| ISSN: 2582-7219 | www.ijmrset.com |

| Volume 3, Issue 3, March 2020 |

Influence of Fibres on Strength of Bituminous Concrete Mix

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ABSTRACT - The conventional bituminous concrete pavement has less durability, limited rutting and fatigue resistance and it should be maintained frequently. In order to increase the durability, rutting and fatigue resistance and to avoid regular maintenance fiber has been used as a reinforcement in the bituminous concrete mix. The nature of the interface between fiber and the matrix influences the extent to which a force is transferred from the matrix to the fiber and cohesion at the interface may be achieved by mechanical, physical or chemical bonding. Even though there have been a number of fibers available in the market, we made an attempt with coir and polypropylene fiber. In this study, the bituminous concrete mix was performed on the fibre reinforced concrete mix with aggregates, M-sand, bitumen, coconut shell and polypropylene. Viscous grade 30 bitumen was used in this study. The aim of this experiment is to study about the performance of fibre in bituminous concrete. From the experimental investigation it was found that the fibre reinforced bituminous concrete mix improves the durability and reduces the routine maintenance compared to conventional concrete.

KEYWORDS: Bitumen, coir fibre, polypropylene fibre

I. INTRODUCTION

A good roadway infrastructure is an essential component of a strong and stable economy. Bituminous Concrete, a mixture of bitumen and aggregate is a widely employed material for pavement construction. As the modern highway transportation has high speed, High traffic density, heavy load and channelized traffic, bituminous concrete pavements are subjected to various types of distress such as fatigue cracking, rutting and raveling. Nowadays fibres are used in bituminous concrete mix to increase the stability and durability. Using fibres the Load bearing capacity of the bituminous concrete mix is increased further and the durability of the bituminous concrete is increased, so that frequent maintenance of the pavement should be reduced. In this project the stability and flow value is compared between the conventional bituminous concrete mix and Fibre reinforced bituminous concrete mix using Marshall Stability Test. The Optimum bitumen content and Optimum fibre content found out using Graphs.

II. MATERIALS

1.1 COIR FIBRE

Coir or Coconut fibre us a natural fibre extracted from the outer husk of coconut. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. It shows resistance to the damages caused by saltwater and it provides strength. The available length of the coir fibre is 10-30cm. Coir fibre varies in two different color white and in brown color. The coir fibre used in the project is of length 10cm and is of brown color.

1.2 POLYPROPYLENE FIBRE

It is the synthetic fibre formed from a polypropylene melt. Polypropylene fibre is generally superior to polyamide fibres in elastic and resiliency, but it has lower water resistance. It displays good heat-insulating properties and is highly resistant to acids, alkalis and organic solvents.

2. TEST ON MATERIALS

The test on the proposed bituminous mix as well as the materials used in the Bituminous mix were tested confirming to the standards mentioned in Table 1 and Table 2 and the results are tabulated as below.

Table 1- TEST ON BITUMEN

DESCRIPTION	TEST VALUES	STANDARD VALUES	IS CODE
Penetration value	70mm	60-70mm	IS 1203: 1978
Ductility Value	720mm	Min 400mm	IS 1208
Softening point	59^0C	Min 45^0C	IS 334: 1982

Table 2 TEST ON AGGREGATES

DESCRIPTION	TEST VALUES	STANDARD VALUES	IS CODE
Aggregate Crushing value	26.52%	Max 30%	IS 2386 (IV)
Aggregate Impact value	30%	Max 35%	IS 2386 (IV)
Los Angeles Abrasion value	22.4%	Max 40%	IS 2386 (IV)
Water Absorption value	2.83%	2.5-2.9	IS 2386 (IV)
Specific gravity value	2.7%	2.65-2.85	IS 2386 (III)
Combined Flakiness Index and Elongation index	24.2%	35%	IS 2386 (I)

Fig. 1 MARSHALL TEST SPECIMEN

Fig.2 MARSHALLTEST APPARATUS

2.1 MARSHAL STABILITY TEST

Bituminous concrete mix is commonly designed by Marshall Method. This test is extensively used in routine test programmes for the paving jobs. The stability of the mix is defined as a maximum load carried by a compacted specimen at a standard test temperature. The flow is measured as the deformation in units between no load and maximum load carried by the specimen during stability test (flow value may also be measured by deformation units of 0.1 mm). This test attempts to get the optimum binder content for the aggregates mix type and traffic intensity. 1200 grams of aggregates blended in the desired proportion is measured and heated in the oven to the mixing temperature. Bitumen is added at the mixing temperature to produce viscosity of 170 ± centi - stokes at various percentage. The materials are mixed in the heated pan with heated mixing tools.

