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Stone Matrix Asphalt (SMA) Mix Design Using Different Filler

Akash Ka. Patel, Prof. Siddharth Gupte, Prof. N. B. Parmar

Civil Engineering Department, Parul Institute of Engineering & Technology, Vadodara, Gujarat, India

ABSTRACT

There are three major types of asphalt surfacing, characterized by a mixture of bitumen and stone aggregate. These are: Dense Graded asphalt (DGA); Stone Matrix Asphalt (SMA) and Open Graded Asphalt (OGA). Asphalt surfacing differs by the proportion of different size aggregate, the amount of bitumen added and the presence of other additives and material. The first aim of this study is to provide an updated systematic review of the evaluation of stone matrix asphalt in construction. The second aim is to study the effect of different fillers on SMA Mix Design. In this study two fillers named brick dust and lime powder are used.

Keywords: SMA mix design, filler type, brick dust and lime powder, comparison.

I. INTRODUCTION

A. SMA was developed in Germany in the 1960s by Zichner of the Straubag-Bau AG central laboratory, to resist the damage caused by studded tires. As SMA showed excellent resistance to deformation by heavy traffic at high temperatures, its use continued even after the ban of studded tires. SMA is a gap graded mixture containing 70-80% coarse aggregate of total aggregate mass, 6-7% of binder, 8-12% of filler, and about 0.3-0.5% of fiber or modifier. The high amount of coarse aggregate in the mixture forms a skeleton-type structure providing a better stone-on-stone contact between the coarse aggregate particles, which offers high resistance to rutting. Aggregate to aggregate contact is also there in dense graded mixtures but it occurs within the fine aggregate particles as the coarse aggregate floats in the fine aggregate matrix, which don't give the same shear resistance as the coarse aggregate skeleton. Brown and Manglorkar (1993) reported that the traffic loads for SMA are carried by the coarse aggregate particles instead of the fine aggregate asphalt-mortar. The higher binder content makes the mix durable. The fibers or modifier hold the binder in the mixture at high temperature; prevent drainage during production, transportation and laying.

SMA is defined as "A gap graded aggregate hot mix asphalt that maximizes the binder content and coarse aggregate fraction and provides a stable stone-on-stone skeleton that is held together by a rich mixture of binder, filler and stabilizing additives". The deformation resistant capacity of SMA stems from a coarse stone skeleton providing more stone-on-stone contact than with conventional dense graded asphalt (DGA) mixes. Improved binder durability is a result of higher bitumen content, a thicker bitumen film, and lower air voids content. This high bitumen content also improves flexibility. Addition of a small quantity of cellulose or mineral fiber prevents drainage of bitumen during transport and placement. There are no precise design guidelines for SMA mixes. The essential features, which are the coarse aggregate skeleton and matrix composition, and the consequent surface texture and mixture stability, are largely determined by the selection of aggregate grading and the type and proportion of filler and binder.

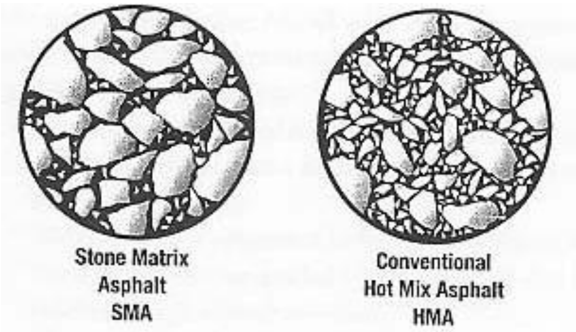

Figure 1. Comparison of Sma And Conventional Mix

II. LABORATORY TESTING

A. Bitumen Testing

Table 1. Physical Properties of Bitumen

Property	Value	Test Method
Flash point	331°C	
Penetration	42.66 mm	IS: 1209 - 1978
Softening point	68.15°C	IS: 1203 - 1978
Specific gravity	1.0285	IS: 1205 - 1978
Elastic recovery@ 25°C	4 cm < 6	IS: 1202 - 1978
Ductility	34 cm > 30	SP:53-2010

In this study PMB-40 used as a binder material (bitumen). The results of physical properties of bitumen testings are discussed above in Table 1.

