An Experimental Study of Warm Mix Application on Dense Bituminous Macadam

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Abstract - Warm Mix Asphalt (WMA) technology is technology in which bituminous mixes are prepared at temperature 20-30˚C lower than as in Hot Mix Asphalt (HMA). In this study Marshall samples of both WMA and HMA with different binder content are prepared and tested using 1% of Zeolite. It is seen from the certain research papers and studies that gyratory compactor is not used for WMA because it is insensitive to the compaction temperature. Marshall Hammer and vibratory compactor give more consistent results than gyratory compactor. We have taken four different percentages of bitumen with 3 samples at each bitumen percent. Total 48 samples were prepared. Test results showed that there is a considerable increase in Marshall Stability Value and optimum bitumen content remains unchanged for WMA. It is also seen that percent VMA, Flow value increase whereas density, VFB, V_b, V_a decreases.

Keywords- Zeolite, Marshall Hammer, vibratory compactor, VMA, VFB, V_b, V_a, Flow value.

1.INTRODUCTION:

WMA is developed by adding chemicals such as Zeolites, asphalt emulsions waxes and water to the binder before mixing. According to a survey of US asphalt producers in 2012 about 25% of asphalt produced is Warm mix. It is seen that after adding certain chemicals or external agents mixing and compaction temperatures are reduce by 20-30˚C whereas workability increases. Benefits of using Warm Mix Asphalt technology are listed below:

(i) reduced environmental hazards (ii) lower emissions (iii) lower production of Green House gases (iv) lower fuel consumption (v) lower health hazard (vi)further, the additional cost of the chemical may be compensated by savings in fuel consumption and other indirect benefits (vii) extended construction time (viii) lower time consumption (upto 20-25% less time required) (ix) proximity to the site (x) similar or better performance (xi) reduced binder ageing

2. EXPERIMENTAL

2.1 Material used

The different materials used in the study are aggregates, conventional and modified binders. Aggregates available in a Hot Mix Plant near Chandigarh were selected. The proportion of aggregates of size 19mm, 10mm, 6.7mm, stone dust are 34%, 19%, 16% and 31% respectively. The types of binder used in the study are VG 30 as conventional binder and CRMB 55 as modified binder.

Specific gravities of 20mm, 13.5mm, 6.7mm and stone dust are 2.66, 2.72, 2.62, and 2.65 respectively.

Table 1.1 Properties of Aggregates

Physical Properties	20 mm	10 mm	Required Values as per MORTH 5th Revision
Sp. Gravity	2.66	2.72	2.6-2.8
Elongation Index, %	15.68	14.82	Combined Elongation and Flakiness Max 30%
Flakiness index, %	12.21	13.25	
Impact value, %	18.5	18.3	24% Max

Bitumen: Two different types of binders have been used VG-30 and CRMB 55 respective binders-

TABLE 1-2 PHYSICAL PROPERTIES OF BITUMEN

Properties	VG-30		CRMB 55		Test Method
	Cal	Req	Cal	Req	
Penetration	50	50-70	58	<60	IS:1203:1978
Softening Point	48.3	47 Min	55	50 Min	IS:1205:1978
Ductility	50	40 Min			IS:1208:1978
Elastic recovery			50.5	50 Min	IS:SP:53:2002
Specific Gravity	1.00	0.99	1.01	>1	IS:1202:1978

3. Mix Design

Design mix is done using job mix formula according to MORTH 5th revision (Ministry of Road Transport and Highway) Table 500-17. The different sizes of aggregates, i.e 20mm, 10mm, 6.7mm and stone dust are selected and the sieve analysis is done to obtain the individual gradation of these aggregates. Grading 2 is used. Then by trial and error method by using Microsoft excel, the desired gradation for DBM as shown in table 4-3. Plain bitumen of grade VG-30 and modifier CRMB 55 used for the study and the physical property of the aggregate should meet the requirement as given in MORTH 5th revision

