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Experimental Study on Filler Replacement & Fibre Addition in Stone Matrix Asphalt

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ABSTRACT*: Stone Matrix Asphalt (SMA) is a gap graded aggregate mix consisting of 80% coarse aggregates by weight and 8-12% of filler by weight. As SMA contains large amount of filler compared to HMA, the type of filler used influences the properties of the mix significantly. The present work discusses the effective use of filler namely Granite powder and a fibre namely viscose fibre. The results concluded that the filler can be replaced at 5% effectively and the fibre can be effectively added at 0.1%.*

KEYWORDS*: Filler, Granite Powder, Optimum Bitumen Content, Stability, Viscose Fibre.*

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I. INTRODUCTION

Stone Matrix Asphalt (SMA) is successfully used by many countries in the world because it offers textured, durable, and rut resistant wearing course. Major portion of SMA consists of coarse aggregates in the mix. Typical SMA composition consists of 70−80% coarse aggregate, 8−12% filler, 6.0−7.0% binder, and 0.3 per cent fibre. Selection of aggregate grading and the type and proportion of filler and binder will determine the stability of the mix. Type of filler used in SMA influences the degree of binding as well as property of interlocking. Filler also has an effect on the asphalt such as penetration, ductility, and of the mixture, such as resistance to rutting. Use of fibers in SMA will results in the reduction of drain down and also improves the stability of the mix.

In the recent experimental investigations the effect of mineral filler on the performance of asphalt paving mixtures was examined in terms of stability of the mix, its consistency, void filling, resistance to displacement and so on.

R Muniandy et al. (2010) have experimented on the impact of different types of fillers and their particle sizes on the engineering and mechanical properties of fine mastics and stone mastic asphalt mixture. In this investigation, four different types of industrial by-product wastes were used as fillers, namely limestone dust, ceramic waste dust, coal fly ash and steel slag mixture. From the results it was concluded that use of industrial by-products as fillers improves the engineering properties of stone mastic asphalt mixtures. It was also found that the filler type and particle size has a significant effect on the mixture properties.

Bindu C.S et al (2010) have conducted the performance tests on SMA mixtures on conventional SMA mixtures and as well as SMA mix with waste plastic as an additive in the range of 5%-12% with an increment of 1% in SMA mix. From the results it was concluded that addition of 10% waste plastic content results in improved stability, split tensile strength and compressive strength. It was also noticed that addition of 10% waste plastic content also results in decrease in angle of shear resistance and drain down values compared to conventional mix.

Ganapathi M. et al. (2012) examined properties of SMA Mix when recycled crumb rubber plus Low Density Polyethylene flakes were used as additive. In this investigation the feasibility of using 15% and 30% CR+LDPE by weight of bitumen with 60/70 penetration grade bitumen for SMA. From the results of the tests namely indirect tensile tests, unconfined compression test and variance analysis it was concluded that the addition of recycled CR+ LDPE using dry process could improve engineering properties of SMA mixtures.

Umadevi R. et al. (2012) examined the performance of SMA, with fly ash as filler and plastic waste as an additive in the range of 2% to 10%. The optimum plastic content obtained from the results is 8% by weight of fly ash. From the laboratory test results it was concluded that utilization of plastic waste increased the indirect tensile strength values, also reduces the rutting.

Baghaee Moghaddam T.et.al.(2012) examined the effect of addition of waste polyethylene terephthalate in SMA in the range of 0% to 1% with an increment of 0.2%. From the tests done on SMA namely Marshall stability, stiffness modulus test, indirect tensile test it was observed that an addition of 0.4% waste polyethylene terephthalate increased the properties of SMA in terms of stability, also increased the mechanical properties compared to the unmodified mix.

Udaya Bhanu.V. et al. (2019) has examined the two types of Glass fibres like Glass-C and ARGF in SMA. It was obtained that Glass –C fibre showed the better properties when compared with ARGF.

