International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 11, November-2016

# Influence of Glass Powder and Quartzite Rock Dust as Fillers in Stone Mastic 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 two fillers namely quartzite rock dust and glass Powder. Quartzite rock dust and glass powder are partially replaced in the range of 3% to 9% by the total weight of stone dust filler. From the results it was found that partial replacement of the stone dust filler by quartzite rock dust significantly improved the properties of SMA mix. It was also found that 5% and 7% were the optimum percentage replacement of quartzite rock dust and glass powder from the stability point of view.**

***Keywords— Filler, quartzite rock dust, optimum bitumen content, glass powder, stability.***

## 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 affect on the rheology of 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.

In the present experimental investigation the effective use of two fillers namely quartzite rock dust and Glass Powder in SMA was examined. Quartzite rock dust and glass powder are varied from 3% to 9% by the total weight of fillers. Marshall Stability and Draindown tests are conducted to determine the performance of filler replacement.

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## II. MATERIAL CHARACTERIZATION AND TEST 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 | Test | IS Code | Test Result (%) |
|---|---|---|---|
| Strength | Aggregate Impact | IS:2386 (Part-I) | 17.7 |
| | Crushing Value | | 25.3 |
| | Los Angles Abrasion Value | | 18 |
| Particle shape | Combined Flakiness and | IS:2386 (Part-I) | 26.7 |
| Water absorption | Water Absorption | IS:2386 (Part-III) | 0.5 |

Glass powder was obtained from Ashwin ceramics private limited, Chennai, India. The specific gravities of stone dust, quartzite rock dust and glass powder are found to be 2.32, 2.65 and 2.5 respectively. Bitumen of grade VG-30 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 | Test method | Result obtained |
|---|---|---|
| Penetration | IS: 1202-1978 | 63 |
| Softening point | IS: 1205-1978 | 49 |
| Ductility | IS: 1208-1978 | >100 |

### *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).

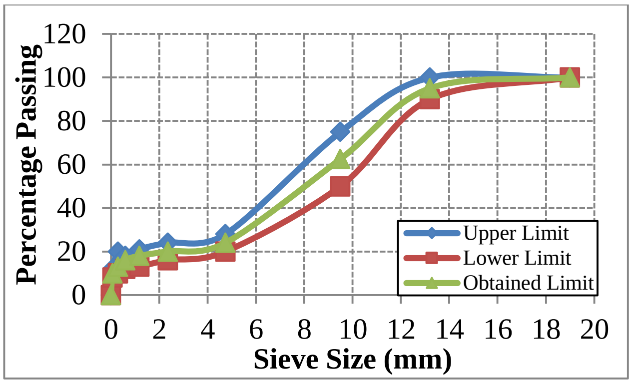


Fig. 1. Aggregate gradation

The heated aggregates and bitumen are thoroughly mixed at a 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

Marshall test has been used to determine the optimum binder content. Optimum bitumen content, stability of the mix, the flow value etc. was determined and the results are discussed below. As per Indian specification IRC-SP: 79-2008, the optimum binder content (OBC) was determined at 4% air voids in the mix.

### *3.1 Stability:*

Fig.2 shows the optimum bitumen of the SMA mix when stone dust is used as filler.

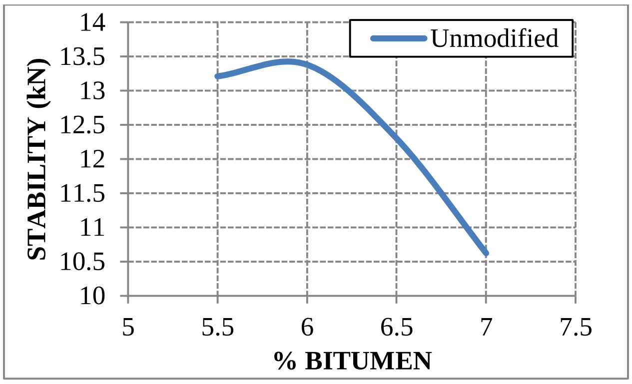


Fig. 2. Variation of stability value with binder content for unmodified mix.

