A Case Study InWarm Mix Application ON Bituminous Concrete

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Abstract- In Warm Mix Asphalt (WMA) technology is technology 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 atfour different binder content are prepared and in WMA 1% of Zeolite is used. It is seen from the several 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

Aggregates available in a Hot Mix Plant near Chandigarh were selected. The proportion of aggregates of size 19mm, 10mm, 6.7mm, stone dust and cement are 10%, 26%, 45%, 16% and 3% 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, stone dust and cement are 2.66, 2.72, 2.62, 2.65 and 3.115 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 Following are the properties of two respective binders-

TABLE 1-2 Physical Properties of Bitumen

Properties	VG-30		CRMB 55		Test Method
	Calculated	Required	Calculated	Required	
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	55	50 Min	**IS:1208:1978**
Elastic recovery			50.5	50 Min	**IS:SP:53:2002**
Specific Gravity	1.00	0.99 min	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

IS Sieve Size	% passing Required	% Passing 20mm	% Passing 10 mm	% Passing 6.7 mm	% Passing S.D / Girt	% Passing Cement	Grading of Mix
19mm	100	100	100	100	100	100	**100**
13.2mm	79-100	10.1	100	100	100	100	**91.01**
9.5mm	70-88	1	86.4	99.4	100	100	**86.468**
4.75mm	53-71	0	0.6	41.7	99.3	100	**54.513**
2.36mm	42-58	0	0	5.8	90.2	100	**44.518**
1.18mm	34-48	0	0	3	68.12	100	**34.134**
600µ	26-38	0	0	3	51.2	100	**26.52**
300µ	18-28	0	0	3	36.8	100	**20.04**
150µ	12-20	0	0	1.7	19.5	100	**12.05**
75µ	4-10	0	0	1.7	10.4	100	**7.952**
Ratio		**0.1**	**0.26**	**0.16**	**0.45**	**0.03**	

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

TABLE 4-4

4.5.3 Comparison of Normal and Warm Mixes of CRMB

Bitumen %	5.51		5.66		5.808		5.956	
	Warm	Normal	Warm	Normal	Warm	Normal	Warm	Normal
Density	2.3305	2.348	2.344	2.351	2.342	2.346	2.325	2.331
Volume of Bitumen, V_b%	12.854	12.041	13.267	13.606	13.602	13.625	13.847	13.883
Volume of aggregates $V_{A\%}$	80.63	81.23	80.808	81.05	80.56	80.70	79.82	80.03
Voids in mineral aggregate (VMA)%	17.84	17.22	17.50	17.26	17.69	17.55	18.43	18.22
Voids filled with bitumen(VFB) %	72.03	75.14	75.78	77.05	76.89	77.08	75.10	76.183
Stability,(KN)	14.56	13.88	15.44	13.96	21.35	18.01	21.23	15.53
Flow value	4.5	3.7	4.2	4.2	4.4	4.25	4.5	4.3

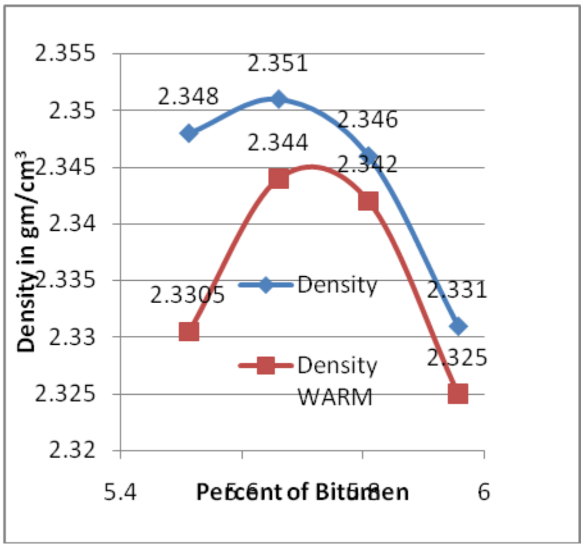

Fig.4-1 Variation of Density of HMA and WMA with respect to Bitumen Content

NOTE: Densities of warm mixes was observed to be decreased as compared to hot mixes i.e from 2.348 to 2.3305, 2.351 to 2.344, 2.346 to 2.342 and 2.332 to 2.325 at binder content 5.5115, 5.66, 5.808 and 5.956 respectively.

