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COMPARATIVE STUDY ON BITUMEN MODIFICATION USING SYNTHETIC AND NATURAL FIBER

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Abstract - *Transportation sector is showing immense growth in the recent decades, modern vehicles introduced require a more stable platform to run better. In terms of road construction, we are not yet reaching the modernized standards adopted by other countries and usage of modern and innovative road construction materials are yet to be used in transportation infrastructure sector. The available roads are also getting damaged due to improper maintenance of top layer of the road and no bond strength between the bitumen and coarse aggregate. To avoid this kind of cracks and failure of surface bitumen, this is the main binder in the road construction need modification. In this study, there is a comparison between the bitumen modification using synthetic fiber and natural fiber. The bitumen used is the VG-30 which has a penetration value of 50-70 mm. The synthetic fiber used is polypropylene fiber and the natural fiber is the sisal fiber.*

Key Words: VG-30 Bitumen, Sisal fiber, PP fiber, marshall stability test

1. INTRODUCTION

A decent roadway framework is a fundamental segment of a strong and stable economy for a developing nation like India. Being the second largest growing economy in the world, road infrastructure in India is developing at a very fast rate. As the present day interstate transportation has fast, high traffic activity, substantial load and channelized traffic movement, bituminous asphalts roads are subjected to different sorts of distresses and the roads laid with conventional bituminous mixes decreases. Due to this riding quality also gets reduced, which results in exorbitant vehicle operating costs and frequent maintenance interventions due to early failure of pavements. Due to variation in climate, rainfall intensities terrain condition, and soil characteristics providing durable roads have always been a problem for a country like India. To solve the problems associated with pavements a good amount of research is throughout the country in this field.

The problems can be reduced by modifying conventional bituminous mix by adding various types of modifiers like polymers and fibers which will strengthen the bonding between the aggregates provided by the binder. This enhances the stone to stone contact resulting in an increasing resistance to crushing and resulted in a stiffer and tougher mix with considerable improvement in compressive strength. Utilization of changed bitumen with added substances like polypropylene (PP) fibers, sisal fibers etc. are picking up fame as method for controlling asphalt distresses. Improvement of polypropylene fibers as modifiers has prompted propelled characteristics known for its great procedure ability, low cost, vital binding property, low density and control of properties of materials at submicron level. By the use of natural fiber, it shows higher compressive strength than the conventional mix, increasing the resistance to crushing with superior water resistance property.

1.1 Literature Review

Ravi K Sharma found that polymer Modified Bitumen have a high elastic recovery (79%), higher rutting resistance and the Marshall stability increases by 27%.

Sumi S and N Unni krishnan found that interest in the natural fibers has resulted in the development of large number of modification techniques to bring them at par and even superior to synthetic fibers and also the applications of natural fibers in engineering projects extend from light weight composites to ground engineering applications.

Mahesh M Barad found that thermal behavior of the polypropylene shows that it softened easily without any evolution of gas around 130-140^{0}C, this has been scientifically verified.

Anzar Hamid Mir found that plastic will increase the melting point of bitumen. It strengthened the road construction, increased the road life and road quality.

Disha Rajyaguru, Rohit Kumar, Prof. C. B. Mishra found that 5% of PP of 12mm length is better than other percentages because the air void increased to 17.45%.

P Teja Abhilash and K Tharani found that By adding 5% of bitumen content and 0.2% of fiber, properties of mix is improved by using sisal fiber with BC

2. EXPERIMENTAL PROGRAM

The experimental study was carried out with the objective to find out the good modifier for bitumen.

2.1 Methodology

Material collection

⇩

Testing of bitumen for the properties

⇩

Preparing modified bituminous concrete mix using synthetic and polypropylene fiber

⇩

Marshall stability test for normal and modified bitumen

⇩

Comparative review of modified bitumen

Material properties

The tests were conducted to ascertain various properties of selected aggregates and VG-30 bitumen and modified bitumen using sisal fiber and PP fiber.