In the present experimental investigation the effective use of the filler and fibre namely Granite Powder and Viscose Fibre in SMA was examined. Granite Powder as a filler at 5% and Viscose fibre as a stabilizer additive at 0.1% can be effectively utilized. Marshall Stability and Draindown tests are conducted to determine the performance of filler replacement.

II. MATERIAL CHARACTERIZATION ANDTEST PROCEDURES

2.1 Material Characterization

Coarse and fine aggregates as well as stone and quartzite rock dust used in this investigation were collected from the locally available sources. The size of the aggregates is varying in between 75 micron to13.2 mm. Various physical properties of aggregates and the tests used to find these properties are mentioned in Table-I.

TABLE-I. PHYSICAL PROPERTIES OF AGGREGATES

PROPERTY	TYPE OF TEST	TEST METHOD	TEST RESULT	IRC SPECIFICATION
Strength	Aggregate Impact Value (%)	IS:2386 (Part-IV)	13.1	< 18%
	Los Angles AbrasionValue (%)		23.4	< 25%
Particle Shape	Combined Flakiness and ElongationIndex (%)	IS:2386 (Part-I)	18.5	< 30%
Specific Gravity	Specific Gravity	IS:2386(Part-III)	2.65	-
Water Absorption	Water Absorption (%)		0.5	< 2%

Granite Powder was obtained from Granite Quarry, Ponduru, Srikakulam, Andhra Pradesh, India. Viscose fibre was obtained from Sompeta, Srikakulam, Andhra Pradesh, India. The specific gravities of stone dust, granite powder and viscose fibre are found to be 2.32, 2.5 and 2.4 respectively. Bitumen of grade VG-40 was collected from HPCL, Visakhapatnam. The specific gravity of the bitumen was found to be 1.02. The physical properties of the binder are mentioned the Table-II.

TABLE-II. PHYSICAL PROPERTIES OF VG 30 GRADE BITUMEN

TEST	IS CODE	RESULTS	REQUIREMENT AS PER IS 73 : 2013
Penetration	IS 1203-1978	37.5	Min 35
Softening Point	IS: 1205-1978	49	Min 50
Ductility	IS: 1208-1978	59.5	Min 25
Specific Gravity	IS: 1208-1978	1.02	Min 0.99

2.2 Aggregate gradation

For the preparation of stone mastic asphalt mixes, the gradation of aggregates adopted was corresponding to SMA- 13 as per IRC-SP: 79-2008. Fig.1 represents adopted aggregate gradation.

2.3 Preparation of stone mastic asphalt specimens

The stone mastic asphalt mixes were designed as per AASHTO MP8 standard specification. Three different mixes were prepared by using three different fillers. For the first mix (unmodified mix), stone dust is used as filler. In case of second and third mixes part of stone dust is replaced with quartzite dust and glass powder in the range of 3 to 9% by total weight of filler. For determining the optimum bitumen content, 1200gm of aggregates and filler is heated to a temperature of 175 – 190^{0}C. Bitumen is heated to a temperature of 121 - 125^{0}C with the first trial percentage of bitumen (say 5 or 5.5% by weight of the mineral aggregates).

