ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

EXPERIMENTAL STUDY OF STONE MATRIX ASPHALT WITH COIR FIBER AND PINEAPPLE FIBER

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DOI: 10.5281/zenodo.167081

ABSTRACT
Stone Matrix Asphalt (SMA) is a gap graded mix which consists of 70−80% coarse aggregate, 8−12% filler, 6.0−7.0% binder, and 0.3 percent fiber. SMA was first used in Europe and later, other countries had adopted the use of SMA for pavements like Germany and US etc. The problem with SMA is drain down during transportation and laying. To reduce the draindown of SMA, stabilizing additives like chemical and natural additives are used. In this present study, the fibers used for Grade-I (MORTH) and Grade-II (IRC) mixes. This research is to check the feasibility of fibers as stabilizing additives in which the flow values and stability values were analyzed by performing Marshall Stability test. Various percentages such as 5.5%, 6%, 6.5% and 7% of bitumen are selected for this study. Draindown test is initially performed to find the optimum fibre content and finally to find the optimum bitumen content. The test results for both grade-1 and grade-2 mixes by the use of fibres reduced the drain down value and maximum stability value for both grade-1 and grade-2 mixes is obtained for coir fibre when compared with pineapple fibre.

KEYWORDS: Draindown, Marshall Stability, Pineapple fiber, Coir fiber, Stone Matrix Asphalt

INTRODUCTION
A highway project requires huge amount of investment. In current situation a Stone Matrix Asphalt (SMA) of strong, resistance to fatigue load, durable and economical is essentially required. SMA is mixture of different grades of aggregate, asphalt as binder and non-conventional fibers. The fibers improve the properties of the SMA mix by forming a type of closely packed structure in the asphalt mix to prevent the drain down of the asphalt so that it will increase the stability and durability of the mixture.

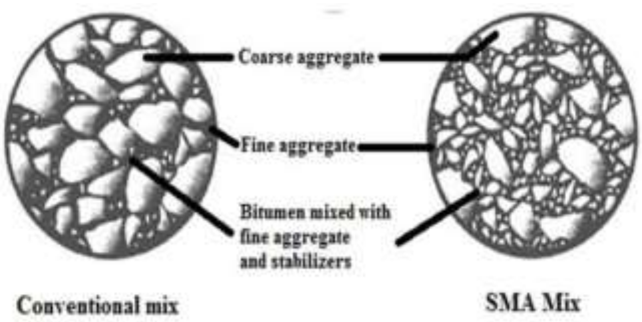

Fig.1 Stone Matrix Asphalt

Advantages of Stone Matrix Asphalt

The advantages of Stone Matrix Asphalt are
- High stability against permanent deformation
- High wear resistance
- Slow aging and durability to premature cracking of the asphalt

- Good low temperature performance
- Longer service-life
- Better long-life behaviour

Objectives and Scope

The main objectives of the present study are as follows:

- To find the suitability of fibers as a stabilizer for use in Stone Matrix Asphalt.
- To find the Optimum Fiber Content of SMA with the help of drain down test.
- To compare the Marshall properties of SMA samples with varying binder Concentrations and to obtain optimum binder content with the help of Marshall Test data.
- To study the Drain down characteristics of the SMA samples prepared at Optimum Bitumen Content with coir fiber and pineapple fiber.

LITERATURE REVIEW

Brown (1992) determined that a lot of range of things can influence the performance of SMA mixtures, as changes in binder supply and mix gradation. Good study of those factors would facilitate to see the future performance of SMA and provides info so changes will be created to suit completely different environmental conditions.

H.Behbahani et.al (2009) studied that Tests such as Marshall Stability, Flow parameters and Indirect Tensile Strength showed that variation of fiber type and content can lead to considerable changes in rutting performance of SMA. Samples with 3% cellulose have shown the highest value of indirect Tensile Strength and least permanent deformation [5].

Beena K.S and Bindu C.S (2010) studied that artificial fibre measures conventionally employed in the development of Stone Matrix Asphalt (SMA) in hydrocarbon pavements. Marshall Stability tests and tri-axial tests were conducted with variable proportion by weight of mineral combination (6% to 8%) and by variable proportion fibre by weight of combine (0% to0.4%). The ripping tensile take a look at shows that the sharp decrease in strength, within the soaked condition was found to be decreasing within the fibre stable SMA at completely different temperatures, therefore fibre is used as an efficient helpful additive in SMA [3].