Table 4-3(Mix Design)

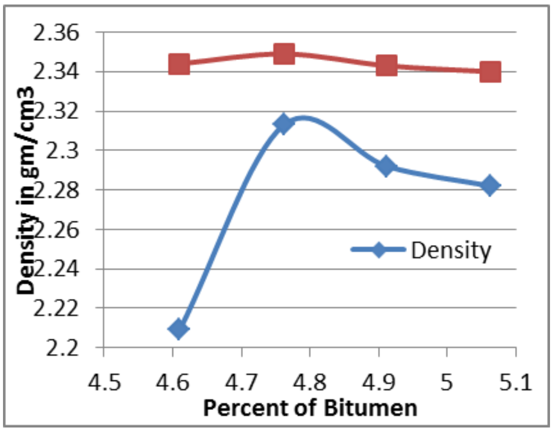
IS Sieve size	% passing (required)	%passing 19mm	%passing 10mm	%passing Grit 6.7mm	% passing S.D	Over all Grading of mix
37.5 mm	100	100	100	100	100	100.00
26.5 mm	90-100	100	100	100	100	100.00
19mm	71-95	74.2	100	100	100	91.23
13.2 mm	56-80	2.2	100	99.4	100	66.65
4.75 mm	38-54	1	0.6	41.7	99.3	37.91
2.36 mm	28-42	0	0	5.8	90.2	28.89
300µ	7-21	0	0	1.9	36.8	11.71
75µ	02-08	0	0	1.7	10.4	3.50
Ratio		0.34	0.19	0.16	0.31	

4.1) Experimental Results of different parameters of Marshall Stability Test for CRMB 55

TABLE 4-4

Bitumen %	4.61		4.762		4.912		5.063	
	Warm	Normal	Warm	Normal	Warm	Normal	Warm	Normal
Density	2.344	2.209	2.349	2.313	2.343	2.292	2.34	2.282
Volume of Bitumen, V_b %	10.805	10.183	11.186	11.014	11.504	11.258	11.847	11.553
Volume of aggregates $V_{A\%}$	83.997	79.16	83.91	82.754	83.527	81.874	83.456	81.3878
Voids in mineral aggregate (VMA)%	16.059	20.894	16.046	17.328	16.414	18.2	16.647	18.713
Voids filled with bitumen(VFB) %	67.283	48.73	69.71	63.561	70.086	61.8571	71.165	61.737
Measured stability,(KN)	13.68	12.41	14.47	12.79	17.29	11.94	13.94	12.09
Flow value	4.125	4.3	4.3	4.5	4.8	4.6	5.2	4.8

4.2 GRAPHS OF INTERPRETATION OF EXPERIMENTS RESULTS FOR CRMB



Fig,4.2.1 Graph of variation of densities w.r.t. bitumen

NOTE- Densities of warm mixes was observed to be increased as compared to hot mixes i.e. from 2.344 to 2.209, 2.349 to 2.313, 2.343 to 2.292 and 2.34 to 2.282 at binder content 4.61, 4.762, 4.912 and 5.063 respectively.

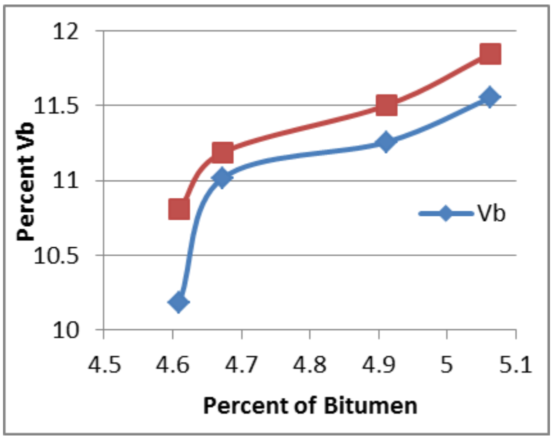


Fig 4.2.2 Graph of variation of percent V_b warm mixes v/s hot mixes

NOTE- - V_b percent was observed to be increased in warm mixes in comparison to hot mixes i.e. from 10.183 to 10.805, 11.186 to 11.01, 11.258 to 11.504 and 11.553 to 11.847 at binder content 4.61 , 4.762 , 4.912 and 5.063 respectively.