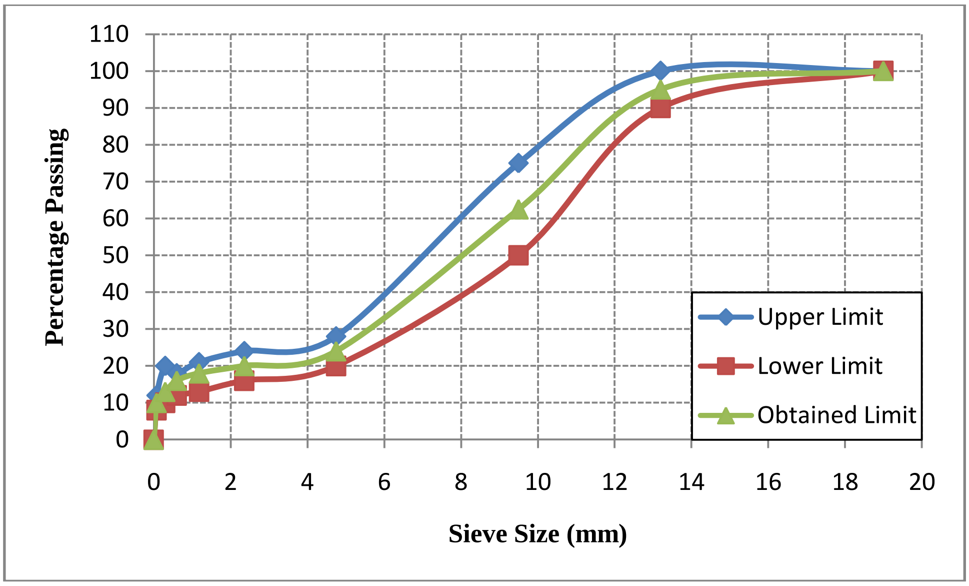

Figure 1: Aggregate Gradation

temperature of 154-160^{0}C. The mix is placed in a preheated mould and compacted by a rammer with 50 blows on either side at temperature of 138^{0}C to 149^{0}C. The weight of mixed aggregates taken for the preparation of the specimen may be suitably altered to obtain a compacted thickness of 63.5+/-3 mm. By varying the bitumen content in the next trials by+0.5% and above procedure is repeated. Now with the obtained optimum bitumen content, other two SMA specimens were prepared.

2.4 Test Procedures Marshall Test:

Marshall Test is used to find the stability and flow value and other properties of bitumen mixes. The different parameters considered in this analysis are stability, flow, percentage air voids (%Vv), percentage voids in mineral aggregates (% VMA), percentage voids filled with bitumen (% VFB). The optimum binder content (OBC) was adopted at 4% air voids (% Vv).

III. RESULTS AND DISCUSSIONS

3.1 Stability

Fig.2 represents the variation in the stability with respect to percentage binder varying from 5.5% to 7.0% at 0.5% increment at optimum stabilizer additives (viscose fibre).the mixes gradually increased the stability and obtained maximum stability at 6% and thereafter stability decreases gradually with the increased binder content.

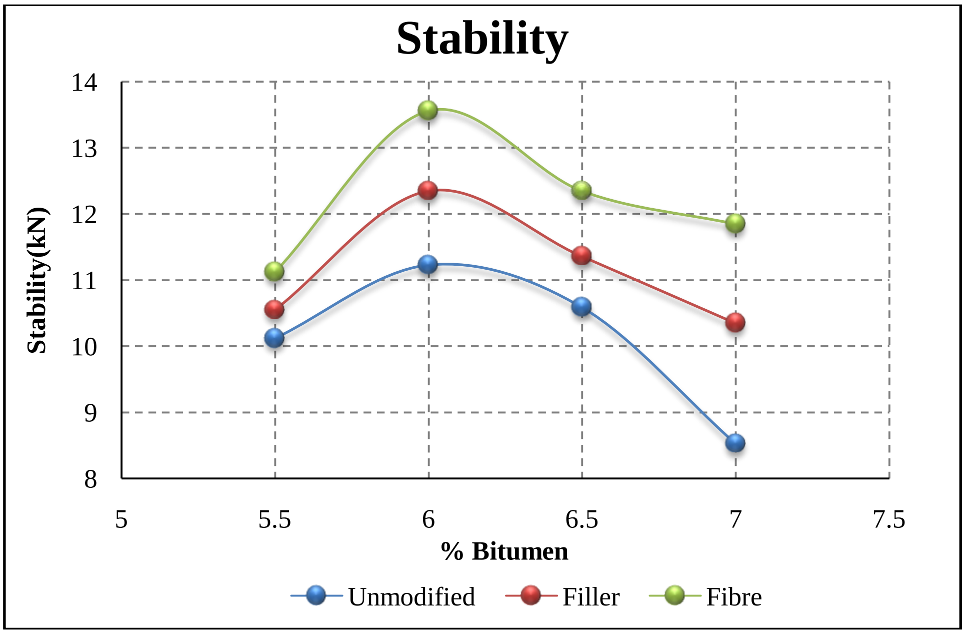

Figure 2: Variation of stability value with binder content for stabilizer additives.

