Utilization of Waste Plastic and Fibres In Stone Mastic Asphalt

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Abstract: The present study investigates the potential use of hospital waste plastic as a modifier for asphalt concrete and with the addition of areca nut fibre to stabilize the asphalt from SMA mixes. Conventional (without plastic) and the stabilized SMA mixtures were subjected to performance tests including Marshall properties such as Marshall stability, flow value, air voids, voids filled with mineral aggregates and voids filled with bitumen tests, with varying percentage of hospital waste plastic (6%, 8%'10% and 12%) by weight of the 60/70 grade of bitumen and 0.2% 0.3% and 0.4%, of areca nut fibre by weight of total aggregate. It is observed that the stability value increases with increase in hospital waste plastic content up to certain value and then the stability value decreases, also stability value increases with increase in fibre content and with further addition of fibre content it decreases. This study evaluates the viability of hospital waste plastic and fibre as stabilizing agent in stone matrix asphalt.

Key words: hospital waste plastic, areca nut fibre, 60/70 asphalt, Marshall Properties

I. INTRODUCTION

General

The length and quality of roads are key indicators of economic well-being of any country. Political and economic success of country is a function of the infrastructure development in that country. Asphalt concrete is one of the primary materials used to build and maintain roadways in the world. Aggregates and asphalts are relatively cheap and abundant materials that exhibit properties such as elasticity, stability, durability and moisture resistance when combined effectively to make hot mix asphalt pavements.

Stone mastic asphalt (SMA), also called stone-matrix asphalt, was developed in Germany in the 1960s with the first SMA pavements being placed as in 1968 near Kiel. It provides a deformation-resistant, durable surfacing material, suitable for heavily trafficked roads. SMA has found use in Europe, Australia, the United States, and Canada as a durable asphalt surfacing option for residential streets and highways. SMA has a high coarse aggregate content that interlocks to form a stone skeleton that resists permanent deformation. The stone skeleton is filled with a mastic of bitumen and filler to which fibres are added to provide adequate stability of bitumen and to prevent drainage of binder during transport and placement. Typical SMA composition consists of 70−80% coarse aggregate, 8−12% filler, 6.0−7.0% binder, and 0.3 per cent fibre.

Fibres are used to increase the performance of bituminous mixes towards deformation and cracking. Fiber plays a vital role in the SMA mixes which is one of the advanced technologies for SMA. Fiber reinforced bituminous asphalt mix has great influence in the volumetric properties and pavement performances in SMA. At present synthetic fibres and natural fibres are used in the bituminous mix. Polypropylene, glass, polymer, carbon and aramid are some of synthetic fibres used in the asphalt mix. Coir, jute, sisal and banana fibres are some of the natural fibres used in the bituminous mix. Different arrangements of fibres such as randomly oriented, woven fabrics and long-unidirectional has been used. Therefore reinforcement of fibres in the asphalt mixes is one of the best approaches to increase the tensile strength and fibres produced in India is four hundred tonnes and more.

Plastic is a very versatile material. Due to the industrial revolution, and its large scale production plastic seemed to be a cheaper and effective raw materials. Unfortunately, the properties of plastic that make it so valuable also make its disposal problematic, such as its durability, light weight and low cost. In many cases plastic are thrown away after one use, especially packing and sheeting, but because they are durable, they persist in the environment.

II. MATERIALS AND METHODOLOGY

This chapter briefly gives information about materials used for the mix and various laboratory tests carried out to determine the performance of SMA mixes using waste plastic and areca nut fiber.

Materials Used For the Study

Aggregates

Obtained from the local quarry and physical properties of aggregate are in the given able1&2 shows the recommended gradation limited by NAPA for SMA mix

Table 2.1 Properties of Aggregates

Tests	Test Methods	Results	Morth specifications
Aggregate impact value	IS:2386 PART 4	19%	Max 20%
Crushing	IS:2386	29%	Max 30%

value	PART 4		
Loss angeles abrasion test	IS:2386 PART 4	23%	Max 25%
Specific gravity	IS:2386 PART 3	2.60	2.5 to 3.0
Water absorption value	IS:2386 PART 3	0.97	Max 2%