The mixture is then placed in a heated Marshall mould with a collar and base and the mixture is spaded around the sides of the mould. A filter paper is placed under the sample and on top of the sample. The mould is placed in the Marshall Compaction pedestal. The material is compacted with 50 blows of the hammer (or as specified), and the sample is inverted and compacted in the other face with same number of blows. After compaction, the mould is inverted. With collar on the bottom, the base is removed and the sample is extracted by pushing it out of the extractor. The sample is allowed to stand for the few hours to cool. The mass of the sample in air and when submerged is used to measure the density of specimen, so as to allow, calculation of the void properties.Specimens are heated to 60 ± 1^{0}C either in a water bath for 30-10 minutes or in an oven for minimum of 2 hours. The specimens are removedfrom the water bath or oven and place in lower segment of the breaking head. Theupper segment of the breaking head of the specimen is placed in position and thecomplete assembly is placed in position on the testing machine. The flow meter isplaced over one of the post and is adjusted to read zero. Load is applied at a rate of 50mm per minute until the maximum load reading is obtained.

Table 3- MARSHALL TEST RESULT FOR ORDINARY MIX

Bitumen by weight of mix (in %)	Weight		Bulk volume	Specific gravity			Volume % total	Voids		
	In air	In Water		Bulk	Bulk Average	Theoritical Maximum	Bitumen	In aggregate (VMA)	Filled with bitumen (VFB)	Voids in mix (V_v)
4.5	1256	697	559	2.27	2.27	2.59	10.25	17.81	57.55	7.56
	1233	695	538							
5	1277	727	550	2.33	2.33	2.54	12.36	17.8	69.61	5.44
	1224	702	522							
5.5	1236	707	529	2.29	2.29	2.52	11.67	15.34	76.07	3.67
	1268	705	563							
6	1236	680	556	2.23	2.23	2.50	13.29	20.48	64.40	7.29
	1245	686	559							

Table 4- MARSHALL TEST RESULT FOR FRBC (PP FIBRE)

Bitumen by weight of mix (in %)	Bitumen by weight of aggregate	MARSHALL VALUE				Flow (mm)	
		Observed	Correction	Corrected	Average	Observed	Average
4	5.42	2820.78	0.86	2425.00	2749.33	4.7	4.72
		3574.02	0.86	3073.66		4.75	
6	5.42	3740.26	0.93	3478.44	3600.43	4.34	5.32
		4002.60	0.93	722.42		6.3	
8	5.42	3537.66	0.89	3147.93	3227.98	4.5	4.15
		3716.88	0.89	3308.02		3.8	

10	5.42	2850	0.93	2700.62	2675.56	5.36	5.48
		2903.89	0.93	2650.50		5.60	

Table 5- MARSHALL TEST RESULT FOR FRBC (COIR)

Bitumen by weight of mix (in %)	Bitumen by weight of aggregate	MARSHALL VALUE				Flow (mm)	
		Observed	Correction	Corrected	Average	Observed	Average
0.3	5.42	1893.95	0.86	1628.80	1614.68	7.30	7.10
		1861.12	0.86	1600.56		6.90	
0.5	5.42	1789.70	0.93	1664.42	1649.34	7.20	7.56
		1757.27	0.93	1634.62		7.90	
0.7	5.42	1667.01	0.89	1483.64	1453.62	7.80	7.98
		1599.55	0.89	1423.60		8.16	