The maximum stability obtained for both the mixes viscose fibre 13.56 kN.

3.2 Flow

Fig.3 represents the variation of flow of the mixes at optimum stabilizer additives (viscose fibre) with the increased percentage binder. The flow value for viscose fiber is ranging from 2.36 mm to 3.1 mm.

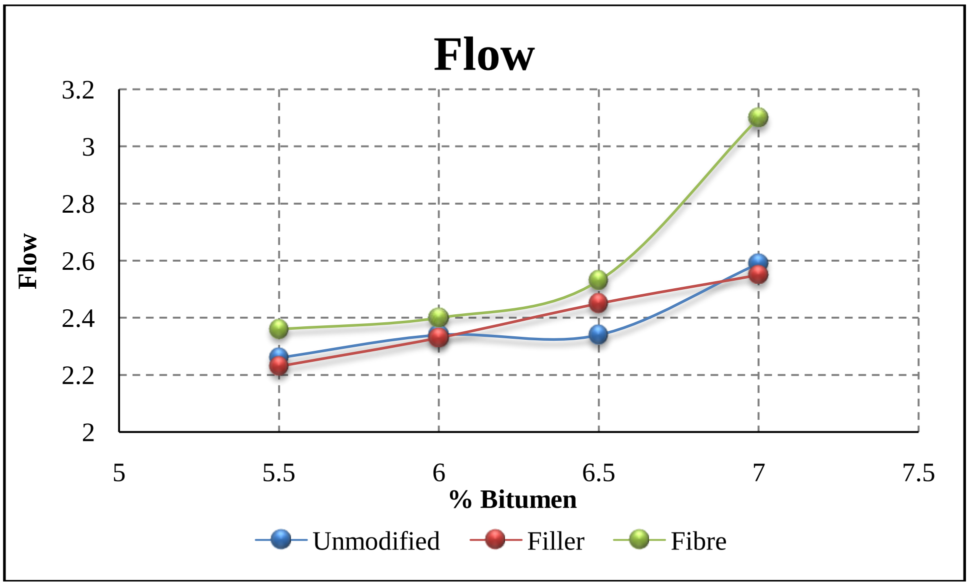

Figure 4.3: Variation of Flow value with respect to binder content for stabilizer additives.

It was observed from the results that the increase in the binder content leads to the increase in the flow value. Due to the elastic nature of the binder and the fibers used in the mixes increased the flow values. Mix with viscose fiber showed the higher flow value.

3.3 Airvoids

Fig.4.4 represents the change in % airvoids with the increase in % binder for the mixes with stabilizer additives. The results represent that the increase in the binder content reduced the airvoids in the mixes. The reason may be attributed as the fibers coated with the binder helps in filling the vacant space in the specimens, thereby resulted in the decrease in the airvoids. By the addition of viscose fiber at different binder percentages resulted in the reduction of airvoids from 4.15% to 2.02%