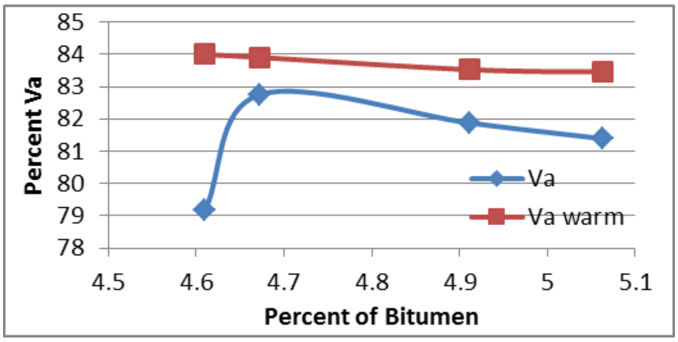
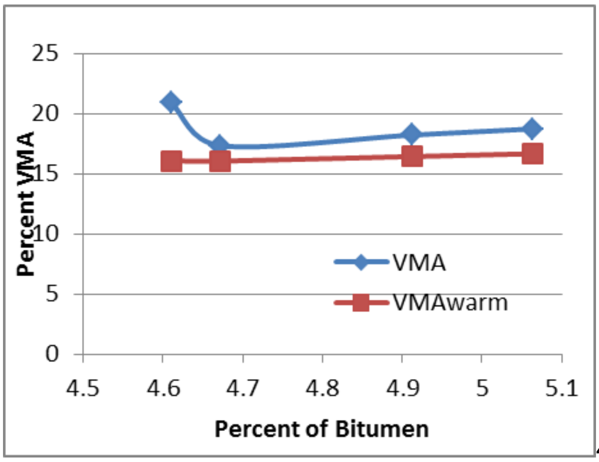


Fig 4.2.3 Graph of variation of percent V_a warm mixes v/s hot mixes

NOTE- - V_A percent was observed to be increased in warm mixes in comparison to hot mixes i.e. from 79.16 to 83.997, 82.754 to 83.91, 81.874 to 83.527 and 81.3878 to 83.456 at binder content 4.61 , 4.762 , 4.912 and 5.063 respectively.



4.2.4 Graphs of variation of percent VMA of warm mixes v/s hot mixes

NOTE- VMA percent was observed to be decreased in warm mixes in comparison to hot mixes i.e. 20.894 to 16.059, 17.328 to 16.046 , 18.2 to 16.414 and 18.713 to 16.647 at binder content 4.61 , 4.762 , 4.912 and 5.063 respectively

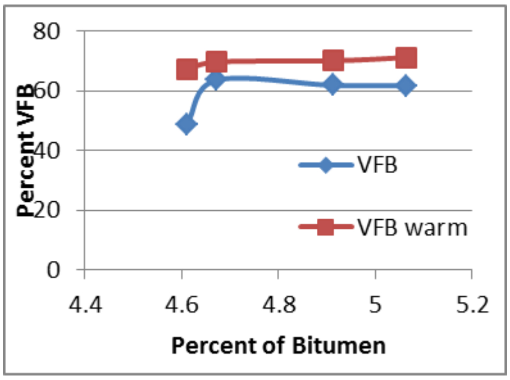


Fig 4.2.5 variation of % VFB of warm mixes v/s hot mixes w.r.t bitumen

NOTE- VFB percent in warm mixes was observed to be higher as in hot mixes i.e. from 48.73 to 67.283, 63.561 to 69.71 , 61.8571 to 70.086 and 61.737 to 71.165 at 4.61 , 4.762, 4.912 and 5.063 bitumen percentages respectively