Table 2.2 aggregate proportion

Sieve mm	% Passing by wt		Cumulative retain %	Individual retain %	% of CA, FA & MF	Individual wt of 1200 gm
	Specification	Blend				
26.5	100	100	0	00	76%(CA)	0
19	90-100	95	5	5		69
13.2	45-70	57.5	42.5	37.5		450
9.5	25-60	42.5	57.5	15		180
4.75	20-28	24	76	18.5		222
2.36	16-24	20	80	4	14%(FA)	48
1.18	13-21	17	83	3		36
0.600	12-18	15	85	2		24
0.300	10-20	15	85	0		0
0.075	8-12	10	90	5		60
Mineral Filler					**10**	**120**
Total					**100**	**1200**

Bitumen

The bitumen was 60\70 penetration grade obtained form vasudha Pvt ltd. Physical properties of bitumen presented table 3

Table 2.3 Properties of bitumen

TESTS	TEST METHODS	RESULTS
Penetration	IS 1203-1978	65 mm
Ductility	IS 1208-1978	58cm
Flash and fire point test	IS 1209-1978	290^0C & 300°C
Softening point	IS 1205-1978	60^0C
Specific gravity	IS 1202-1978	1.01
Viscosity	IS 1206-PART -2	255 sec

Filler Material

Stone dust is used as a filler material. The dusts are collected nearby site and are produced by crushing stones. Dust passes through 0.075mm sieve consider as filler material. Table 2.4 shows properties of filler material used in this study.

Table 2.4 Properties of filler material

Test	Result
Specific gravity	2.60

Areca nut fiber

The husk of the Areca is a hard fibrous portion covering the endosperm. It constitutes 30-45% of the total volume of the fruit. Areca fibers contain 13 to 24.6% of lignin, 35 to 64.8% of hemicelluloses, 4.4% of ash content and remaining 8 to 25% of water conten

Waste Plastics

Plastic mainly consist of polystyrene, poly propylene, ploy vinyl chloride, HDPE and LDPE. In this study mainly hospital plastic wastes are concerned, LDPE glucose bottles are used to study increase road life compared to conventional road.

Design Method Of Stonte Mastic Asphalt Mix

In this study mix designs was carried out to find the OBC by Marshall Method and for this OBC rutting specimens were prepared to find resistance to deformation.

Mix Preparation

For the preparation of sample following procedure was adopted as per MORTH specification.

1. The aggregates are proportioned to require specification as shown in Table 2.1. The total weight of coarse aggregates, fine aggregates and filler in the mix is about 1200 gm. The mix proportions of aggregates are heated to 155°C-165°C. Fig 2.2 shows the aggregate proportion for sample preparation.
2. The bitumen is heated about 150°C to 160°C and then bitumen is added to heated aggregates. Samples are prepared with different bitumen content like 5-6.5 percent with an increment of 0.5% by weight of mix and then uniform mixing is done at a temperature of 160°C.
3. After preparation of mix, mixture is poured into the mould of diameter 10.16 cm and height 6.35 cm.
4. Then level the top surface of the mould, the mixture was compacted by using rammer. Rammer weight is 4.54 kg and rammer height is 45.7 cm with 50 blows on each side of the mould at temperature of about 150°C. For varied bitumen content (5-6.5 per cent with an increment of 0.5%) by weight of aggregates four numbers of samples were prepared. By using specimen extractor compacted specimens are removed after 24 hours.
5. Bitumen content varied from 5, 5.5, 6 and 6.5 % by weight of aggregate is used for the preparation of conventional samples and then OBC is found.

6. Plastic is used as a additive and is cut into pieces of uniform size. By varying percentages of plastics 4, 6, 8 and 12% by weight of bitumen is used as additive with OBC for the preparation of samples.
7. Then areca nut fibers are added by 0.2, 0.3 and 0.4% of weight of aggregate.
8. Marshall Tests were conducted on conventional, plastic modified specimens and areca nut fiber used specimens. Marshall Properties such as Marshall stability, flow value, bulk density, voids in total mix (Vv), VMA and VFB were analyzed.