TABLE 1

PROPERTIES OF NORMAL BITUMEN (VG – 30)

Property	Obtained Value	Specified Value (IS 73:2006)
Penetration	68.67 mm	50-70 mm
Softening Point	51.5°C	47°C (min)
Viscosity	129 sec	70 sec (min)
Ductility	88cm	40 cm (min)
Specific Gravity	1.04	0.97-1.20

TABLE 2

PROPERTIES OF AGGREGATES

Property	Obtained Value	Specified Value (MORTH Specification)
Impact value of aggregate	19.76%	Max. 30%
Combined elongation and flakiness index	43.56%	-
Specific gravity of 12 mm aggregate	2.69	2.5-3.0
Specific Gravity of 6 mm aggregate	2.696	2.5-3.0
Specific gravity of M-sand	2.74	2.5-3.0
Specific gravity of dust	2.691	2.5-3.0
Water absorption of 12mm aggregate	0.2%	Max 2%

Polypropylene fibers were selected as synthetic fiber for obtaining FRBC. The fibers were 100% virgin homo-polymer containing no reprocessed olefin material and were specifically engineered and manufactured in an ISO 9002 facility.

TABLE 3

PHYSICAL AND CHEMICAL PROPERTIES OF POLYPROPYLENE FIBERS

Properties	Results
Absorption	Nil
Fiber Length	10mm
Melt Point	324°F
Thermal Conductivity	Low
Acid and Salt Resistance	High
Specific Gravity	0.91
Modulus (Young's)	0.5 (3.5 kN/mm)
Ignition Point	1,100°F
Electrical Conductivity	Low
Alkali Resistance	Alkali Proof

Sisal fiber is selected as natural fiber for obtaining FRBC

TABLE 4

PHYSICAL AND CHEMICAL PROPERTITES OF SISAL FIBERS

PROPERTY	VALUE
Density (gm/cm3)	1.5
Elongation (%)	2.0-2.5
Tensile Strength (MPa)	511-635
Young Modulus (MPa)	9.4-2.0
Cellulose (%)	66-78
Hemi-cellulose (%)	10-14
Lignin (%)	10-14
Pectin (%)	10
Moisture content (%)	10-22
PH	5.7-6.2

TABLE 5

PROPERTIES OF BITUMEN MIXED WITH SISAL FIBER

Property	0.1% of sisal fiber	0.2% of sisal fiber	0.3% of sisal fiber	0.4% of sisal fiber
Penetration	41.33 mm	75.67 mm	40 mm	37mm
Softening point	63^{0}C	73^{0}C	84^{0}C	89^{0}C
Viscosity	180 sec	290.3 sec	488 sec	590 sec
Ductility	64 cm	53 cm	46 cm	36 cm

TABLE 6

PROPERTIES OF BITUMEN MIXED WITH POLYPROPYLENE FIBER

Property	0.1 % of PP fiber	0.2 % of PP fiber	0.3 % of PP fiber	0.4 % of PP fiber	0.5 % of PP fiber	0.6 % of PP fiber
Penetration (mm)	61	60	58	54.5	53	49
Softening point (^{0}C)	48	50	50.5	51	52	55.5
Viscosity (sec)	77	85	90	98	110	150
Ductility (cm)	86	71	55	50	44	37

Aggregates which possess sufficient strength, hardness, toughness were chosen, keeping in view the availability and economic consideration. Aggregates of size 12mm (A), 6mm (B), M-sand (C) and quarry dust (D) were selected and graded. Based on the individual grading of aggregates, a suitable gradation for the mix was arrived upon as shown in Table 7 shows the gradation curve of the selected proportion of aggregates.

TABLE 7

FINAL GRADATION OF AGGREGATES

Sieve size (mm)	%finer	MORTH specifications
19	100	100
13.2	93.43	90-100
9.5	80.10	70-88
4.75	70.35	53-71
2.36	57.98	42-58
1.18	39.67	34-48
0.6	30.11	26-38
0.3	20.56	18-28
0.15	11.99	12-20
0.075	5.57	4-10
Pan	0	0

The following proportions were obtained:

Aggregate A- 25%

Aggregate B- 15%

Aggregate C- 22%

Aggregate D- 38%

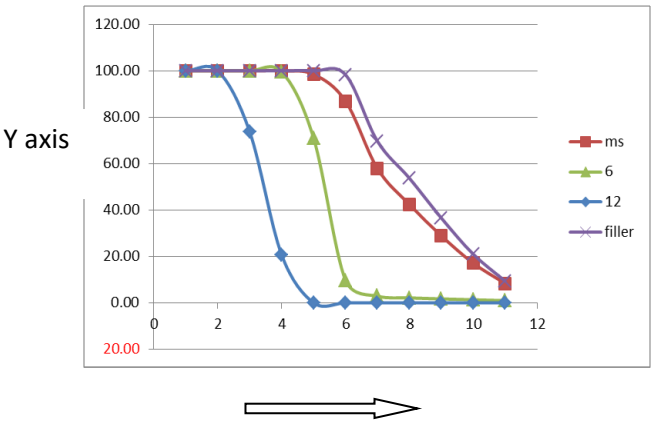

Fig: Gradation Curve

TABLE 8

MARSHALL STABILITY TEST RESULTS OF BITUMEN

Binder Content (%)	Flow value (mm)	Stability Value (kN)
5	2.45	18.01
5.5	2.33	19.92
6	2.36	17.25
6.5	2.91	15.73

