IFERP connecting engineers... developing research
ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 4, April 2017

Optimum Performance of Synthetic Fiber in Asphalt Concrete

[1]Burkhande Gaurav Rajeshwar, [2]Prof. Ashita J. Sheth
[1]PG student (M.Tech Construction Management), [2]Associate Professor
[1][2]Department of Civil and Environmental Engineering,
Veermata Jijabai Technological Institute,Mumbai,

***Abstract*— Generally a bituminous mixture is a mixture of coarse aggregate, fine aggregate, filler and Binder. Hot Mix Asphalt is a bituminous mixture where all constituents are mixed, placed and compacted at high temperature. HMA can be Dense Graded mixes (DGM) known as Bituminous Concrete (BC). In the present study, an attempt has been made to study the effects of use of Synthetic fiber called Polypropylene fiber as an additive in BC. For preparation of the mixes aggregate gradation has been taken as per MORTH specification, binder content has been varied regularly from 5% to 7% and fiber content Varied from 1% to maximum 9% of total mix. Using Marshall Procedure Optimum Fiber Content (OFC) and Optimum bitumen Content (OBC) are arrived at for BC mixes. The BC prepared at OBC and OFC are subjected to different performance tests like Marshall Stability, Marshall Flow, unit weight, Air Void, Void in Mineral Aggregate (VMA) and Void Filled with Bitumen (VFB). The results indicated that adding (5%) of the Synthetic fiber by the total weight of Bitumen with (12mm) length increases Marshall stability value as compared with the conventional mix.**

***Index Terms* — Hot Mix Asphalt (HMA), Optimum Bitumen Content, Optimum Fiber content (OFC) ,Voids in Mineral Aggregate(VMA),Voids Filled with Bitumen(VFB),Optimum Fiber Content (OFC),Polypropylene Fiber(PP), Bulk Specific Gravity or Unit Weight (Gmb), Theoretical Specific Gravity(Gt),Bulk Specific Gravity of Aggregates (Gsb)**

I. INTRODUCTION

Road network is vital to the economic development, trade and social integration of a country. It facilitates smooth conveyance of both people and goods. Global competition has made the existence of efficient road transport an absolute imperative. Transport demand in India has been growing rapidly since independence. Easiness in accessibility, flexibility of operations, door-to-door service and reliability has earned road transport an increasingly higher share of both passenger and freight trafficr transport modes. In recent years this demand has shifted mainly to the advantage of road transport, which carries about 87 percent and 61 per cent of passenger and freight transport respectively. Road transport has grown, despite significant barriers, to inter- state freight and passenger movement compared to inland waterways, railways and air which do not face rigorous enroute checks/barriers

Now a days, high quality and durability of the pavement are demanded. A number of studies have been employed to deal with the damage and prolong life of pavement. The use of fibre as an additive in asphalt mixtures is to improve road performance and many researchers have investigated advantages of such mixtures including convenience of construction.

Asphalt concrete (AC) is a composite material consisting of aggregate, asphalt binder (mastic), and air void. AC has been primarily used as a material in constructing road and airport pavements. However, under the effects of repeated vehicle loading at high temperature, moisture cycling, and low-temperature contraction, AC mixture is susceptible to distresses of rutting (permanent deformation), stripping (separation of asphalts from aggregates), and cracking, etc. use of fibers alters the visco-elasticity characteristics of the mixture enhances its dynamic modulus enhances sensibility against humidity, enhances flow coherence, and provides resistance against the rutting as well as decreases the amount of reflective cracks in asphalt mixtures and pavement. Various fibers like Cellulose, Asbestos, Lignin, Polyster, Polypropylene, Steel, Polyparaphenylene terephtalamide can be used in asphalt concrete.

This paper aims at studying the effect of polypropylene fibres as reinforcement in bituminous pavements. The optimum binder content are determined for the selected aggregate gradation and then PP fibers of graded length has added to the obtained optimum binder content. Different percentages of PP fibres (1%-9%) by weight of bituminous binder are added to different samples. Marshall's stability tests have conducted on these specimens and Marshall Stability value and flow value are

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 4, April 2017

found out. From the obtained data, optimum fibre content are determined.