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Bitumen content is varying from 5.5% to 7.0% with an increment of 0.5%.It is clear from the results At 6% binder content mix has attained maximum stability of 13.38 kN. It can be seen from figure that up to 6% binder content the stability is increasing there after the stability of the mix is decreasing. The optimum binder content considered for all the mixes is 6.06%. The obtained OBC is used for further analysis.The reason may be attributed as, the increase in the binder content increases the stability and attains maximum stability at certain point, further increase in the binder results the over flow of the binder and stability decreases gradually.

Fig.3 represents the variation in the stability of fillers with the % replacement of stone dust by new fillers quartzite rock dust and glass powder. It is clear from the results that, as the % replacement of the filler content increases the stability increases gradually and attains peak value at a certain point and decreases gradually by the increased filler content. In case of quartzite rock dust (QRD) filler the maximum stability is 15.19kN is obtained at 5% replacement. The maximum stability attained is 13.51 kN at 7% replacement in case of glass powder filler.

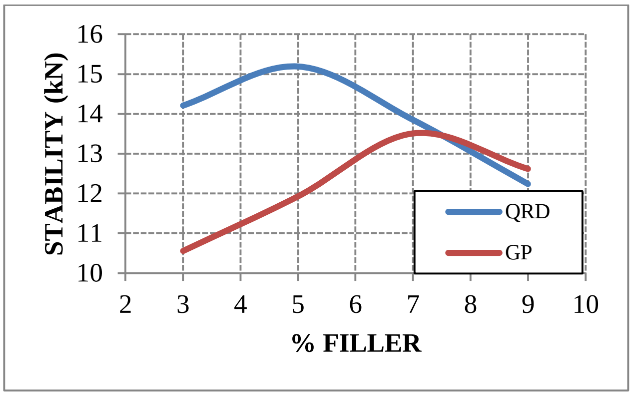


Fig. 3. Variation of stability value with binder content for alternative fillers.

Replacement of stone dust by quartzite rock dust results in an increment of 13.53% in its stability. In case of glass powder as a partial replacement there is only marginal increment in the strength. Enhanced stability in case of quartzite rock dust reason may be attributed to its rough texture compared to the GP helps in holding the binder.

*3.2 Flow*

Fig.4 represents the variation of flow of mix, with the increase in % binder in case of unmodified mix.

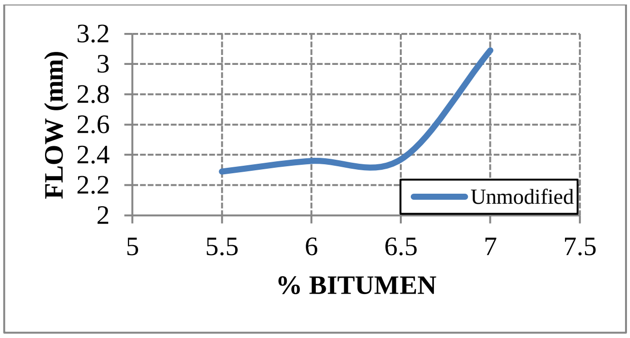


Fig. 4. Variation of Flow value with respect to binder content for unmodified mix.

It is clear from the results that increase in the binder content leads to the increase in the flow value. The flow obtained for unmodified mix is 2.36 mm at the optimum binder content.The increase in the flow may be due to the elastic nature of bitumen which affects the flow.

Fig.5 represents the variation of flow value of the mix with the increase in the filler percent. It was observed from the results that there is a linear increment in the flow value as the filler content increases.

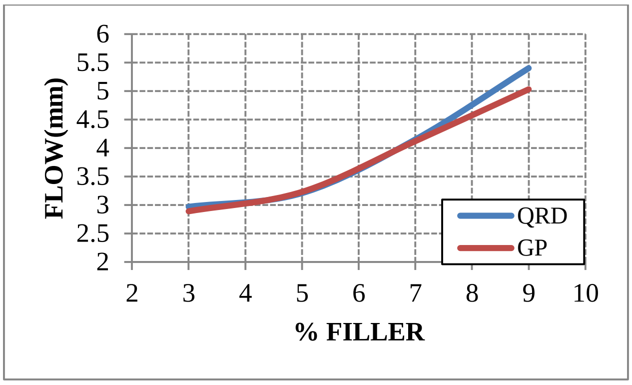


Fig .5. Variation of Flow value with respect to binder content for different fillers.