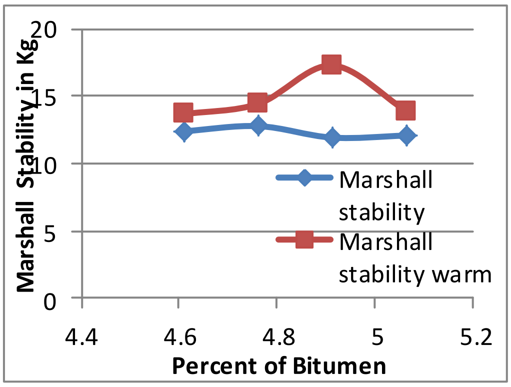


Fig. 4.2.6 Graph of variation of Marshall Stability w.r.t. bitumen content

NOTE- Marshall Stability was observed to be increased in warm mixes as compared to hot mixes i.e. from 12.41 to 13.68, 12.79 to 14.45, 11.94 to 17.29 and 13.94 to 12.09 at binder content 4.61, 4.762, 4.912 and 5.063 respectively.

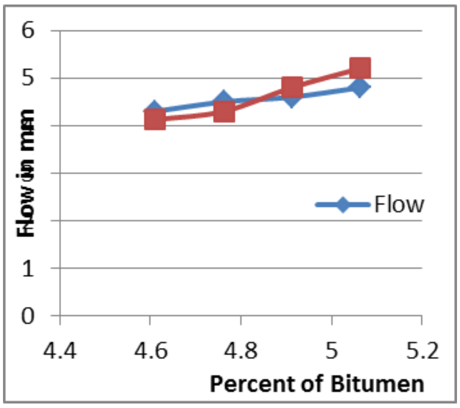


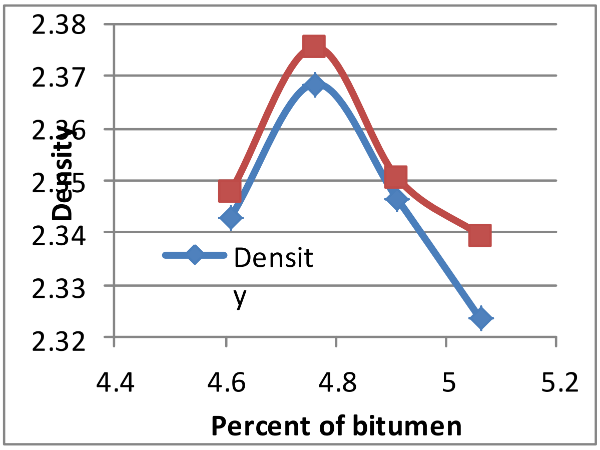
Fig 4.2.7 (c) Graph of variation of flow w.r.t. bitumen

NOTE- Flow of warm mixes seems to be decreased from 4.3 to 4.125 and from 4.5 to 4.3 at bitumen content of 4.61 and 4.762 respectively afterward it starts increasing from 4.6 to 4.8 and from 4.8 to 5.2 at 4.912 and 5.063 percentage of bitumen respectively

EXPERIMENTAL RESULTS OF VG-30

Bitumen %	4.61		4.762		4.912		5.063	
	Warm	Normal	Warm	Normal	Warm	Normal	Warm	Normal
Density	2.3479	2.343	2.3755	2.3685	2.3505	2.3465	2.3395	2.3235
Volume of Bitumen, V_b %	10.283	10.8	11.312	11.278	11.545	11.526	11.844	11.763
Volume of aggregates $V_{A\%}$	84.137	83.962	84.991	96.732	83.964	71.417	83.438	82.867
Voids in mineral aggregate (VMA)%	15.843	16.01	15	15.231	15.996	16.139	16.548	17.119
Voids filled with bitumen(VFB) %	68.314	67.457	75.5	74.04	72.714	71.417	71.573	68.71
Measured stability,(KN)	12.17	11.29	14.38	12.18	12.53	15.17	11.25	14.35
Flow value	3.3	3.95	3.5	4.6	3.7	4.95	4.2	4.95