II. LITERATURE REVIEW

Qunshan and Shaopeng added cellulosic fiber, polyester fiber and mineral fiber additives to the asphalt mixture as fiber-reinforced asphalt binder in 0–1.0% concentrations. Experimentally obtained results indicated that fiber-reinforcement increased the viscosity of asphalt binder until 0.5% by mass. Besides, in this study it is implied that the strengthening effects of these fibers are more important in low frequency ranges.

Chen and Lin investigated a bitumen mixture strengthened by fiber-reinforcement. As a result of this study, it was concluded that optimum fiber content depended on fiber type, length and diameter . In addition to these studies, a number of researchers carried out researches regarding fatigue, performance crack propagation, etc. in fiber-reinforced asphalt mixtures
Mustafa and Serdal (2007) used waste marble dust obtained from shaping process of marble blocks and lime stone as filler and optimum binder content was determined by Marshall test and showed good result.

Bordelon and Roesler investigated the applications of fibers on a thin concrete overlay bonded to asphalt pavement

III. METHODOLOGY

- To conduct Standard tests for the properties of Aggregates, Binder as per IS code and MORTH Specification.
- To study of Marshall Properties of BC with Fly Ash as a filler and without fibre.
- To study of BC mixes with fly ash as a filler and Polypropylene fibre as a stabilizer...
- 60/70 Penetration Grade Bitumen are used.
- Coarse and Fine Aggregates are used.

IV . MATERIAL PROPERTIES.

Table I .Physical Properties of Coarse Aggregates and their verification

Test	Test Method	Requirement	Test Results	
			M_{10mm}	M_{20mm}
1. Aggregate Impact Value %	IS:2386 (P.4)	24% maxi.	12.36	12.70
2.Aggregate L.A.Abrasion Value%	IS 2386 (P.4)	30%maxi.	17.80	17.89
3.Combined Flakiness and Elongation Index%	IS:2386 (P.1)	30%maxi.	26.21	27.28
4.Water Absorption %	IS:2386 (P.3)	2%maxi.	0.993	0.93

Table II Properties of Bitumen

Property	Test Method	Value
1.Penetration	IS : 1203-1978	67.5
2.Softening Point	IS : 1203-1978	47.4

Table III Specific Gravities of Material Used

M_{10mm}, M_{20mm}	2.81,2.72
Stone dust	2.47
Fly ash	2.2
Bitumen	1.01

Table IV Physical Properties of Polypropylene Fibre

Properties Type	Specification Data Polypropylene, 100%
Cross Section	Round
Specific Gravity	0.91gram/cm^3
Diameter	19 microns
Melting Point	160-165 °C
Softening Point	140-165 °C
Tensile Strength	400 MPa
Fiber Length	6 - 24 mm
Modulus of Elasticity Acid and Salt Resistance	4.1 GPa High
Acid and Salt Resistance	High

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 4, April 2017

V . MIX DESIGN

The Following Steps are adopted for design of Bituminous Concrete.

A) *Gradation of Aggregate*

Aggregates which possesses sufficient strength, hardness, toughness and durability are chosen,. Aggregates of size 20mm (A), 10mm (B), Stone Dust (C) and Fly ash (D) are selected and graded. The Following Proportions are Obtained :A: 24%, B: 31%, C :40%, D :5%

Table V Final Gradation of Aggregates

Sieve Size(mm)	% Finer	MORTH Specifications
26.5	100	100
19	94	90-100
13.2	76.35	59-79
9.5	71.97	52-72
4.75	46.55	35-55
2.36	33.2	28-44
1.18	25.22	20-34
0.6	21.2	15-27
0.3	17	10-20
0.15	11.616	5-13
0.075	7.35	2-8