III. ANALYSIS OF RESULTS AND DISCUSSIONS

Marshall Test Results for SMA with Conventional Mix

Table 3.1 Properties of SMA for control mix (CM)

Tests	**Bitumen content by weight of aggregate**			
	5.0%	**5.5%**	**6%**	**6.5%**
Marshall stability(kN)	12.59	14.1	16.14	15.4
Flow volume(mm)	4.8	5.1	5. 6	5.8
Bulk density(gm/cc)	2.302	2.315	2.318	2.308
Volume of voids (Vv) (%)	5.73	4.33	3.5	2.91
Voids in mineral aggregate VMA (%)	17.11	17.34	17.43	17.0
Voids filled with bitumen VFB (%)	66.48	74.43	79.05	83.72
Optimum Bitumen Content (%)	5.82			

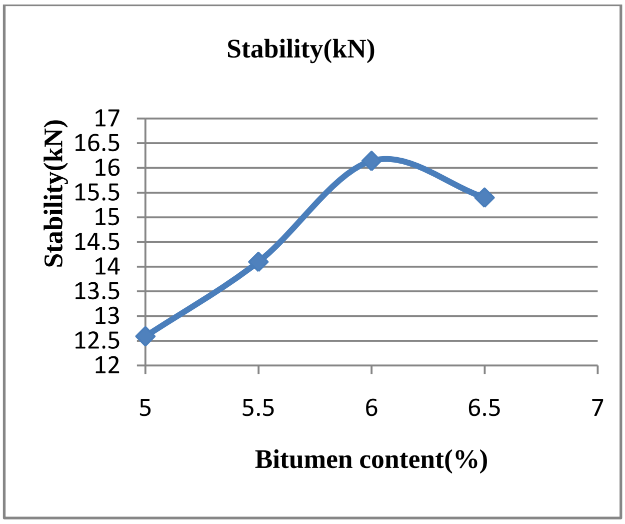


Fig 3.1 Bitumen Content Vs Marshall stability (kN)

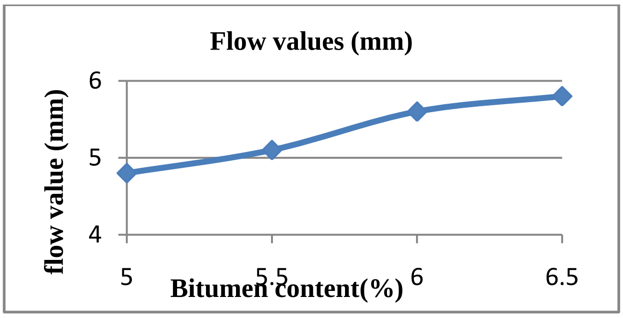


Fig 3.2 Bitumen Content Vs flow value (mm)