K.B.Raghuram et.al (2013) studied that different fiber such as coir fibres, Jute Fibres and glass fibres. The length of fibers used in this study is of 10mm specifies the addition rate of cellulose fibres as minimum 0.3% The tests such as stability, flow value showed the increase in compressive strength and decrease in drain down characteristics [6].

Tay lay ling et.al (2015) studied that Asphalt content of 0%, 5%, 10 %, 15% and 20% used to increase the Resilient Modulus, VMA, VFB and increases the stability, skid resistance, improve the indirect tensile strength and static creep behaviour of the modified asphalt pavement [1].

B.Gopi Raju et.al (2015) studied that the percentage fibre content in SMA is varied from 0.2 to 0.4% with increments of 0.1 % for different series of tests. Analyzing the results are the addition of 0.3% fibre is found to be the optimum fibre content in SMA. The Marshall Stability value of SMA with optimum fibre content was found to be 16.237 KN, which is higher than the prescribed value of 6.20, the flow value of SMA with 0.3% fiber and 10mm length fibre was found to be 4.32 mm where as the flow value for conventional mix is 5 [8].

MATERIALS AND METHODOLOGY

1. **Aggregates**

The size of aggregates varying from 19mm to 75micron was used. Qualities of aggregates were check through various tests.

Table-1 Properties of aggregates

Property	Test	Test Methods	Results	Recommended values
Strength	Crushing Value	IS:2386 (IV)	25.3 %	30 % max
	Aggregate Impact Value	IS:2386 (IV)	17.7%	18 % max
Specific Gravity	Specific Gravity Test	IS:2386 (III)	2.65	2.6-2.8
Water Absorption	Water Absorption	IS:2386 (III)	0.5 %	2% max

2. Bitumen

Bitumen of VG-30 grade was acquired from HPCL; Visakhapatnam is used for preparation of specimens.

Table-2 Properties of Bitumen

Property	Test	Test Methods	Results	Recommended values
Hardness	Penetration Test	IS:1203-1978	63	50-70
Softening Point	Softening Point Test	IS:1205-1978	49	>47
Elongation/Deformation	Ductility test	IS:1208-1978	>100	>75

3. Additive:

3.1 **Coir Fibre**

Coir fibre is acquired from local market in Srikakulam.

Table-5 Physical properties of Coir fiber

Physical Properties	
Length (in)	6 to 8
Density (g/ cc)	1.40
Tenacity (g/tex)	10.0
Breaking elongation (%)	30
Diameter (mm)	0.1 to 1.5
Rigidity of modulus (dyne /cm^2)	1.8924
Swelling in water (diameter)	5 %
Moisture at 65 % RH (%)	0.50

Table-6 Chemical properties of Coir fiber

Chemical Composition	
Lignin (%)	45.84
Cellulose (%)	43.44
Hemi cellulose (%)	0.25
Pectin (%)	3.00
Water soluble (%)	5.25
Ash (%)	2.22

Fig.2 Coir fiber

3.2 **Pineapple Fibre**

Pineapple fibre was acquired from Lakshmi enterprises, Guntur.

Table-7 Physical properties of Pineapple fiber

Physical Properties	
Length (in)	3 to 9
Density (g/ cc)	4 to 8
Tenacity (g/tex)	50
Breaking elongation (%)	30
Diameter (mm)	20 to 80

Table-8 Chemical properties of Pineapple fiber

Chemical Composition	
Lignin (%)	4.6-12
Cellulose (%)	43.44
Hemi cellulose (%)	16-19
Pectin (%)	2-3

Fig.3 Pineapple fiber

4. Mineral filler:

Mineral fillers have a significant impact on the properties of SMA mixtures. The filler materials used are quarry dust and lime. Of the 10% (passing 0.075mm IS sieve) filler used, 8% is stone dust and 2% is lime.

