA Mix performs well, so this could be adopted in field in a wide way in order to have better pavement with long serviceability.

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