2.2 TEST ON BITUMINOUS MIX

3.2.1GRAPHS FOR ORDINARY MIX

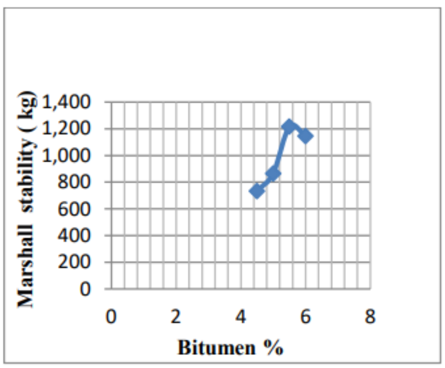


Fig.3Stability v/s Bitumen Content

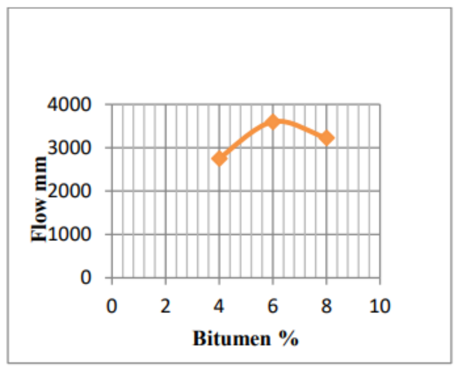


Fig. 4 Flow Value v/s Bitumen Content

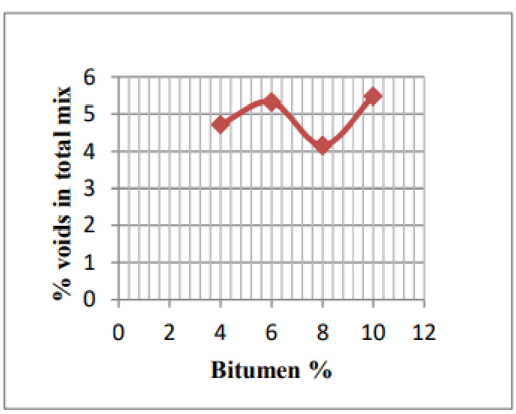


Fig. 5 %voids in mix v/s Bitumen content

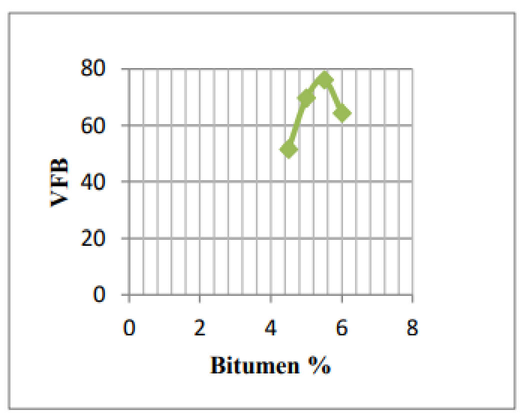


Fig.6 VFB v/s Bitumen content

International Journal Of Multidisciplinary Research In Science, Engineering and Technology (IJMRSET)

| ISSN: 2582-7219 | www.ijmrset.com |

| Volume 3, Issue 3, March 2020 |

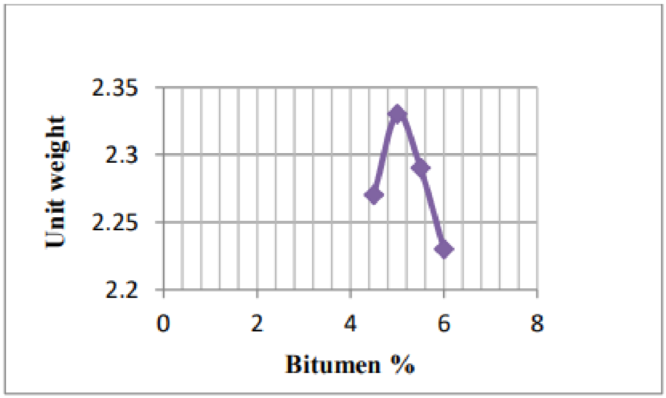


Fig.7 Unit weight v/s Bitumen content

The Optimum binder content of 5.27% by weight of mix gave best Marshal stability values at standard test temperature.