B. Aggregate testing

Table 2. Physical Properties of Aggregates

TEST	20 mm	10 mm	Method
Flakiness index	14.63	15.24	IS:2386(P-1)
Elongation index	17.55	12.01	
L.A abrasion	17.96	16.40	IS:2386(P-4)
Agg. Impact value	7.69	8.26	
Specific gravity	2.80	2.77	IS:2386(P-3)
Water absorption	0.2 %	0.7%	

In this study 20 mm , 10 mm , 6 mm aggregates are used for the SMA mix design. The results of physical properties of aggregates are discussed in Table 2.

C. Filler testing

Table 3. Filler Testing

	Brick dust	Lime powder
Specific gravity	2.675	1.923
% passing from 75µ sieve	91	87.4

III. MIX DESIGN AND ANALYSIS

A. SMA gradation

Table 3. Gradation for SMA

IS Sieves (mm)	% Passing				Adopted grading (%) A:B:C:D 48:24:15:13	Specified grading IRC: SP-79 (%)
	20mm (A)	10mm (B)	6mm (C)	Filler (D)		
26.5	100	100.0	100.0	100.0	100.0	100
19	83.57	100.0	100.0	100.0	92.1	90-100
13.2	1.13	98.5	100.0	100.0	52.2	45-70
9.5	0.2	88.5	99.9	100.0	49.3	25-60
4.75	0	9.1	81.3	100.0	27.4	20-28
2.36	0	0.6	27.2	100.0	17.2	16-24
1.18	0	0.2	7.4	100.0	14.2	13-21
600 µ	0	0.0	2.3	100.0	13.3	12-18
300 µ	0	0.0	0.3	98.0	12.8	10-20
75 µ	0	0.0	0.0	91.0	11.8	08-12

Figure 1. Mixing of Aggregates and Bitumen

B. Marshall test results

Table 4. Marshall Test Results

Filler type	Bitumen content (%)	G_t	G_m	V_v	V_b	VMA	VFB	Stability (KN)	Flow (mm)
Brick dust	5	2.58	2.45	5.03	11.35	16.38	69.28	12.3	2.4
	5.5	2.57	2.46	4.40	12.46	16.86	73.90	16.8	2.6
	6	2.55	2.44	4.30	13.44	17.74	75.75	16	2.9
	6.5	2.53	2.43	4.0	14.42	18.42	78.31	11.8	3.1
	7	2.51	2.42	3.72	15.38	19.10	80.53	13	3.4
Lime powder	5	2.47	2.33	5.60	10.80	16.40	65.85	9.2	2.6
	5.5	2.45	2.34	4.33	11.89	16.22	73.30	12.9	2.9
	6	2.44	2.33	4.32	12.85	17.17	74.85	12.2	3.1
	6.5	2.42	2.32	4.11	13.78	17.88	77.04	7.7	3.4
	7	2.41	2.31	3.95	14.73	18.68	78.86	7.8	3.9