4.4) GRAPHS OF INTERPRETATION OF EXPERIMENTS RESULTS FOR VG-30



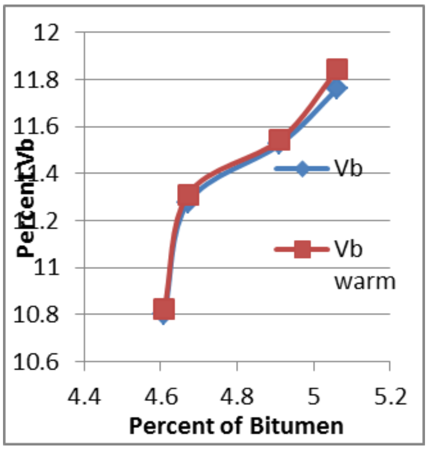


Fig 4.4.2 Graph of variation of % V_b of warm mixes v/s hot mixes

NOTE- percent V_b was observed to be slightly higher in warm mixes than hot mixes i.e. 10.8 to 10.823, 11.278 to 11.312, 11.328 to 11.545 and 11.763 to11.844 at 4.61, 4.762, 4.912 and 5.063 respectively

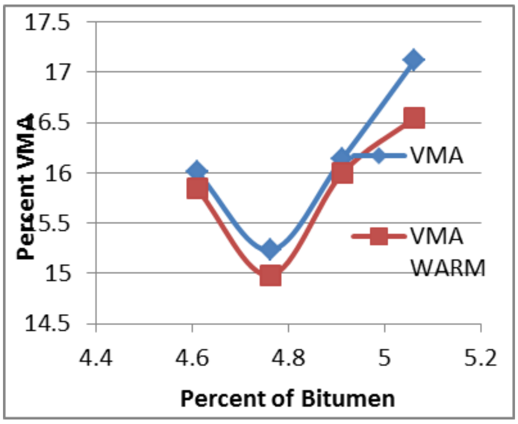


Fig 4.4.4 Graphs of variation of % VMA of warm mixes v/s hot mixes w.r.t bitumen percent

NOTE – Percent VMA was found to be decrease in warm mixes as compared to hot mixes i.e. from 16.01 to 15.843, 15.231 to 15 16.139 to 15.996 and 17.119 to 16.548 at binder content 4.61, 4.762, 4.912 and 5.063 respectively.

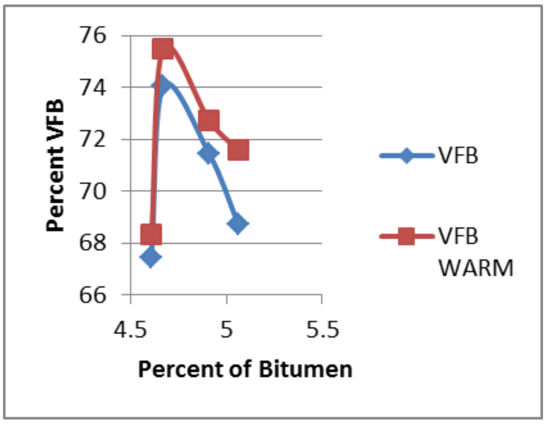


Fig4.4.5 (i) Graphs of variation of % VFB of warm mixes v/s hot mixes

NOTE- Percent VFB was observed to be increased in warm mixes in comparison to hot mix i.e. from 67.457 to 68.314, 74.04 to 75.5, 71.417 to 72.714 and 68.71 to 71 .573 at binder content 4.61, 4.762, 4.912 and 5.063 respectively