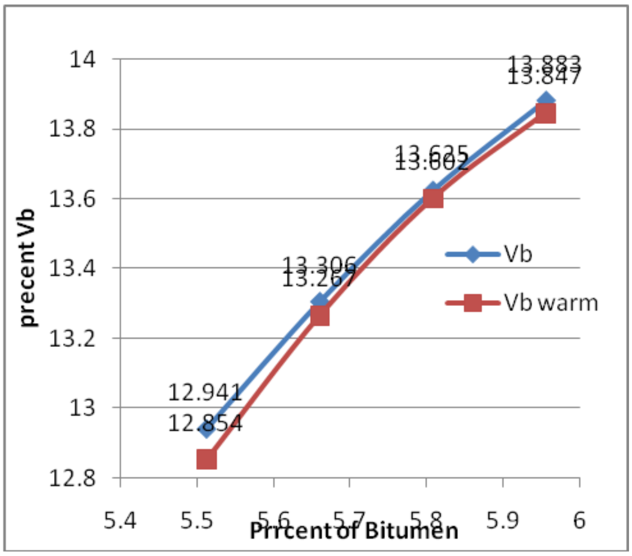

Fig. 4-2 Variation of V_b of HMA and WMA with respect to Bitumen Content

NOTE- $V_b$was observed to be decreased in warm mixes as compared to hot mixesi.e from 12.941 to 12.854, 13.306 to 13.267, 13.625 to 13.602 and 13.883 to 13.847 at binder content5.5118, 5.66, 5.808 and 5.956 respectively.

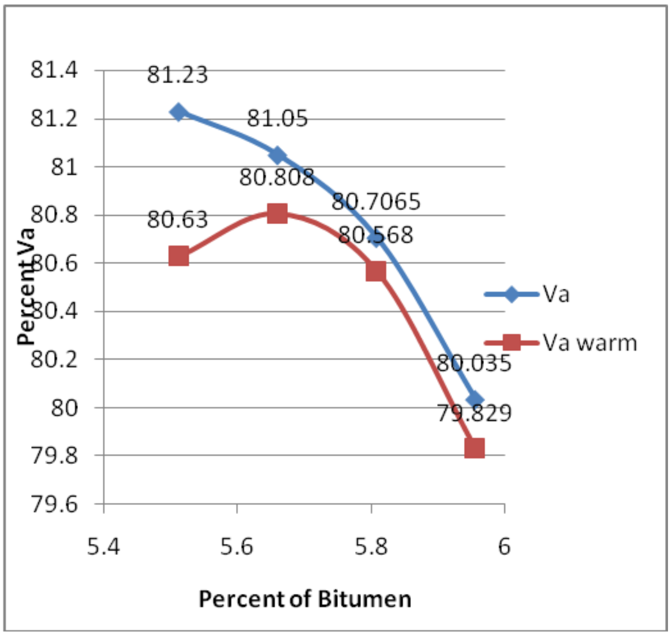

Fig. 4-3 Variation of $V_a$of HMA and WMA with respect to Bitumen Content

NOTE- V_A was observed to be decreased in warm mixes as compared to hot mixesi.e from 82.8 to 81.23 to 80.63, 81.05 to 80.808, 80.7065 to 80.568 and 80.035 to 79.829 at binder content 5.5118, 5.66, 5.808 and 5.956 respectively.

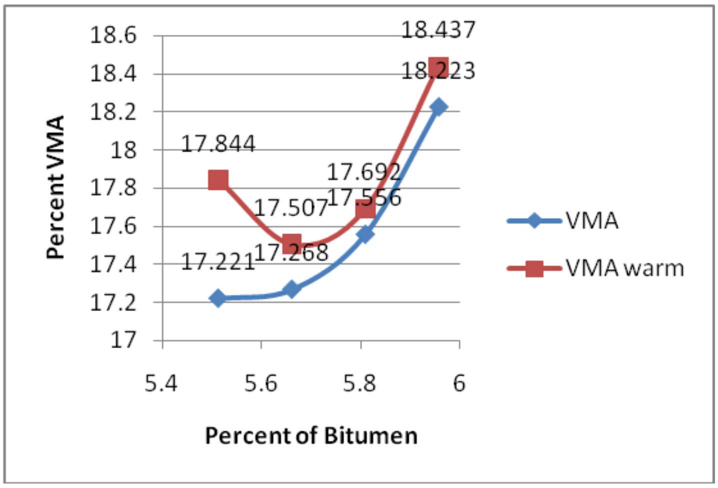

Fig. 4-4 Variation of VMA of HMA v/s WMA with respect to Bitumen Content

NOTE- Percent VMA was observed to have increased in warm mixes as compared to hot mixes i.e from 17.221 to 17.844, 17.268 to 17.507, 17.556 to 17.692 and 18.223 to 18.437 at Binder content 5.5118, 5.66, 5.808 and 5.956 respectively.