The flow values at OBC with respect to optimum filler replacement with quartzite rock dust and glass powder are 3.21 mm and 4.12 mm respectively. There is a slight increment in case of quartzite rock dust filler beyond 7% filler replacement.

*3.3Airvoids*

Fig.6 represents the change in % airvoids with the increase in % binder for unmodified mix. The results represent that as the binder content increases the % airvoids decreases.

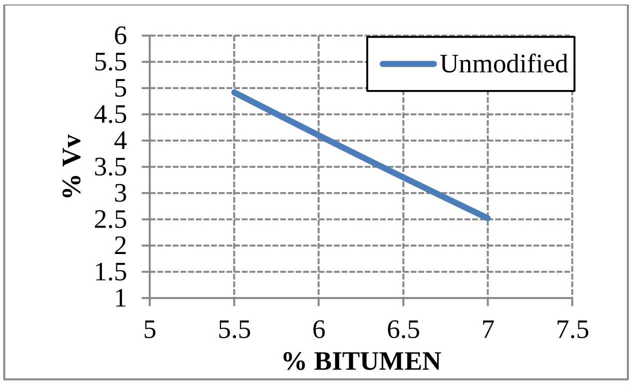


Fig. 6. Variation of % Air voids with respect to binder content for unmodified mix.

The % air voids observed for unmodified mix are 4.1% at optimum binder content. The reason may be attributed as the increased binder content fills the unfilled space in the specimen, thereby results in decrease of airvoids.

Fig.7 represents the variation in the percentage air voids with the variation in percentage filler for quartzite rock dust and glass powder fillers. The percentage airvoids at OBC with respect to optimum filler replacement with quartzite rock dust and glass powder are 3.03% and 4.12% respectively. The results represent that the increased filler content results the linear decrement in % airvoids.

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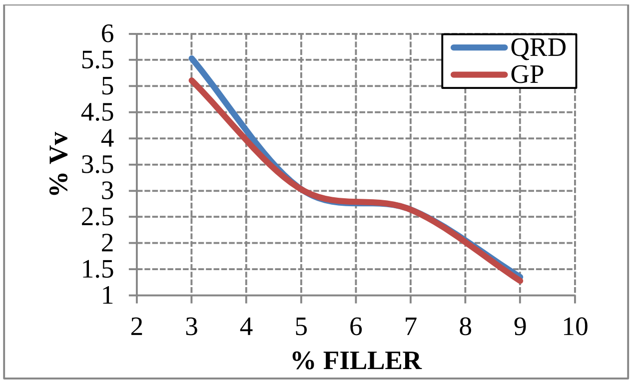


Fig. 7. Variation of % Air voids with respect to binder content for different fillers.

*3.4 Voids in mineral aggregates*

Fig.8 represents the variation in the percentage voids in mineral aggregate with the increase in the percentage binder. The percentage voids in mineral aggregates obtained for unmodified mix is 17.86% at optimum binder content. It was observed that from 5% to 6.5% there was an increment in the %VMA. Thereafter there was a fall down in the % VMA. Increment or decrement of VMA is based on the interlocking and shape in between the aggregate which is affected by compaction, temperature.

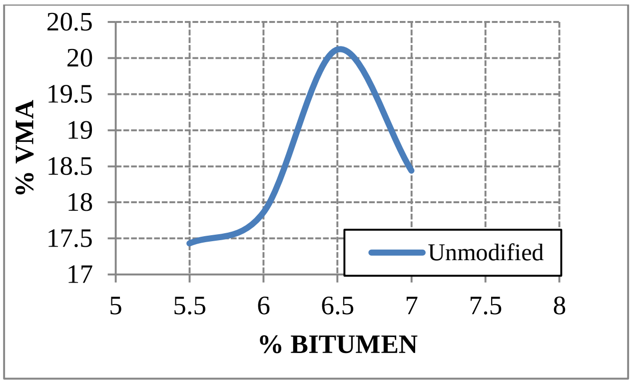


Fig. 8. Variation of % Voids in Mineral Aggregate with respect to binder content for unmodified mix.

Fig.9 represents the variation in the percentage voids in mineral aggregate with the increase in the percentage filler.