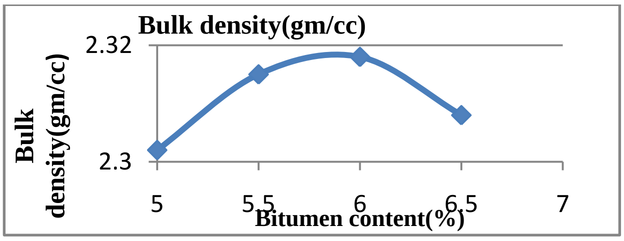


Fig 3.3 Bitumen content Vs Bulk density

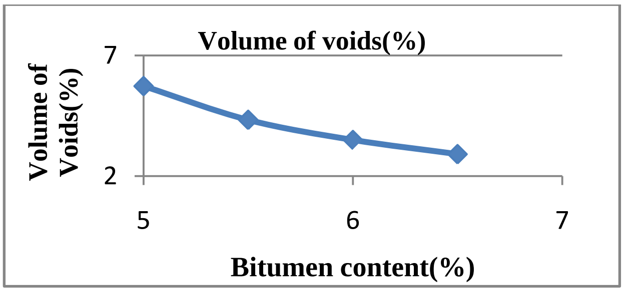


Fig 3.4 bitumen content Vs Volume of Voids

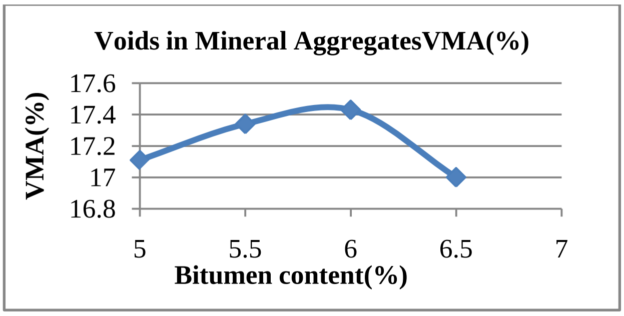


Fig 3.5 Bitumen content Vs Voids in Mineral Aggregates in percentage

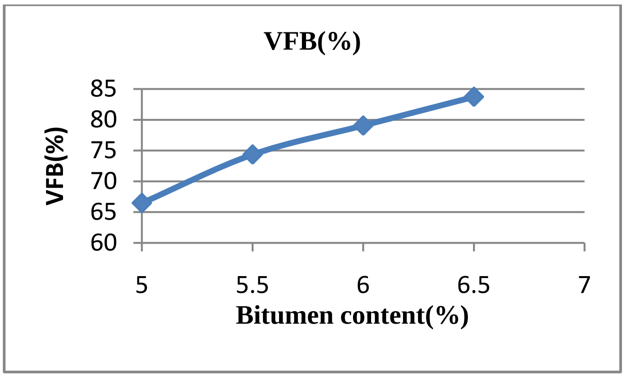


Fig 3.6 Bitumen Content Vs Voids Filled with Bitumen

Marshall Test Results for SMA With Plastic Waste

Table 3.2 Marshall Test results for SMA with plastic waste

TESTS	Plastic content by weight of bitumen			
	6%	8%	10%	12%
Marshall stability (kN)	17.3	17.94	17.18	16.8
Flow volume(mm)	5.6	5.8	5.9	6.2
Bulk density(gm/cc)	2.228	2.30	2.271	2.12
Volume of voids Vv(%)	4.983	4.48	4.3	4.1
Voids in mineral agg. VMA(%)	17.45	17.91	18.84	19.0
Voids filled with bitumen VFB(%)	71.25	74.94	75.36	76.4
Optimum Plastic Content (%)	8			

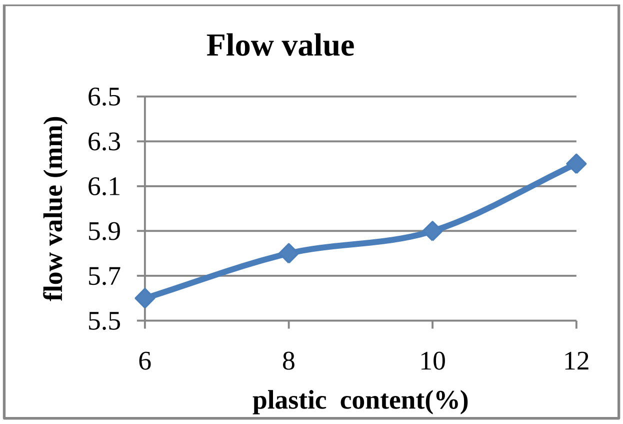


Fig 3.7 plastic content Vs flow value (mm)

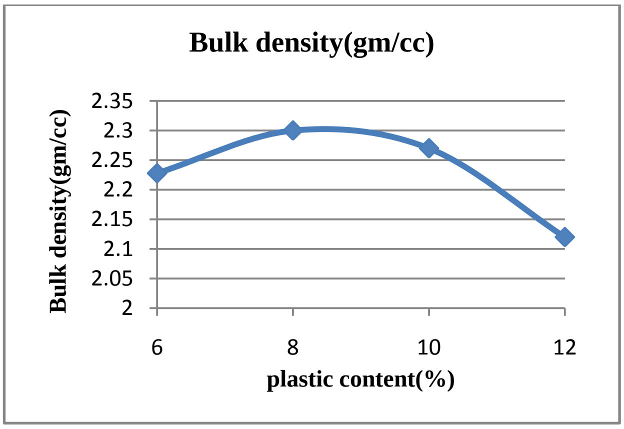


Fig 3.8 plastic content Vs bulk density (gm/cc)

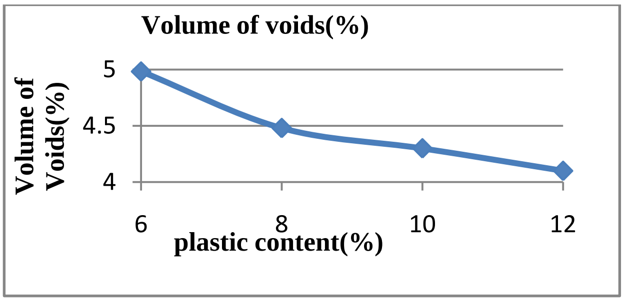


Fig 3.9 plastic content Vs volume of voids (%)

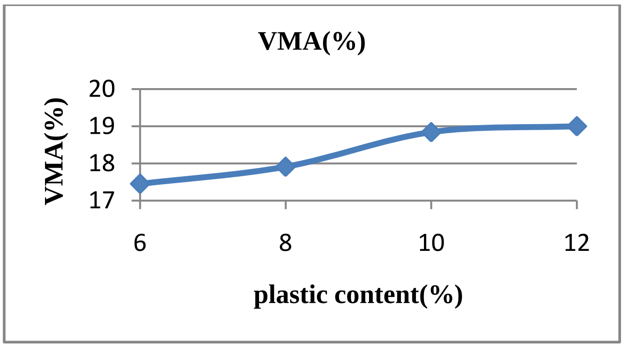


Fig. 3.10 plastic content Vs VMA(%).