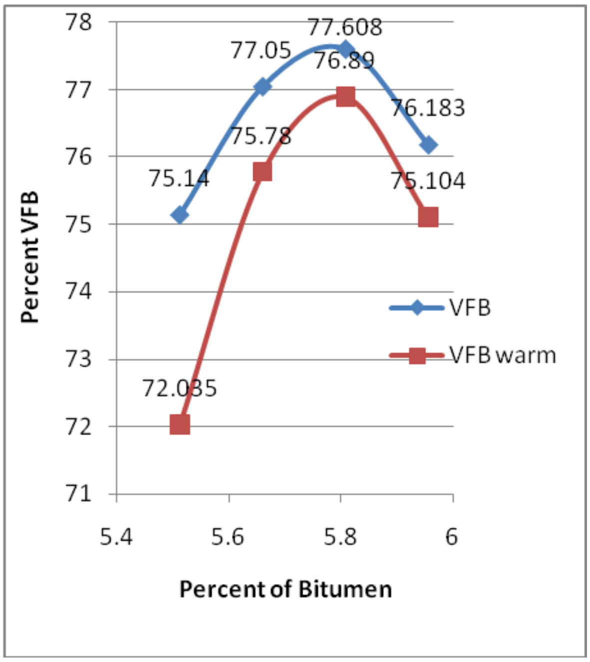

Fig. 4-5 Variation of VFB of HMA and WMA with respect to Bitumen Content

NOTE – Percent VFB was observed to be decreased in warm mixes as compared to hot mixes i.e from 75.14 to 72.035, 77.05 to 75.78, 77.608 to 76.89 and 76.183 to 75.104 at Binder Content 5.5118, 5.66, 5.808 and 5.956 respectively.

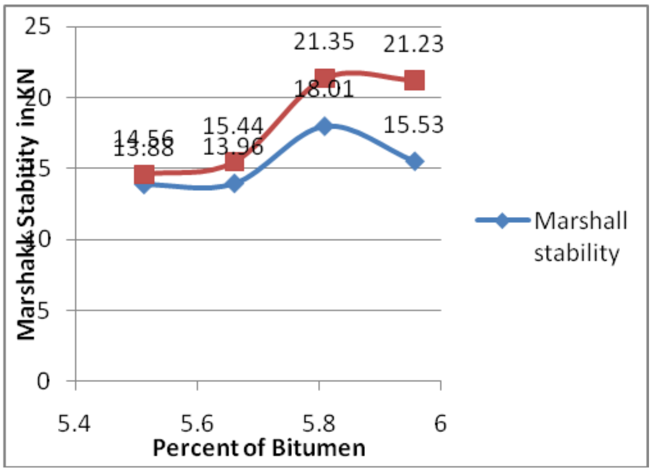

Fig. 4-6 Variation of Marshall Stability value of HMA and WMA with respect to Bitumen Content

NOTE- Marshall Stability was observed to have increased in warm mixes as compared to hot mixes i.e from 13.88 to 14.56, 13.96 to 15.44, 18.01 to 21.35, 15.53 to 21.23 at Binder Content 5.5118, 5.66, 5.808 and 5.956 respectively.