3.2.2 GRAPHS FOR FRBC (PP FIBRE)

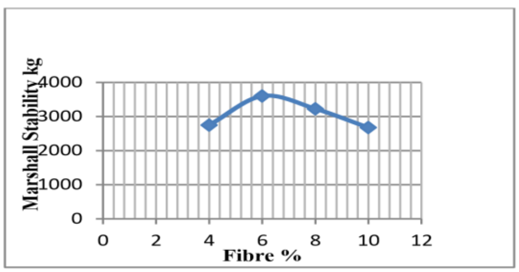


Fig. 8 Stability v/s Fibre Content

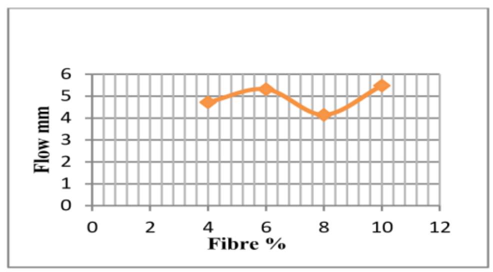


Fig. 9 Flow Value v/s Fibre Content

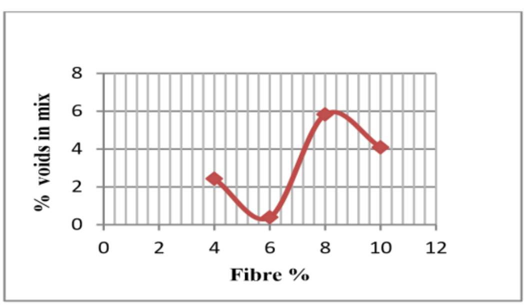


Fig.10 %voids in mix v/s Fibre Content

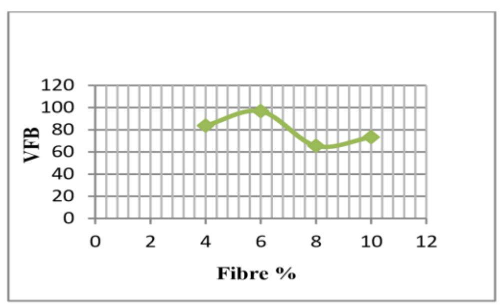


Fig. 11 VFB v/s Fibre Content

| ISSN: 2582-7219 | www.ijmrset.com |

| Volume 3, Issue 3, March 2020 |

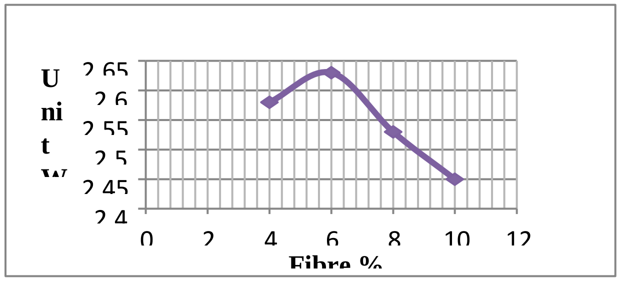
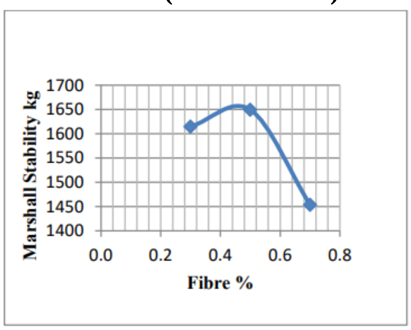


Fig. 12 Unit weight v/s Fibre content

From the Marshal stability test results it was found that Optimum fibre content of 0.43% by weight of mix gave best results.

3.2.3 GRAPHS FOR FRBC (COIR FIBRE)



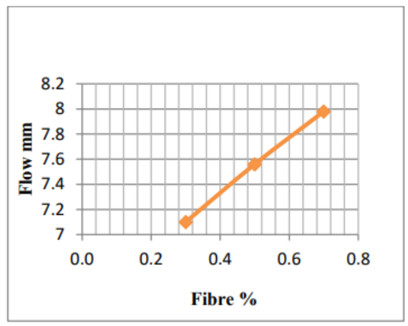
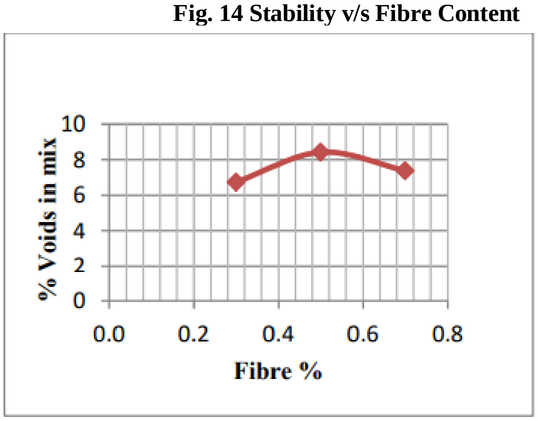