TABLE 9

MARSHALL STABILITY TEST RESULTS OF BITUMEN MIXED WITH SISAL FIBER

Binder Content (%)	Flow value (mm)	Stability Value (kN)
5	1.74	17.59
5.5	2.40	19.92
6	2.77	17.24
6.5	3.25	14.76

TABLE 10

MARSHALL STABILITY TEST RESULTS OF BITUMEN MIXED WITH POLYPROPYLENE FIBER

Binder Content (%)	Flow value (mm)	Stability Value (kN)
5	1.86	18.38
5.5	3.01	20.46
6	4.52	18.67
6.5	3.31	17.75

3. RESULTS AND DISCUSSIONS

The curves obtained from the tests on bitumen without and with sisal fiber and PP fiber are shown in Figures below. It may be noted from these figures that modification of bitumen with fiber increases the stability and decreases the binder content.

Test Results for Normal Bitumen

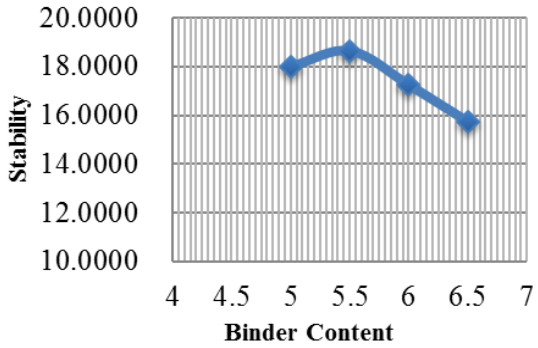

Fig.1: Stability Value vs Binder Content

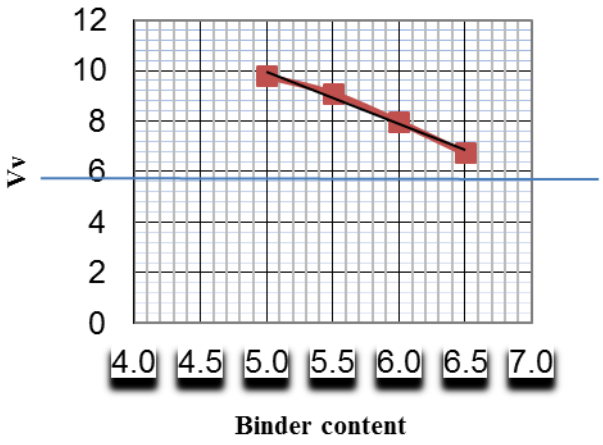

Fig.2: Binder Content vs Vv

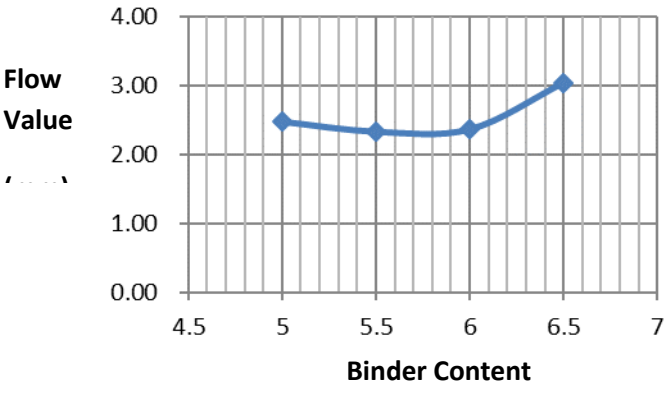

Fig.3: Binder Content vs Flow Value

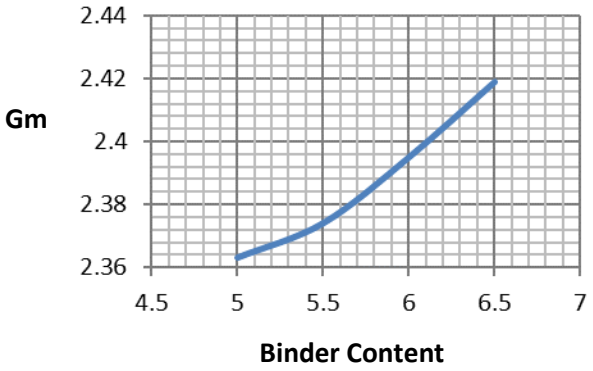

Fig.4: Binder Content vs Bulk Specific Gravity

From these graphs by taking the maximum stability, mid-range of flow value, mid-range of void content and mid-range of bulk specific gravity, the optimum binder content for normal bitumen is taken as 5.9%.