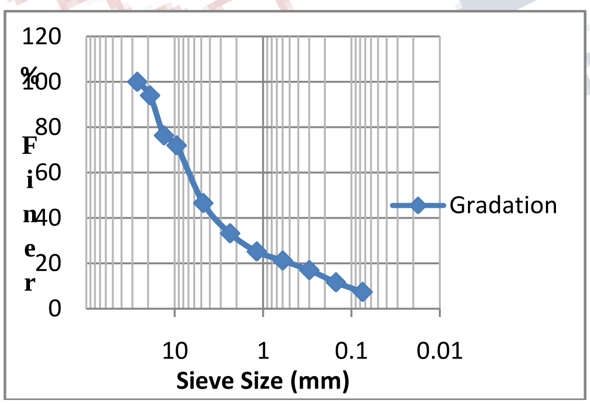

Fig 1. Final Gradation Curve

A) *Marshall Mix Design*

The mixes are prepared according to the Marshall procedure specified in ASTM D1559. For BC the coarse aggregates, fine aggregates and filler are mixed according to the adopted gradation as given in Table V. Here Optimum Binder Content (OBC) has found by Marshall Test where binder content are varied from 5% to 7%. Then Optimum Binder Content (OBC) and Optimum fiber Content (OFC) of BC has found by Marshall test. The Polypropylene fibers of 12mm are added by complex method to the aggregate and bitumen sample in different proportions. The mineral aggregates and binders are heated separately to the prescribed mixing temperature. To determine the optimum fiber content , three specimens each with optimum binder content but varying fibre content of 1%, 3%, 5%,,7% and 9% by weight of optimum binder content respectively are cast and the Marshall's test has conducted on them.

The 1200 gm mixture are then poured in to pre-heated Marshall Moulds and the samples are prepared using a compactive effort of 75 blows on each side. The specimens are kept over night for cooling to room temperature. Then the samples are extracted and tested at 60°C according to the standard testing procedure.

(c)

Fig 2 (a),(b),(c) Preparation of Sample

IFERP
connecting engineers... developing research
ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 4, April 2017

Fig 3 Marshall Sample

Fig 4. Marshall Stability Test in Progress

Table No VI Details of Experimental Results of Mix Design of BC without using Fiber

Sr No	Bitumen Content % by weight of Total Mix	Marshall Stability Kg	Flow mm	Gsb g/cm^3	Gmb g/cm^3
1	5	1017.43	3.1	2.508	2.42
2	5.5	1000.32	3.3	2.508	2.39
3	**6**	**1198.27**	**3.56**	**2.508**	**2.42**
4	6.5	1041.97	3.46	2.508	2.39
5	7	1031.91	3.43	2.508	2.40

Sr No	Gt g/cm^3	AV %	VMA%	VFB%
1	2.53	5.06	15.93	67.95
2	2.52	4.89	17.90	73.41
3	2.50	4.26	18.57	77.07
4	2.48	3.49	18.88	81.63
5	2.47	2.83	16.63	82.92

Table No VII Details of Experimental Results of Mix Design of BC using Polypropylene Fiber

Sr No	Bitumen Content % by weight of Total Mix	Marshall Stability Kg	Flow, mm	Gsb g/cm^3	Gmb g/cm^3
1	1	1231.4	4.41	2.48	2.37
2	3	1234.90	4.5	2.49	2.38
3	**5**	**1288.60**	**4.67**	**2.50**	**2.41**
4	7	1215.66	4.86	2.50	2.39
5	9	1153.14	4.1	2.48	2.39

Sr No	Gt g/cm^3	AV %	VMA%	VFB%
1	2.52	5.2	19.12	73.52
2	2.51	4.9	18.69	73.94
3	2.50	3.6	17.19	79.13
4	2.47	3.3	16.57	80.08
5	2.46	2.92	15.84	81.67