Fig. 14 Stability v/s Fibre Content

Fig. 15 Flow Value v/s Fibre Content



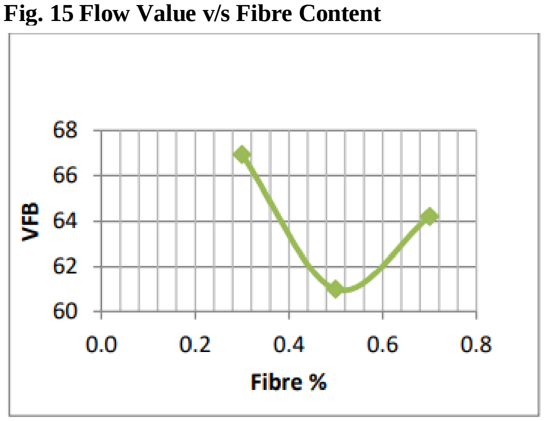


Fig. 16 %voids in mix v/s Fibre Content

Fig. 17 VFB v/s Fibre Content

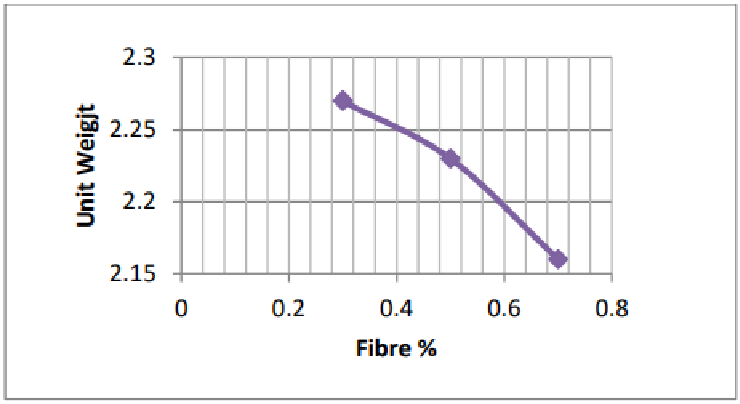


Fig. 18 Unit weight v/s Fibre content

The Optimum fibre content is 0.43% by weight of mix

IV. RESULT

The Graphs shown in the above figures were plotted using the results obtained from the Marshall Stability test.Fromthe graph the optimum bitumen and fibre content were calculated by taking the average value of the bitumen content found from the 1. Bitumen content corresponding to maximum stability. 2. Bitumen content corresponding to maximum unit weight. 3. Bitumen content corresponding to median of the percent of air voids in total mix. From the graph it is made clear that the stability value increases and flow value decreases in addition of fibre.

V. CONCLUSION

The basic test on Aggregates were carried out such that their characteristic properties lies within the standard limits mentioned in the Indian standards. A total of 22 specimens of these 8 of ordinary bituminous concrete mix, 8 of Polypropylene fibre bituminous concrete mix, 6 of coir fibre bituminous concrete mix are made and Marshall stability test were carried out in each of the specimen. The fibres used as a reinforcement are of fixed length 10mm. The Marshall stability value and flow value are obtained from the Marshall stability test and other Marshall properties of the specimen are calculated using formulas. The optimum binder and Fibre content were calculated from the graph plotted using obtained values from the Marshall stability test. Based on the results it is clear that the addition of polypropylene and coir fiber to bituminous mixture increased the Marshall Stability value and decreased the flow value. A polypropylene fibre content of 7.39% and coir fibre content 0.43% and binder content of 5.42% provide good stability and volumetric properties. The variation in stability and flow value improves the structural resistance of bituminous concrete to distress occurring in flexible pavement.

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