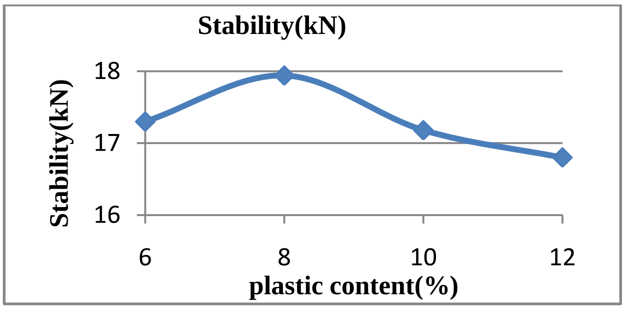


Fig. 3.11 plastic content Vs stability(kN)

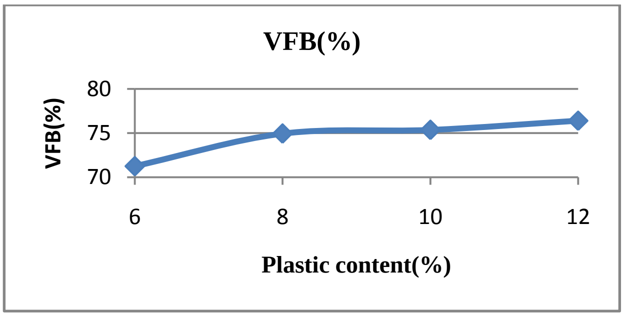


Fig. 3.12 Plastic content Vs VFB (%)

Marshall Properties for Areca Nut Fiber Used Specimens

Table 3.3 Test results of SMA mix using areca nut fiber

Properties	**Percentage of areca nut fiber in mix**			
	0%	**0.2%**	**0.3%**	**0.4%**
Marshall Stability (kN)	16.14	16.87	17.10	16.92

Flow value (mm)	4.6	4.3	4.1	3.7
Bulk density (g/cc)	2.318	2.348	2.360	2.353
Volume of voids V_v (%)	3.9	4.15	4.54	5.2
VMA (%)	17.43	17.95	17.61	17.80
VFB (%)	79.05	79.53	81.05	83.27

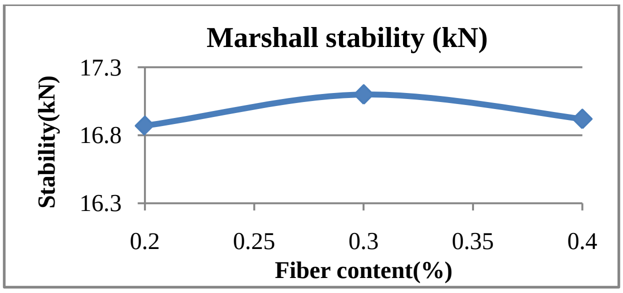
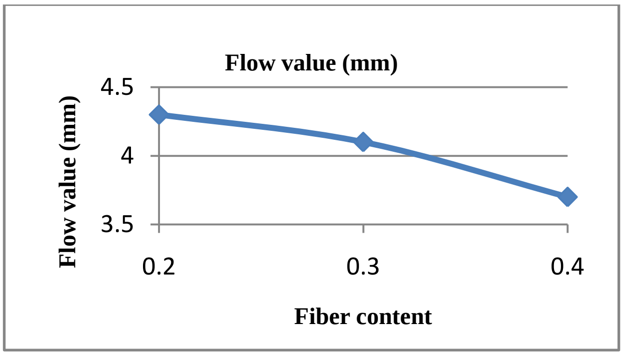