VI . RESULTS

1) The average value of the properties of the mix are determined for each mix with different bitumen content and the following graphical plots are prepared :
1. Binder content versus Marshall stability
2. Binder content versus Marshall flow
3. Binder content versus percentage of void (Vv) in the total mix
4. Binder content versus voids filled with bitumen (VFB)
5. Binder content versus unit weight or bulk specific gravity or mass density (Gmb)
6. Binder content versus voids filled with bitumen (VMA)

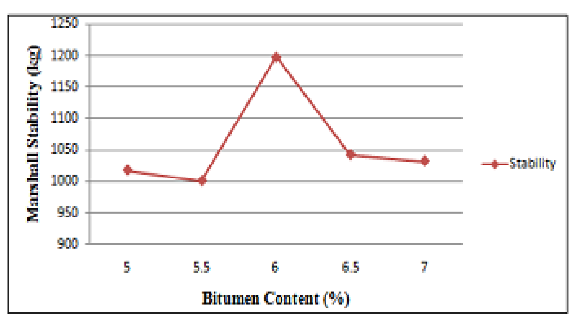

Fig 5 Variation of Marshall Stabilty with different

binder content

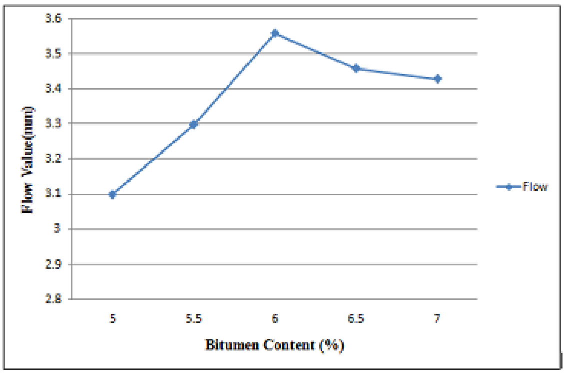

Fig 6 Variation of Flow value with different binder content

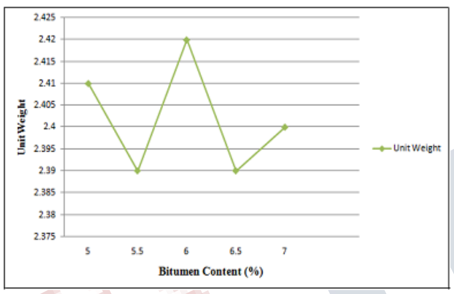

Fig 7 Variation of Unit Weight with different binder content

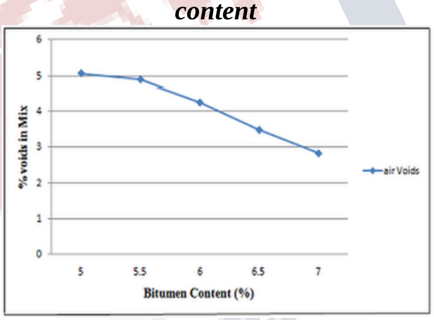

Fig 8 Variation of air Voids with different binder content

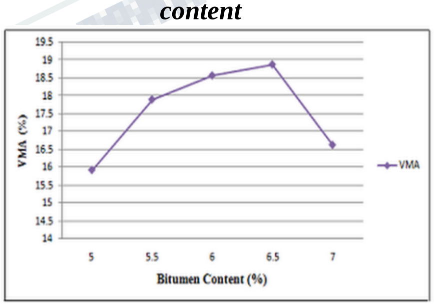

Fig 9 Variation of Voids in Mineral Aggregate with different binder content

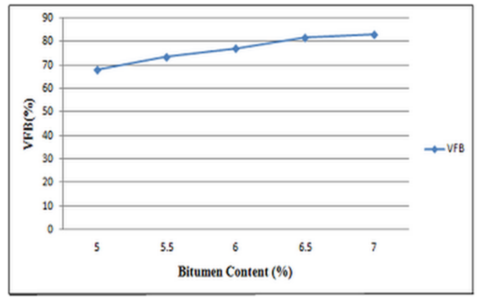

Fig 10 Variation of Voids Filled With Bitumen with different binder content

Optimum Bitumen Content is found out by taking average value of following three bitumen content found from above graph i.e.