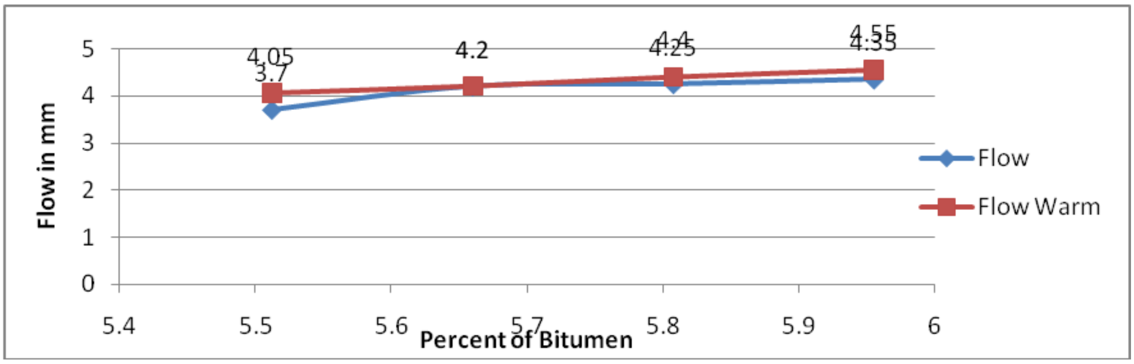

Fig. 4-7 Variation of Flow of HMA and WMA with respect to Bitumen Content

NOTE – flow was observed to be increased in warm mixes i.e from 3.7 to 4.05, 4.25 to 4.4, 4.35 to 4.55 at Binder Content 5.5118, 5.808, 5.956 bitumen percentage and remains same at bitumen % of 5.66.

4.1) Experimental Results of different parameters of Marshall Stability Test for VG-30

TABLE 4-4

3 Comparison of Normal and Warm Mixes of VG-30

Bitumen %	5.51		5.66		5.808		5.956	
	Warm	Normal	Warm	Normal	Warm	Normal	Warm	Normal
Density	2.33	2.34	2.34	2.35	2.337	2.343	2.33	2.34
Volume of Bitumen, V_b%	12.87	13.03	13.29	13.45	13.57	13.60	13.87	13.93
Volume of aggregates $V_{A\%}$	80.73	81.09	80.97	81.30	80.41	80.60	80	80.34
Voids in mineral aggregate (VMA)%	17.52	17.25	17.04	17.01	17.75	17.54	18.11	17.76
Voids filled with bitumen(VFB) %	73.46	75.56	78	79.07	76.44	77.58	76.62	78.49
Measured stability,(KN)	15.08	15	15.88	15.18	21.86	18.35	21	18.28
Flow value	3.9	4	4.0	4.6	4.45	4.7	4.8	4.95

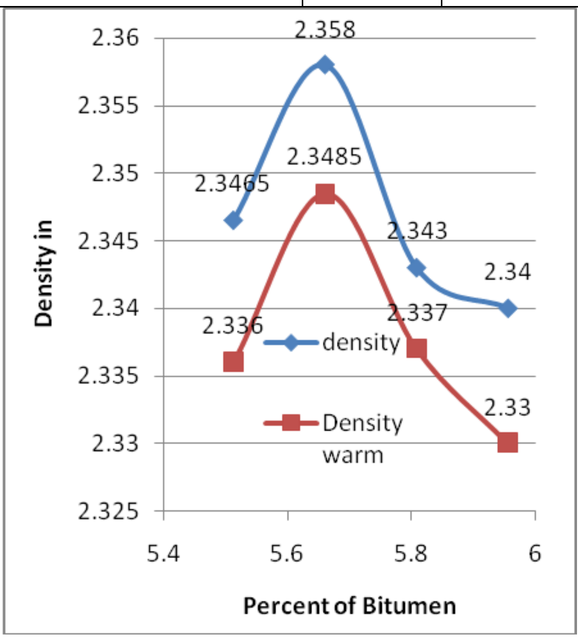

Fig. 4-8 Variation of Density of HMA and WMA with respect to Bitumen Content

NOTE- densities of warm mixes are observed to have decreased in warm mixes as compared to hot mixes i.e from 2.3465 to 2.336, 2.358 to 2.3485, 2.343 to 2.337 and 2.34 to 2.33 at binder content 5.5118, 5.66, 5.808 and 5.956 respectively.