Test Results for Modified Bitumen with Sisal Fiber

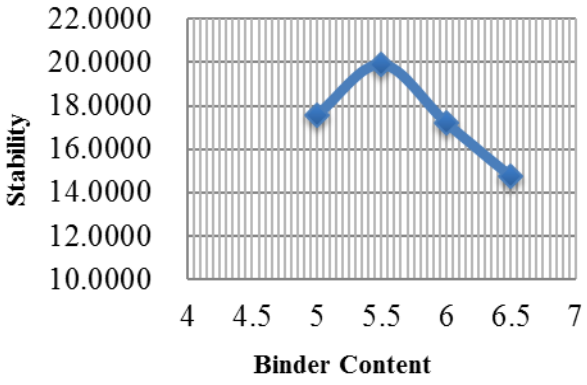

Fig.5: Stability value vs Binder Content

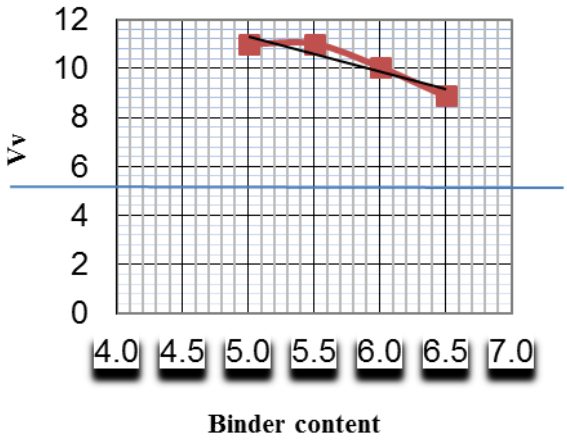

Fig.4.6: Binder Content vs Vv

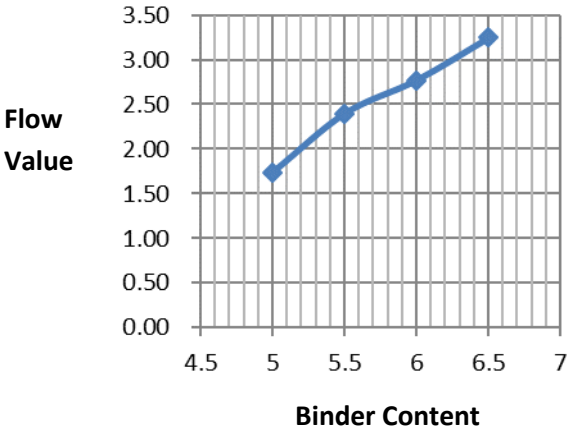

Fig.7: flow value vs binder content

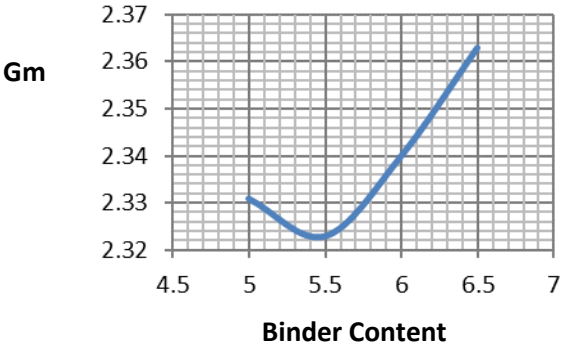

Fig.8: Binder Content vs Bulk Specific Gravity

From these graphs, the optimum binder content of modified bitumen with sisal fiber is obtained as the 5.8%.