I. Bitumen content correspond to maximum stability = 6

II. Bitumen content correspond to maximum unit weight = 6

III. Bitumen content corresponding to the median of designed limits of percentage air voids i.e 4 % of air voids in total mix =6

Optimum Binder Content is 6 % by Weight of Mix.

2) The average value of the properties of the mix are determined for each mix with different Fibre content and the following graphical plots are prepared :

1. Fibre content versus Marshall stability
2. Fibre content versus Marshall flow
3. Fibre content versus percentage of void (Vv) in the total mix
4. Fibre content versus voids filled with bitumen (VFB)
5. Fibre content versus unit weight or bulk specific gravity or mass density (Gmb)
6. Fibre content versus voids filled with bitumen (VMA)

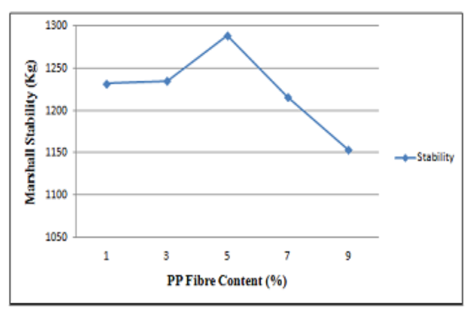

Fig 11 Variation of Marshall Stability with different Fiber content

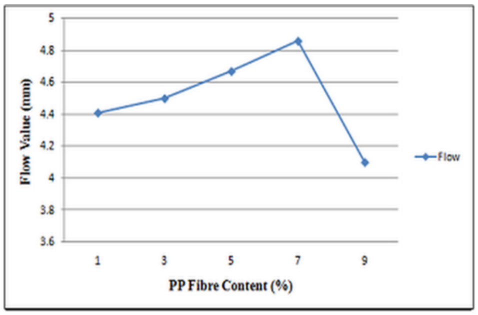

Fig 12 Variation of Flow value with different Fiber content

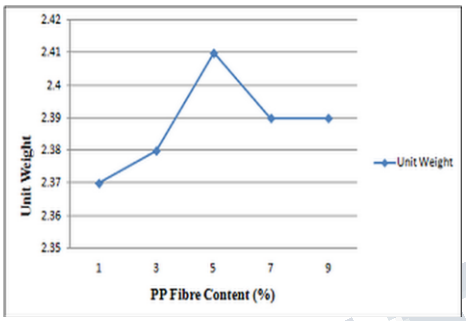

Fig 13 Variation of Unit Weight with different Fiber content

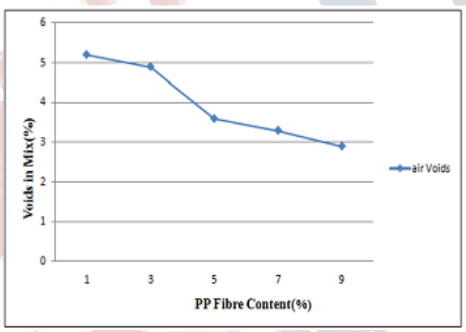

Fig 14 Variation of Air Voids with different Fiber content

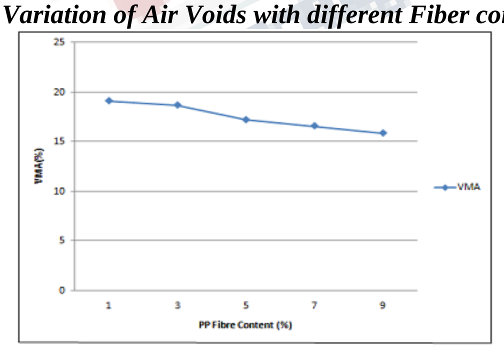

Fig 15 Variation of Voids in Mineral Aggregate with different Fiber content

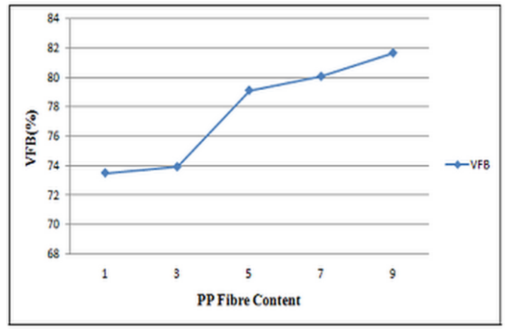

Fig 16 Variation of voids Filled with Bitumen with different Fiber content

Optimum Fiber Content is found out by taking average value of following three Fiber content found from above graph i.e.

1.Fibre Content Corresponding to Maximum Stability = 5

2.Fibre Content Corresponding to Maximum Unit Weight = 5

3.Fibre Content Corresponding to median of designed limits of percentage air voids i.e 4 % of air voids in total mix = 5

Optimum Fiber Content is 5% by Weight of Bitumen.

VII. CONCLUSION

The addition of PP fibers to bituminous mixtures increased the Marshall Stability value will help achieve stronger pavement sections. Such an increase may be attributed to the improved load transfer mechanism on addition of polypropylene fiber to the bituminous mix. and increased the flow value as depicted in Fig.11 and Fig.12. It can be inferred that the flow value decreases with increasing fiber length. A fiber content of 5% and a binder content of 6% provide good stability