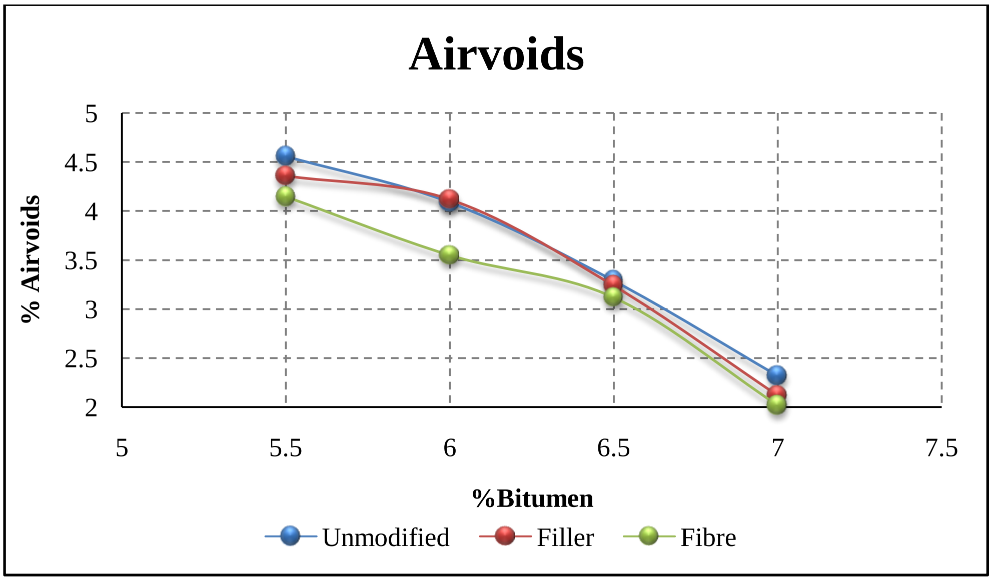

Figure 4.4: Variation of % Air voids with respect to binder content for stabilizer additives.

3.4 Voids in mineral aggregates

Fig.4.5 represents the variation in the percentage voids in mineral aggregate for the mixes with respect to the increase in the percentage binder. In case of viscose fiber as stabilizer additive the voids in mineral aggregates gradually decreases from 18.35% to 17.85%.

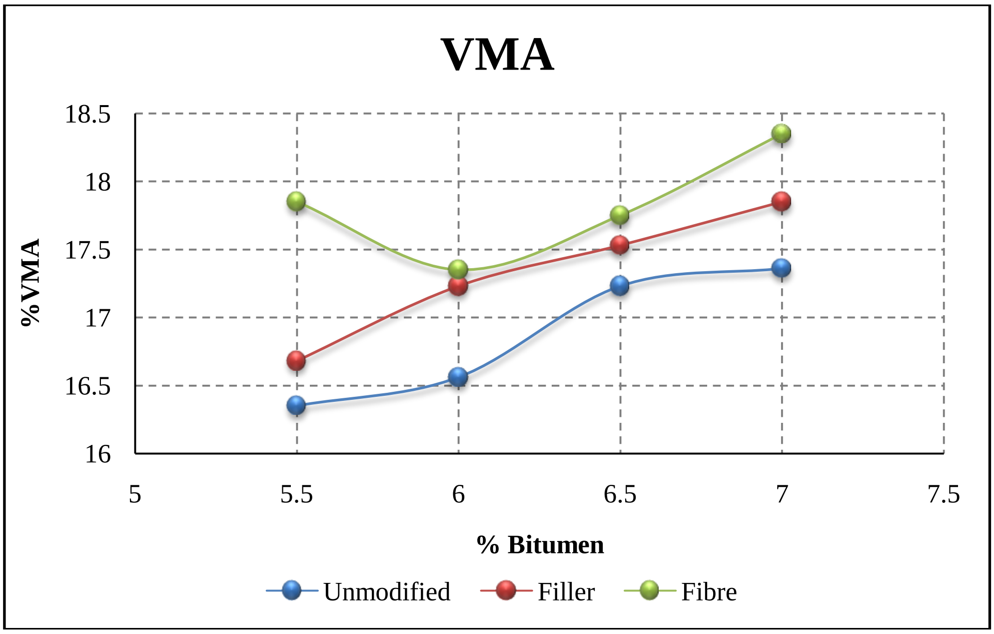

Figure 4.5: Variation of % Voids in Mineral Aggregate with respect to binder content for stabilizer additives.