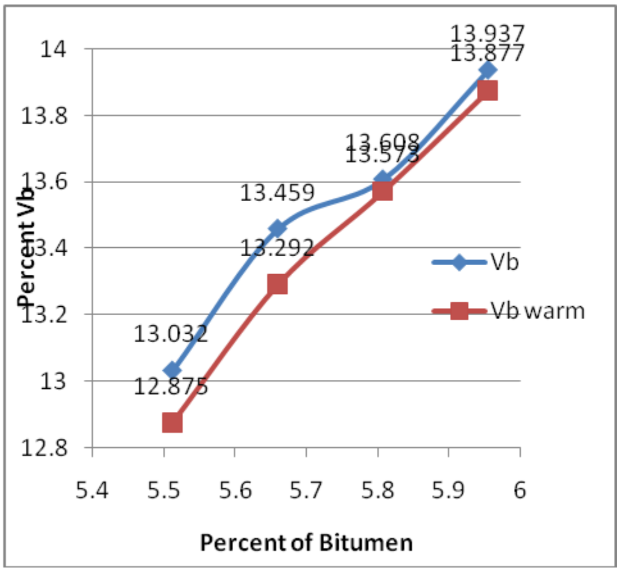

Fig. 4-9 Variation of V_b of HMA and WMA with respect to Bitumen Content

NOTE- $V_b$of Warm Mix is observed to be decreased when compared to Hot Mix i.e 13.032 to 12.875, 13.459 to 13.292, 13.608 to 13.573 and 13.937 to 13.877 at binder content 5.5118, 5.66, 5.808 and 5.956 respectively

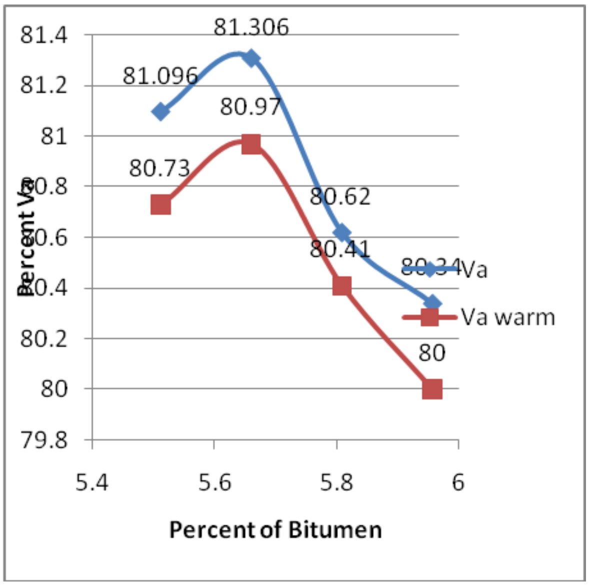

Fig. 4-10 Variation of $V_a$of HMA and WMA with respect to Bitumen Content

NOTE- $V_a$of Warm Mix is observed to be decreased when compared to Hot Mix i.e 81.096 to 80.73, 81.306 to 80.97, 80.62 to 80.41 and 80.34 to 80 at binder content 5.5118, 5.66, 5.808 and 5.956 respectively.

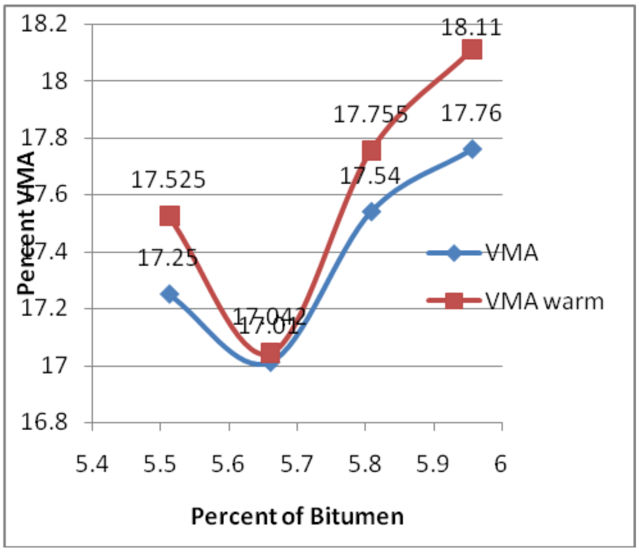

Fig. 4-11 Variation of VMA of HMA and WMA with respect to Bitumen Content

NOTE- VMA of Warm Mixes is observed to have increased when compared to Hot Mixes i.e 17.25 to 17.525, 17.01 to 17.042, 17.54 to 17.755 and 17.76 to 18.11 at binder Content 5.5118, 5.66, 5.808 and 5.956 respectively.