Table-7 Gradation requirements for Mineral filler

IS Sieve (mm)	Cumulative % passing by weight of total aggregate
0.600	100
0.300	95-100
0.075	85-100

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CODEN: IJESS7

5. Aggregate Gradations

Designation	16mm SMA
Course where used	Wearing Course
Nominal Aggregate size	16 mm
IS Sieve(mm)	% passing
19	100
16	90-100
13.2	60-80
9.5	40-60
4.75	20-32
2.36	18-27
1.18	14-22
0.600	12-19
0.300	10-16
0.150	9-14
0.075	8-12

Table-8 Aggregate Composition of SMA (Chinese Specifications)

SMA Designation	19mm SMA
Course where used	Binder Course
Nominal Aggregate size	16 mm
IS Sieve(mm)	% passing
26.5	100
19	90-100
13.2	45-70
9.5	25-60
4.75	20-28
2.36	16-24
1.18	13-21
0.600	12-18
0.300	10-20
0.075	8-12

Table-9 Aggregate Composition of SMA (IRC: SP: 79-2008)

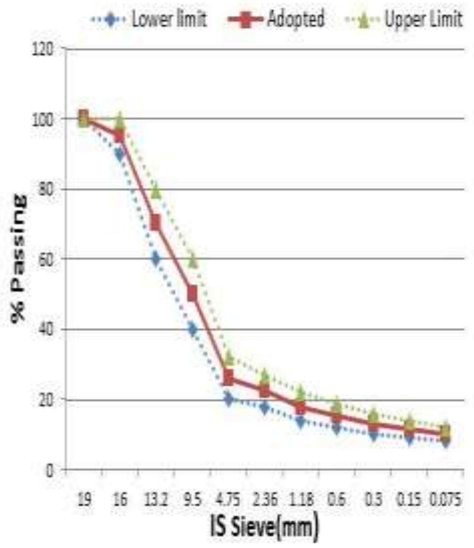

Fig.4 Gradation curve of SMA using CHINESE Specifications

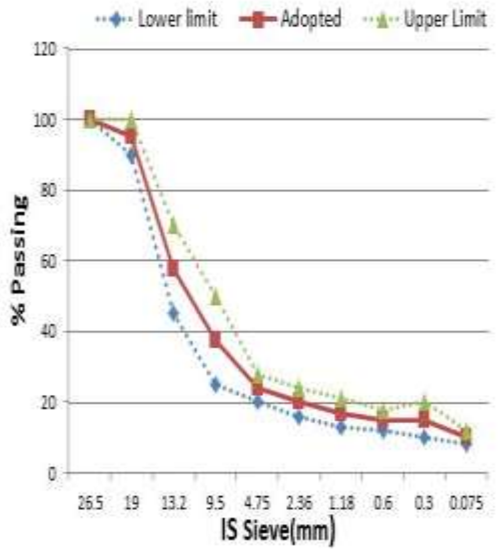

Fig.5 Gradation curve of SMA using IRC: SP: 79-2008 specifications

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6. **Methodology**

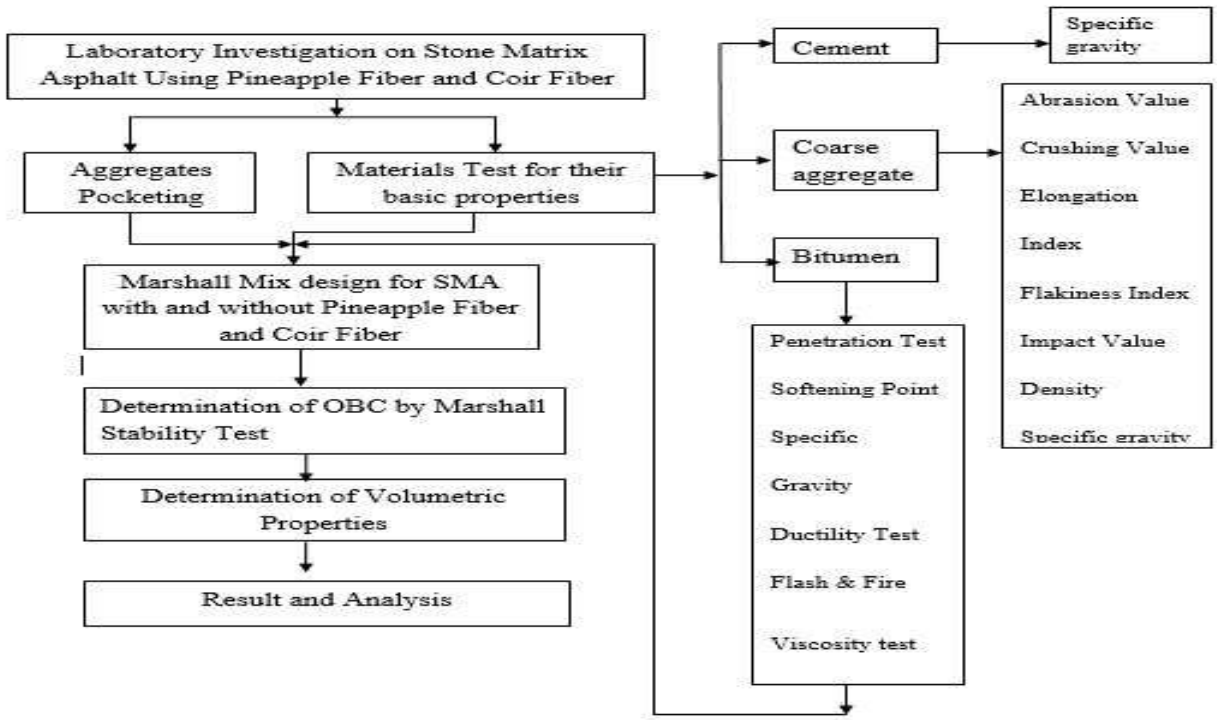

Fig. 6 Methodology

RESULTS AND DISCUSSIONS

Bitumen Drain down Test Results:

Table-10 Bitumen Drain Down test results for Grade-I mix

Type of fiber	0	0.1	0.2	0.3	0.4
COIR	1.55	0.28	0.16	0.11	0.09
PINEAPPLE	1.55	0.22	0.17	0.09	0.06