Figure 3. Prepared Sample

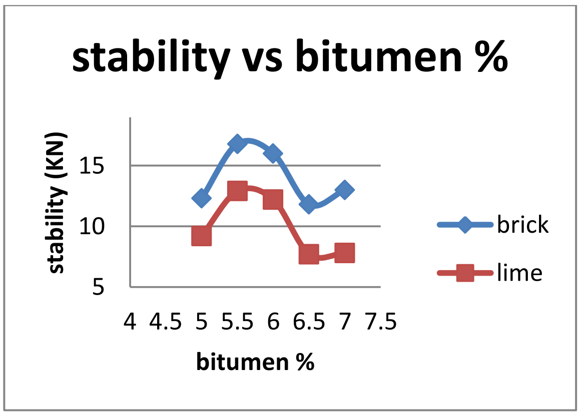

Figure 4. Stability Vs Bitumen %

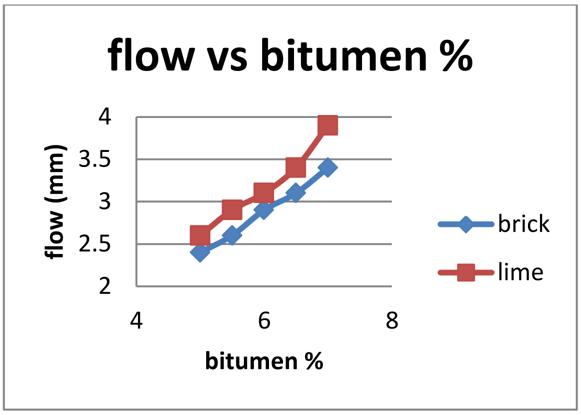

Figure 5. Flow Vs Bitumen %

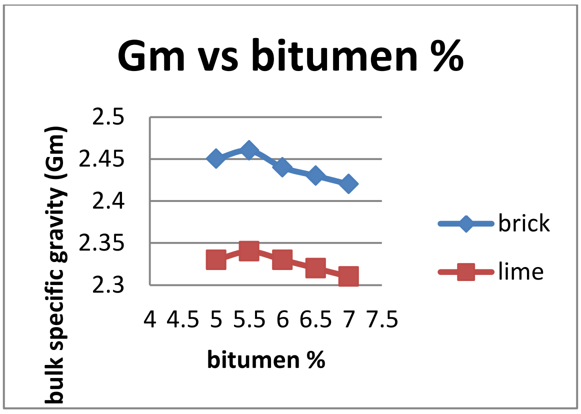

Figure 6. GM Vs Bitumen %

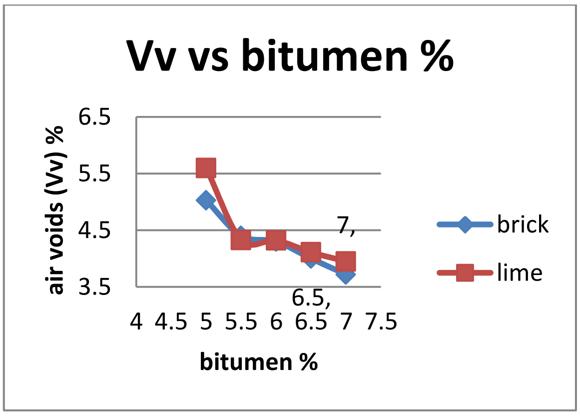

Figure 7. VV Vs Bitumen %

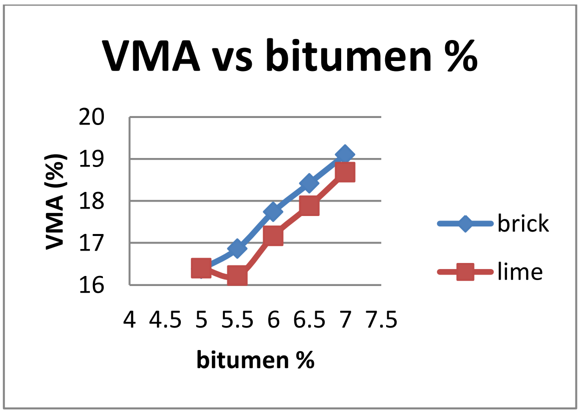

Figure 8. VMA Vs Bitumen %

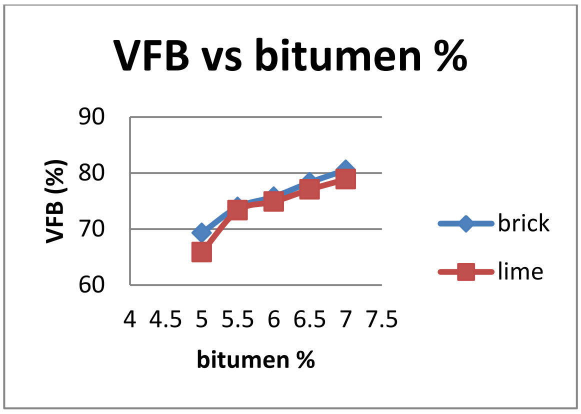

Figure 9. VFB Vs Bitumen %

IV.CONCLUSION

The aim was of this thesis is to find out the alternative filler material to achieve similar or higher strength for stone matrix asphalt mix design over existing fillers used mixes. Brick dust and lime powder both are economical and easily reliable compared to cement, steel slag and fly ash. However from above results and analysis it is found that highest stability value for brick dust and lime powder were 16.8 KN and 12.9 KN respectively. Optimum binder content (OBC) for brick dust was 5.83 % and 6.0% for lime powder. It is observed that as bitumen content increases the flow value increases for both type of mixes. It is also observed from literature review that use of PMB-40 giving higher stability value compared to VG-30(60/70). Because of higher coarse aggregates content in mix setting time is higher compared to ordinary mixes. And also observed that voids in mineral aggregates (VMA) are higher in range of 16-19 % for both type of fillers. The specific gravity of brick dust was found 2.675 and 1.925 for lime powder. However both type are satisfying basic SMA requirements.

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