Test Results for Modified Bitumen with Polypropylene Fiber

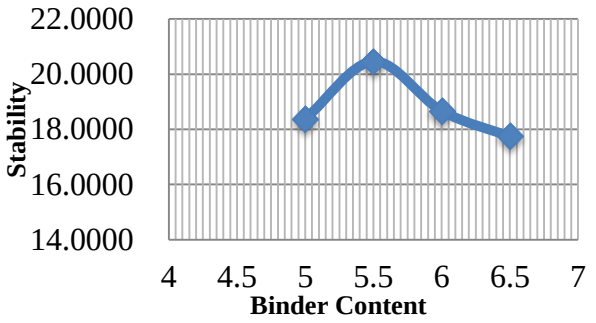

Fig.9: Stability value vs Binder Content

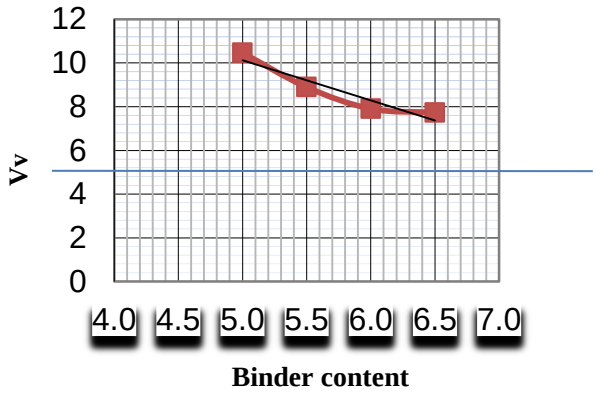

Fig.10: Binder Content vs Vv

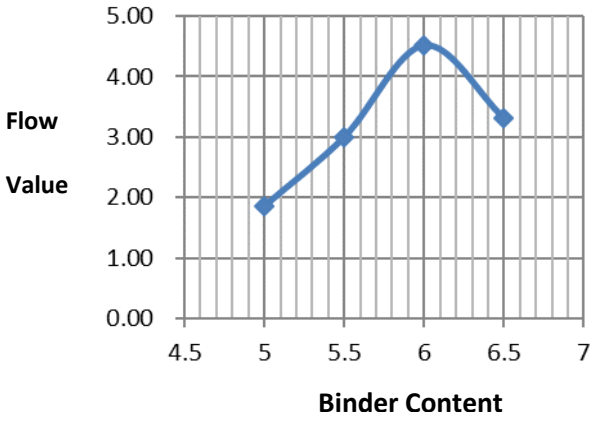

Fig.11: Binder Content vs Flow Value

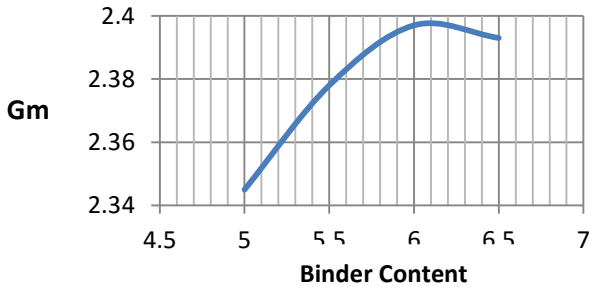

Fig.12: Binder Content vs Bulk Specific Gravity

From these graphs, the optimum binder content of modified bitumen with PP fiber is obtained as 5.3%.

3. CONCLUSIONS

The trends obtained in these laboratory tests are in good agreement with the results reported in the literature. The result shows that fiber improves the fatigue life by increasing the resistance to cracking and permanent deformation. The fiber reinforcement thus provided additional tensile integrity in the mixes and hence increasing the strain energy absorption thereby inhibiting the formation and propagation of cracks.The major conclusions that can be drawn from the present study are as follows:

- The tests on normal bitumen were conducted and the properties were obtained.
- The properties of bitumen modified with sisal fiber for 0.1 to 0.4% were obtained and found out the optimum percentage as 0.3%.
- The properties of modified bitumen with PP fiber for 0.1% to 0.6% were obtained and found out that 0.5% is the optimum percentage.
- The properties of aggregates and the filler material were tested and fixed the mix ratio as 25:15:22:38 (12 mm aggregate: 6 mm aggregate: M-sand: dust).
- The Marshall Stability test for normal bitumen and modified bitumen with sisal and PP fiber was conducted.
- It is found out that 5.9% is the optimum binder content for normal bitumen
- 5.8% and 5.4125% are the optimum binder content of modified bitumen with sisal and PP respectively.
- From this work, it was found out that by adding fibers as modifiers in bitumen the stability value increases and also the binder content can be reducing certain amount.
- Among the synthetic and natural fiber, best modifier is the synthetic fiber.
- Among these the main advantage is that PP fiber is that which is one of the plastic material so by utilizing plastic waste PP fiber is obtained from the waste there by reducing the plastic waste.
- Also have a disadvantage that while heating the
- PP fiber it causes some sort of pollutions.
- Besides that, PP fiber is a good modifier.

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