Table-11 Bitumen Drain Down test results for Grade-II mix

Type of fiber	0	0.1	0.2	0.3	0.4
COIR	0.93	0.24	0.17	0.06	0.04
PINEAPPLE	0.93	0.22	0.09	0.08	0.06

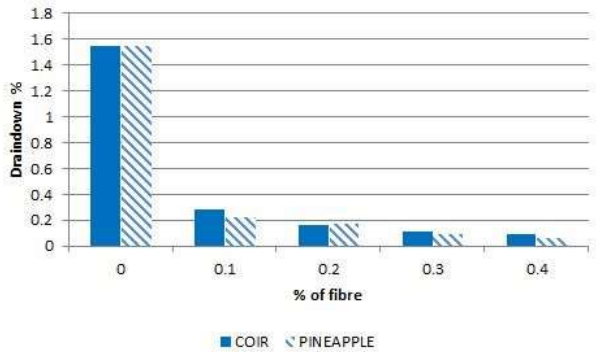

Fig. 7 Graph between Draindown % and % fibre for coir fibre and pineapple fibre for Grade-I mix

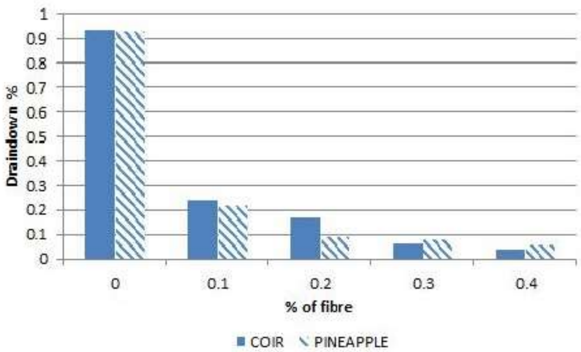

Fig. 8 Graph between Draindown % and % fibre for coir fibre and pineapple fibre for Grade-I I mix

From the above graphs, it was shown that drain down value decreases with increase in fiber content.

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Marshall Stability Test Results:

Results of coir fibre as an additive

Property	Bitumen content by weight of mix			
	5.5	6.0	6.5	7.0
Gradation I (16mm)				
Bulk density	2.311	2.315	2.318	2.316
Volume of voids, Vv (%)	5.47	4.85	4.10	3.58
Voids in Mineral Aggregate, VMA (%)	17.96	18.46	18.86	19.47
Voids filled with Bitumen, VFB (%)	69.54	73.76	78.29	81.63
Marshall stability (KN)	13.87	14.53	16.04	15.18
Flow (mm)	2.86	3.97	4.44	7.02
Optimum Bitumen content, OBC (%)	*6.60*			
Gradation II (19mm)				
Bulk density	2.308	2.328	2.336	2.324
Volume of voids, Vv (%)	5.76	4.31	3.39	3.25
Voids in Mineral Aggregate, VMA (%)	18.20	18.23	18.27	19.19
Voids filled with Bitumen, VFB (%)	68.38	76.04	81.44	83.09
Marshall stability (KN)	14.36	15.09	15.47	13.23
Flow (mm)	5.65	6.47	7.04	8.63
Optimum Bitumen content, OBC (%)	*6.25*			