In case of viscose fibre as stabilizer additive, it was observed that from 5.5% to 6.0% there is decrement from 17.85 to 17.35% and thereafter there is an increment up to 7% binder by obtaining 18.35% in the %VMA.

3.5 Voids Filled with Bitumen

Fig.4.6 represents variation in the voids filled with bitumen with the percentage of bitumen for the mixes with respect to the increase in the percentage binder.

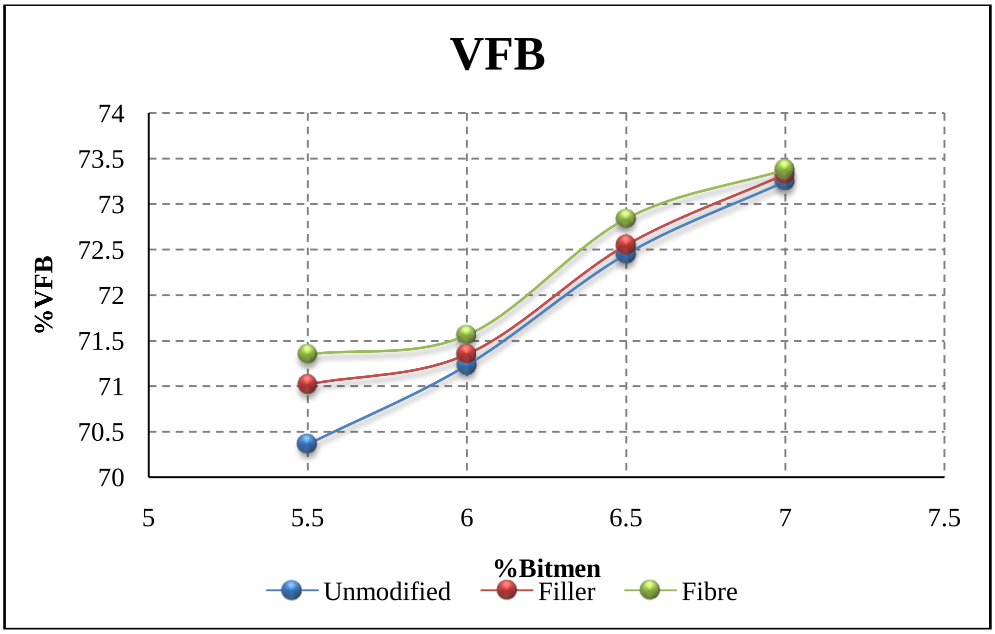

Figure 4.6: Variation of % Voids Filled with Bitumen with respect to binder content for stabilizer additives.

The results indicate that with the increase in percentage bitumen there was an increment in VFB. The reason may be attributed to filling of the airvoids present in the specimen by the increased binder content. As a result, there is a decrement in % air voids, and there must be an increment in % VFB. The range of increment in viscose fiber is from 71.35 to 71.56% and for the increment is in the range of 72.84% to 73.38%.

IV. CONCLUSIONS AND SCOPE FOR FURTHER STUDIES

In this laboratory analysis, the influence of quartzite rock dust, glass powder as filler replacement in stone mastic asphalt (SMA) mix in terms of Marshall properties has been analyzed for the comparison with unmodified mix. From the results obtained the following conclusions have been drawn.

- Granite Powder (GP) can be used as filler replacement at 5% and 7% respectively for the effective stability.
- Viscose Fibre at 0.1% as a stabilizer additive can be effectively used in the SMA mixes
- The stability values attained are 11.23 kN/m3 for unmodified mix, 11.93 kN/m3 for granite powder (GP) as filler replacement. 13.56 kN/m3 for viscose fibre(VF).
- In unmodified case optimum binder content (OBC) was obtained at6.06%.
- In case of % fibre the optimum binder content was 6.01% for viscose fiber and 6.03%.

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