and volumetric properties. The variation in stability and flow values improves the structural resistance of bituminous concrete to distresses occurring in flexible pavements. This decrease in flow value due to increase in the length of the fiber reinforcement is due to the fact that increase in length of fiber provides improved interlock of fibers and hence minimizes the vertical deformation on application of compressive load. But practically, on increasing the fiber length, it becomes difficult to obtain a homogeneous bituminous mix since balling of fiber occurs.

REFERENCES

[1] V.S.Punith, R. Sridhar, Dr.AVeeraragavan, A (2007) "Behavior of asphalt concrete mixture with reclaimed polyethylene as additive" Journal of material in civil engineering ASCE/June 2007/501.

[2] ASTM D 1559 (1989), "Test Method for Resistance of Plastic Flow of Bituminous Mixtures Using Marshall Apparatus"

[3] IS: 2386 (1963), "Methods of Test for Aggregates for Concrete (P-IV): Mechanical Properties", Bureau of Indian Standards, New Delhi.

[4] IS SP 73 (2007)," Paving bitumen Specifications" , Indian Standards Institution, New Delhi,India

[5] IS: 2386 (1963), "Methods of Test for Aggregates for Concrete (P - I): Particle Size and Shape", Bureau of Indian Standards, New Delhi.

[6] IS: 2386 (1963),"Methods of Test for Aggregates for Concrete(P-III):SpecificGravity, Density, Voids, Absorption, Bulking", Bureau of Indian Standards, New Delhi

[7] IS: 1203 (1978) "Methods for Testing Tar and Bituminous Materials: Determination of Penetration", Bureau of Indian Standards, New Delhi.

[8] IS: 1205 (1978), "Methods for Testing Tar and Bituminous Materials: Determination of Softening Point", Bureau of Indian Standards, New Delhi.

[9] Kumar P Chandra, S and Bose S. (2006)"Strength Characteristics of polymer Modified Mixes". International Journal of pavement engineering (IJPE), Vol. 7, No. , pp. 63-71.

[10] Claudio Brovelli, Maurizio Crispino,Jorge C. Pais and Paulo A.A Pereira " Assesment of Fatigue Resistance of additivated asphalt concrete Incorporationg Fibers and Polymers", Journal of Material in civil Engineering ASCE/March2014/554-558

[11] QinwuXu, Huaxin Chen, Jorge A. Prozzi" Performance of fiber reinforced asphalt concrete under environmental temperature and water effects" Journal of construction and Building materials/2010/24