Table-12 Marshall stability test Results of coir fibre as an additive for Grade-I and Grade-II mixes

Results of pineapple fibre as an additive

Property	Bitumen content by weight of mix			
	5.5	6.0	6.5	7.0
Gradation I (16mm)				
Bulk density	2.301	2.316	2.308	2.307
Volume of voids, Vv (%)	6.04	4.52	4.31	3.95
Voids in Mineral Aggregate, VMA (%)	18.44	18.53	19.21	19.78
Voids filled with Bitumen, VFB (%)	67.27	76.04	76.55	80.03
Marshall stability (KN)	12.32	15.34	14.86	14.12
Flow (mm)	4.71	5.82	6.04	9.01
Optimum Bitumen content, OBC (%)	*6.7*			
Gradation II (19mm)				
Bulk density	2.343	2.346	2.336	2.325
Volume of voids, Vv (%)	4.32	3.77	3.35	3.20
Voids in Mineral Aggregate, VMA (%)	17.06	17.56	18.23	19.16
Voids filled with Bitumen, VFB (%)	74.51	78.56	81.66	83.30
Marshall stability (KN)	15.39	14.03	13.65	12.77
Flow (mm)	5.3	8.8	9.35	11.42
Optimum Bitumen content, OBC (%)	*5.75*			

Table-13 Marshall stability test Results of pineapple fibre as an additive for Grade-I and Grade-II mixes

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Test Results Of Coir Fiber And Pineapple Fiber For Grade-I Mix