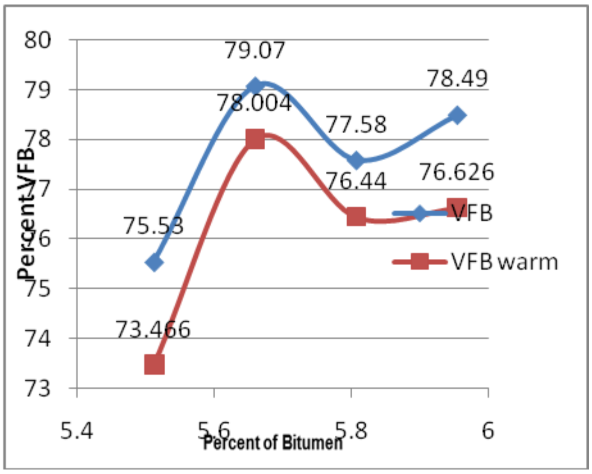

Fig. 4-12 Variation of VFB of HMA and WMA with respect to Bitumen Content

NOTE- VFB of Warm Mixes is observed to have decreased when compared to Hot Mixes i.e 75.53 to 73.466, 84.11 to 78.004, 77.58 to 76.44 and 78.49 to 76.626 at Binder Content 5.5118, 5.66, 5.808 and 5.956 respectively.

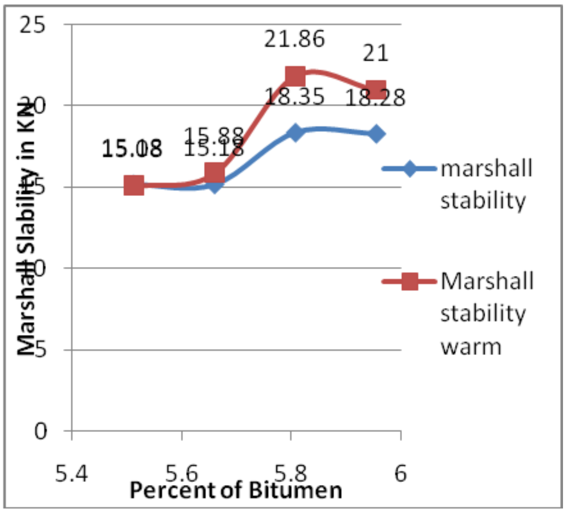

Fig. 4-13 Variation of Marshall Stability value of HMA and WMA with respect to Bitumen Content

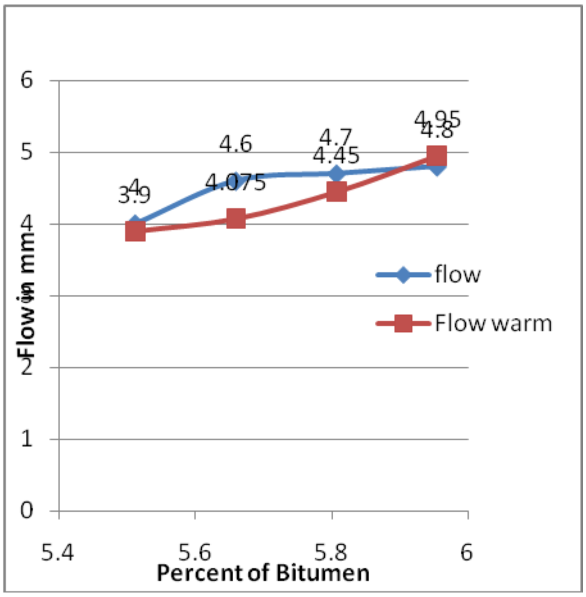

Fig. 4-14 **Variation of Flow of HMA and WMA with respect to Bitumen Content**

NOTE- flow of warm mix is observed to be decreased as compared to hot mixes i.e 4 to 3.9, 4.6 to 4.075, 4.7 to 4.45 and 4.95 to 4.8 at binder content 5.5118, 5.66, 5.808 and 5.956 respectively.

5 CONCLUSIONS:

- Density of Warm Mix Asphalt samples is lower as compared to Hot Mix Asphalt.
- Optimum binder content for Normal Mixes is found out to be 5.75 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. It concludes that Warm Mix sample have higher strength than Hot Mix samples.
- Percent VFB was found to be decrease in warm mixes as compared to hot mixes
- Percent VMA (Voids in Mineral Aggregates) were found to be increased in warm mixes than hot mixes.
- V_A and V_B were found to be decreased in warm mixes when compared to hot mixes.

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