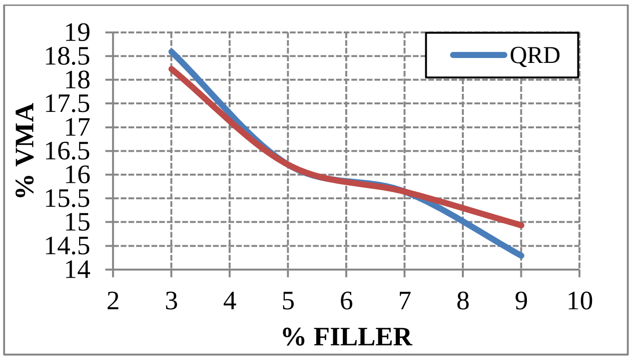


Fig. 9. Variation of % Voids in Mineral Aggregate with respect to binder content for different fillers.

The percentage voids in mineral aggregates observed at OBC with respect to optimum filler replacement with quartzite rock dust and glass powder are 16.21% and 15.64%.It was observed from the results that with the increase in the filler percentage filler replacement a decrement in the percentage of VMA. From the results it was observed that replacement of stone dust by new fillers resulted in better interlocking between the particles.

*3.5 Voids filled with bitumen*

Fig.10 represents variation in the voids filled with bitumen with the percentage of bitumen for unmodified mix. The percentage voids filled with bitumen observed in unmodified mix is 77.04% at optimum binder content. The results indicate that with the increase in percentage bitumen there was an increment in VFB.

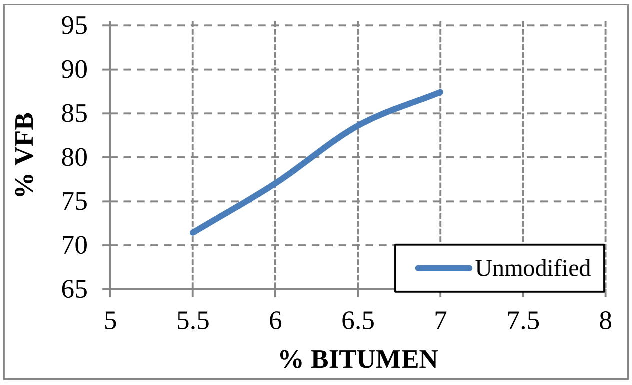


Fig.10. Variation of % Voids Filled with Bitumen with respect to binder content for unmodified mix.

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.

Fig.11 represents the variation in % voids filled with bitumen and the percentage filler. The percentage voids filled with bitumen observed at OBC with respect to filler replacement with quartzite rock dust and glass powder are 81.31% and 83.12%.The results show that there is an increment in VFB with the increased filler content. The reason may be attributed as the increased filler content replaces the airvoids.

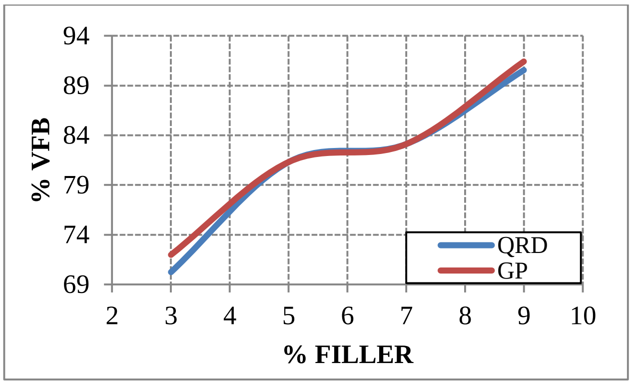


Fig. 11. Variation of % Voids Filled with Bitumen with respect to binder content for different fillers.

## IV. CONCLUSIONS

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.

- The filler replacement of 5% with quartzite rock dust enhanced the stability of SMA mix by 13.53% compared to the its stability when stone dust alone is used as a filler.
- The replacement of stone dust by glass powder resulted in marginal increment in the stability comparing to stone dust alone as filler.
- Quartzite rock dust as filler replacement showed better properties comparing to filler replacement with glass powder.
- The % airvoids decreased in case the fillers replaced instead of stone dust.
- The flow value and voids filled with bitumen (VFB) increased with the filler increment.

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