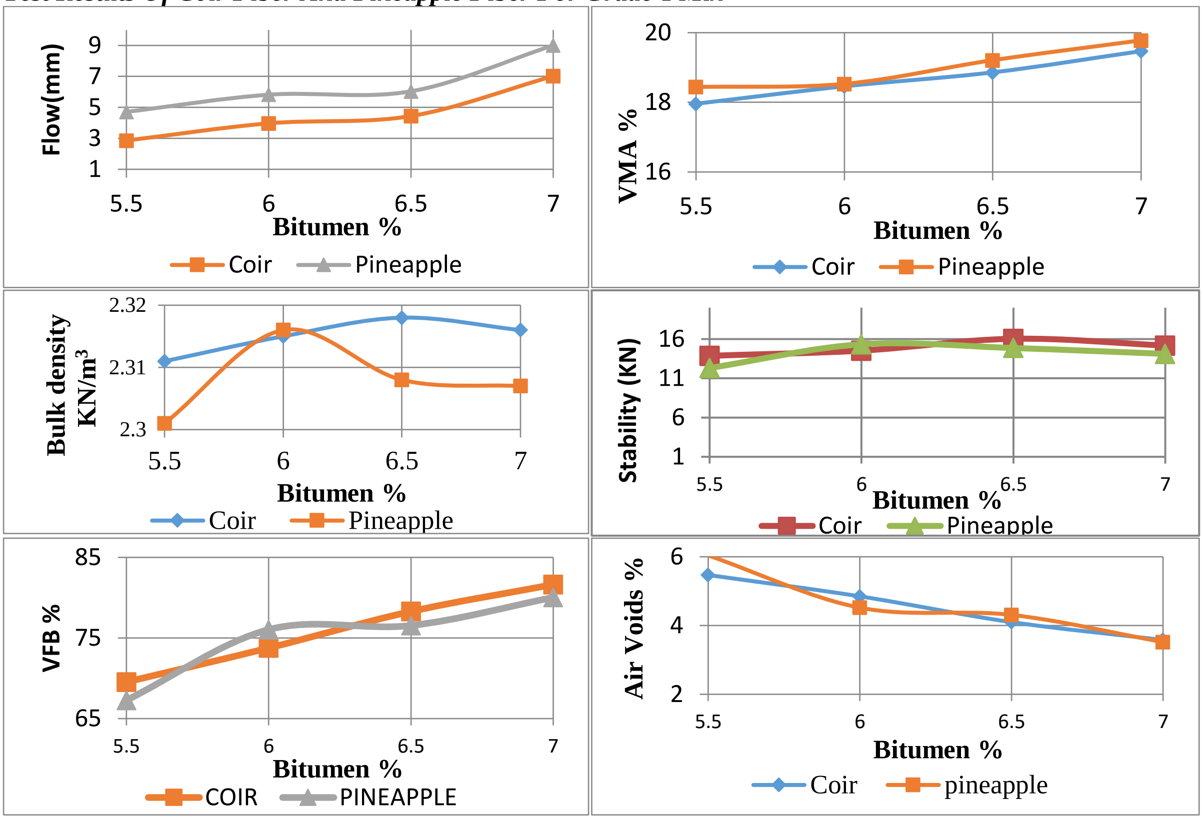

Fig.9 Graphical representation showing test results of coir fiber and pineapple fiber for Grade-I mix

The Stability and Bulk Density values gradually increase upto certain bitumen content and then gets decreased. VMA, VFB, Flow values increases with increase in Bitumen Content.

Test Results Of Coir Fiber And Pineapple Fiber For Grade-II Mix

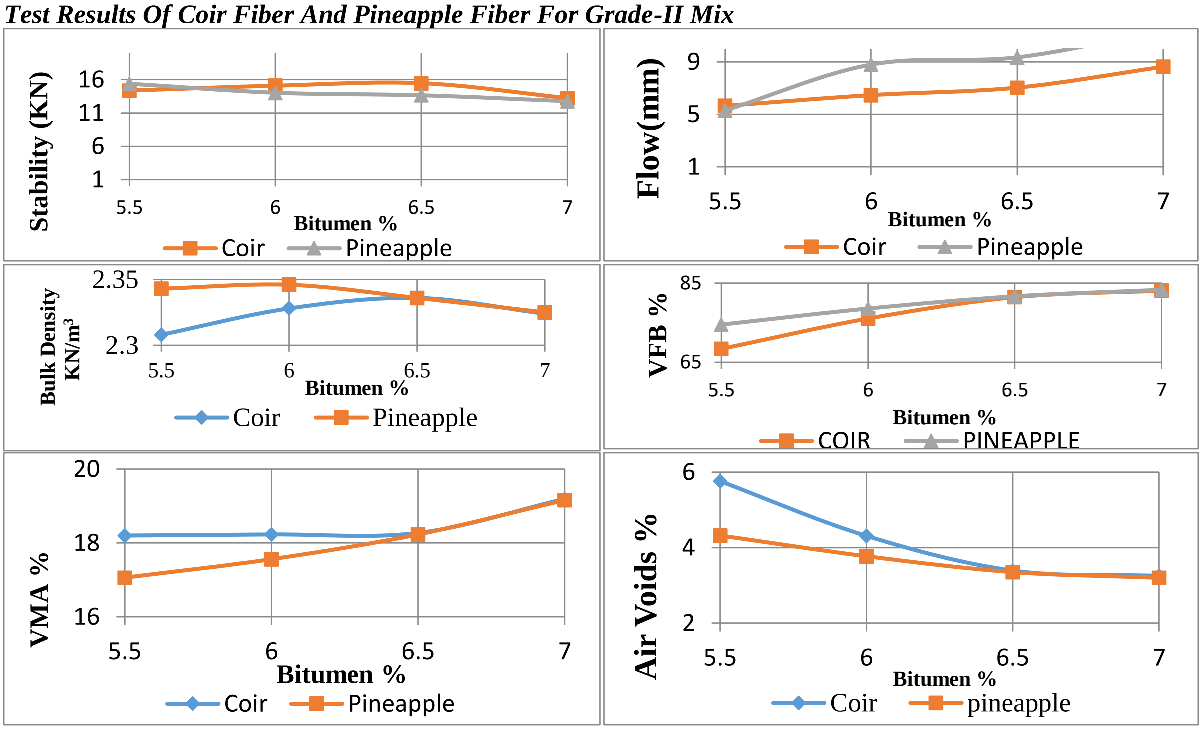

Fig.10 Graphical representation showing test results of coir fiber and pineapple fiber for Grade-II mix

The Stability and Bulk Density values gradually increase upto certain bitumen content and then gets decreased. VMA, VFB, Flow values increases with increase in Bitumen Content.