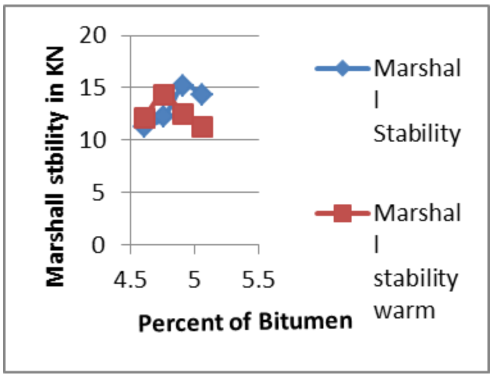


Fig 4.4.6 (g) Graphs of variation Marshall stability of warm mixes v/s hot mixes

NOTE- Marshall stability was found to be increased from 11.29to 12.17 and 12.18 to 14.38 at bitumen percentage of 4.61 and 4.762 afterward it decreasing from 15.71 to 12.53 and 14.35 to 11.25 at bitumen percentage 4.912, 5.063 respectively

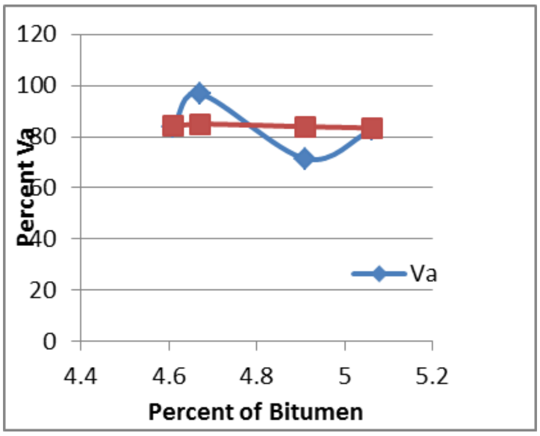
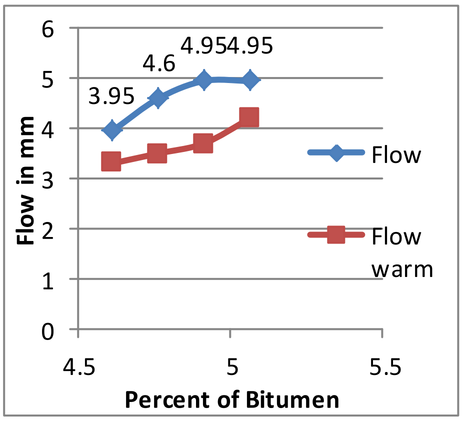


Fig 4.4.3Graph of Variation of percent V_a of warm mixes v/s hot mixes



NOTE- Flow of warm mixes was observed to be decreased as compared to hot mixes i.e. from 3.3 to 3.95, 3.5 to 4.6, 3.7 to 4.7, 4.2 to 4.95 at binder content 4.61, 4.762, 4.912 and 5.0

CONCLUSIONS:

Following are the outcomes of the experiment conducted for comparison of WMA mixes and HMA mixes:

- Density of Warm Mix Asphalt samples is higher as compared to Hot Mix Asphalt.
- Optimum binder content for Normal Mixes is found out to be 4.672 by comparing certain specifications from MORTH 5th revision it is found out that Optimum Binder Content for Warm Mixes is same as that of Normal samples. It clearly indicates that there is no change in Optimum Binder Content for Warm Mixes.
- There is a considerable increase in Marshall Stability value of Warm Mix as compared to Hot Mix Asphalt in CRMB but it firstly increases and than decreases in VG30. It concludes that Warm Mix sample have higher strength than Hot Mix samples.
- There is noticeable increase in percent VFB in warm mixes as compared to hot mixes in both types of bitumen.
- Percent VMA decreases in warm mixes as compared to hot mixes in both type of bitumen.
- Volume of bitumen V_b was observed to be increases in warm mixes as compared with hot mixes.
- Volume of aggregate was observed to be increased in CRMB 55 and in VG 30 it was observed that firstly it starts increasing than its value falls down.

Overall from this study we have concluded that in spite of being expensive WMA have good performances than HMA.

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