Fig. 3.13 Marshall Stability Vs fiber content



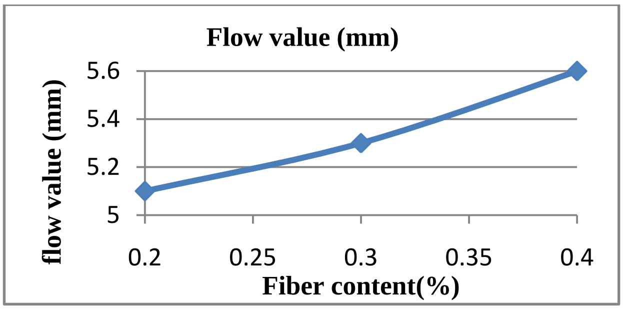


Fig. 3.14 Flow value Vs areca nut fiber

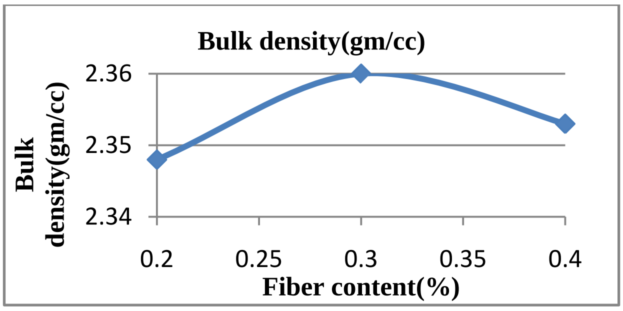


Fig. 3.15 Bulk density Vs Fiber content

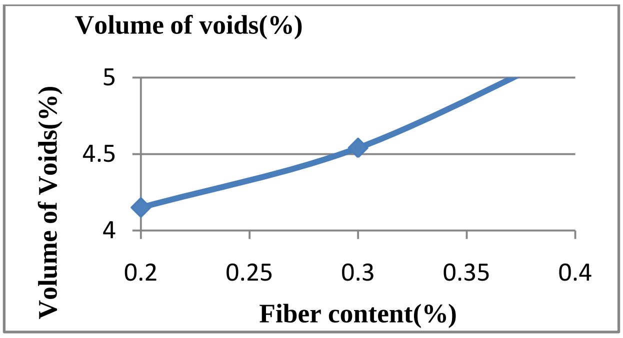


Fig. 3.16 Air voids Vs Fiber Content

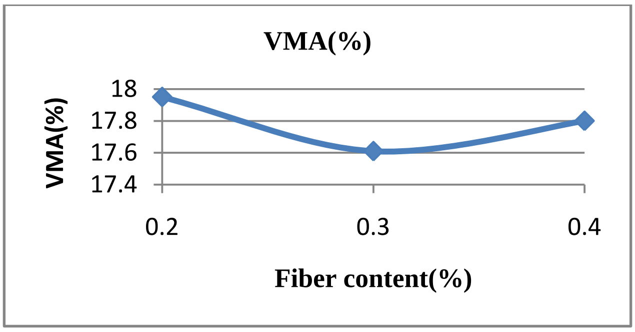


Fig. 3.17 VMA Vs arecanut fibers

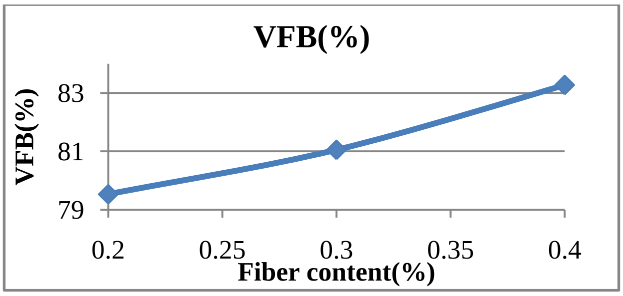


Fig. 3.18 VFB Vs Areca nut fibers

IV. CONCLUSIONS

The following conclusions are derived from the results of the present study by considering Marshall Properties and rutting characteristic of SMA Mixes.

1. Aggregates and bitumen used for this study satisfies the requirements of MORTH specification.
2. The optimum bitumen content for SMA mix is 5.82%.
3. 8% addition of plastic to the mix shows better stability compared to other proportions. The stability at this proportion is greater than controlled mix.
4. Addition of 0.3% of areca nut fiber shows higher stability value (17.10) compared to control mix (16.14) .
5. Based on stability, flow value and volume of voids it is concluded that stable mix can be obtained with 8% shredded waste plastic and 0.3 areca nut fiber.

V. FUTURE SCOPES

1. SMA mix with different type of fibres with different filler materials.
2. SMA mix with different grade of aggregate and filler materials like marble, GGBS and hydrated lime can be used.
3. Indirect tensile strength and tensile strength ratio test can be carried out

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