Drain Down Test Results for Optimum bituminous mixes

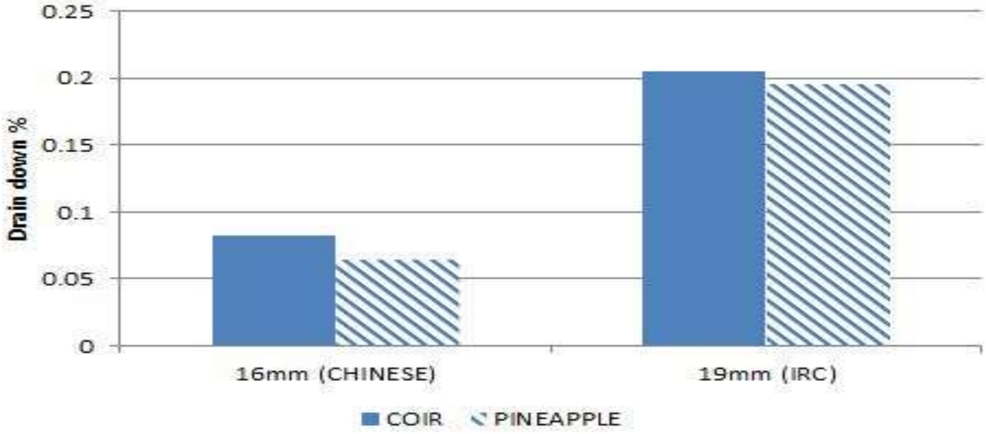

Fig.11 Comparison of drain down test values at OBC for both fibres at both gradations.

The draindown is reduced by increasing the fiber content in optimum bituminous mixes.

CONCLUSION

1. The Optimum coir Fiber and Optimum Pineapple fiber contents obtained from test results for both grade-I and grade-II mixes was 0.3% and 0.1% respectively.
2. The OBC value for coir fiber is found to be 6.6 % & 6.7% and for Pineapple fibre it is found to be 6.25 % & 5.75% for grade-I and grade-II mixes respectively.
3. Coir fiber showing better stability when compared to pineapple fiber in both mixes.
4. From the test results, it was concluded that coir fiber and pineapple fiber reduces the draindown and increases the stability of the sample for Grade-I and Grade-II SMA mixes.

REFERENCES

[1] Tay Lay Ling, Ramadhansyah Putra Jaya, Narhidayah Abdul Hassan, Haryati Yaacob, Devi Sri Jayanthi (2015), "A review of Coconut Shell and Coconut fiber in Road Construction ". Journal Teknologi, September, 2015.
[2] Vivek B.R., Dr.Sowmya N.J (2015), "Utilization of Fibre as a strength Modifier in Stone Matrix Asphalt ". IJRASET, Vol.3, June 2015.
[3] Bindu C.S and Dr. K.S.Beena (2010), "Waste plastic as stabilizing additive as Strength Modifier in Stone Matrix Asphalt ". IJET, Vol.2, pp.379-387
[4] Bindu C.S & Dr.K.S.Beena (2012), "Influence of additives on the drain down characteristics of Stone Matrix Asphalt mixtures ". IJRET, Vol.3
[5] H.Behbahani, S.Nowbakht, H.Fazaeli and J.Rahmani (2009), "Effects of fiber type and content on the Rutting Performance of Stone Matrix Asphalt ". Journal of Applied Sciences, Vol.9(10), pp.1980-1984
[6] K.B.Raghuram and Venkaiah Chowdary (2013), "Performance evaluation of Stone Matrix Asphalt (SMA) using Low Cost Fibres ". Journal of the Indian Roads Congress, Vol.74-2, Paper No.595
[7] P.A.Udaykumar, Rajanna, Ramalingaiah (2014), "Study on effects of short coir fiber reinforcement on flexural properties of polymer matrix ". IJRET , eISSN: 2319-1163
[8] B. Gopi Raju, K. Naga Sreenivasa Rao (2015), "Characterization of Fibre Reinforced Bituminous Mixes", IJSR, Vol. No. 4, Issue 12, September 2015.
[9] Supriya C B, B H Manjunath , S V Dinesh, "Influence of the fiber on improving mechanical Properties of bituminous mixes", IRJET, Vol.2, Issue 1, 2013.
[10] Bureau of Indian Standards (BIS) IRC:SP:79-2008, Tentative Specifications for Stone Matrix Asphalt, IRC(2008)
[11] Bureau of Indian Standards (BIS) IS: 1202-1978, "Methods for Testing Tar and Bituminous Materials; Determination of Specific Gravity." Bureau of Indian Standards, India