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Research Article

Experimental Investigation of Warm Mix Using Rediset as additive with PMB 40 in Mix Design

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Abstract

In India, rapid growth in urbanization fuelled by growth in the industrial and service sectors resulted in rapid growth of laden vehicles in limited road space to withstand high stresses with minimum maintenance. Also increasing concerns on environment and greenhouse effect, increased construction prices led to the development of new technologies. WarmMix Asphalt (WMA) is one of newest technologies that allow mixing, production, placing and compaction of asphalt mixes at significantly lower temperatures due to chemical modification of the bitumen as compared to the traditional Hot Mix Asphalt (HMA) practice. Lower temperatures result in reduced fuel usage, fume exhausts, greenhouse gas emissions, reduces wear and tear, while enhancing worker health and safety conditions during pavement construction. WMA practice could be a potential step towards preserving resources and can have a significant impact on transportation construction projects, while addressing growing environmental sustainability. It is utmost important to investigate WMA technologies with and without PMB 40 grade mix to attain the required performance of pavement characteristic.

Keywords: *Warm mix, Rediset, PMB 40.*

1. Introduction

India is a very vast country, with cities recognising as engines of progress, having widely varying climate, terrain, construction materials and mixed traffic both in terms of loads and volume. The road structures have deteriorated rapidly than expected due to increase in traffic density, axle loading and tyre pressure and an insufficient degree of maintenance. Binder modification is a major breakthrough and the continuous research to enhance the physical property of bitumen to meet the needs of a particular paving project by satisfying the recommendation and requirements of MoRTH Section 508. The main idea of this research paper was to use the established industry standards of PMB 40 asphalt mixtures with and without required dosage of relatively new warm mix asphalt (WMA) technology in order to create a more sustainable and eco-friendly asphalt paving process.

Typically, the mixing temperatures of warm mix bitumen range from 100° to 130 °C compared to the mixing temperatures of 150°C to 160 °C for hot mix Bitumen. Warm mix additives namely Rediset dose in 1.5%, 2.0% and 2.5% is used with PMB 40 to reduce the temperature of production and compaction. Rediset WMX system enables the production of hot mix ≥ 30°C lower temperature compared to control Hot Mix, to meet the demands of better pavement, enhanced performance, reduced energy consumption and increase in environment benefits. (Brain D. Prowell, Ph.D , P.E, Principal Engineer, Warm mix Asphalt Best Practices, National Asphalt Pavement Association, Quality Improvement Series 125)

2. Materials & Methodology

2.1 Polymer Modified Binder (PMB 40)

Polymer Modified Bitumen is manufactured with a specially blended feed, making the binder homogenous and storage stable. It is obtained from Hincol Industry, Savli, Vadodara district, Gujarat. It enhances the key properties of asphalt mixes, i.e. deformation resistance and fatigue life. These improvements are the result of three vital physical changes which the polymer makes in the conventional binder structure: reduced temperature susceptibility, increased stiffness modulus and enhanced elasticity. (Gagandeep Singh, Satish Pandey, M.N.Nagabhusana, P.K.Jain, 2013))

2.2 Warm Mix – Adhesion Promoter (Rediset)

The newest Warm Mix Asphalt (WMA) production technology involves chemical modification of the bitumen. In this study Rediset WMX is used, it is a proprietary chemical additive that comes in a pellet solid form designed as a warm mix additive with adhesion promotion properties. It is added to the binder in 1.5%, 2.0% and 2.5% by weight of binder and blending it to proper mixing

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Table 1 Physical Properties of Aggregate

Sr.No.	Property	Test	Result		Recom.Value (MoRTH 500 section-508)	
1	Cleanliness (dust)	Grain size analysis	2.11%		Max 5% passing 0.75 mm sieve	
2	Toughness	Aggregate Impact value	11.3%		24% Max	
3	Particle shape	Flakiness and elongation Index (combined)	22.44%		30% Max	
4	Water absorption	Water absorption	20 mm Agg.= 0.3% 6 mm Agg. = 1.66%		2% Max	
5	Specific Gravity & Gradation	Specific Gravity	Sp.gr	Wt. of sample	% of Sample	-
		20 mm Agg	2.64	564	47	
		6 mm Agg.	2.49	276	23	
		Stone dust	2.49	324	27	
		Lime	2.26	36	03	
		Total		1200	100	

Table 2 Test Result of PMB 40

Sr.No.	Tests	Results		Recommendation as per IS 15462-2004
		PMB 40	PMB 40 Rediset	
1	Penetration at 25 °C, 0.1 mm, 5 sec	48	44	30-50 (IS:1203)
2	Softening Point, °C, min	65	64.1	60 (IS:1205)
3	Specific Gravity	1.016		---
4	Viscosity, 150 °C , (Poise)	8.45	7.6	3-9 (IS:1206 Part-1)
5	Elastic recovery, 15 °C, % (min)	75	78	70(---)

at 110 °C temperature.(Animesh Das Warm mix Asphalt (2010))

3. Experimental Investigations

Initially the study shows the tests determining the physical properties of crusher aggregate sizes 20 mm and 6mm obtained from quarry of Chikhli, Navsari district. In order to meet the suitable mixes for bituminous mixes design, gradation meeting MoRTH section 508 using nominal aggregate size is taken with stone dust and lime as filler material. The Bitumen used for this study is ready made PMB 40 obtained from Hincol Company, GIDC Savli, Baroda District. Relevant tests to determine the properties on PMB 40 with and without rediset material are carried out.

Finally samples are prepared for Mix Design (Marshall Test) to determine the Optimum Bitumen Content of PMB 40. To it varied proportions of 1.5%, 2.0% and 2.5% of Rediset material is added by weight of PMB 40 to determine optimum temperature and optimum dosage of rediset to meet the required quality by satisfying the recommendation and requirements of MoRTH Section 508.

1. Laboratory Investigations to determine physical properties of aggregates quarry of Chikhli, Navsari District.

2. Gradation of Aggregates Meeting MoRTH Section 508

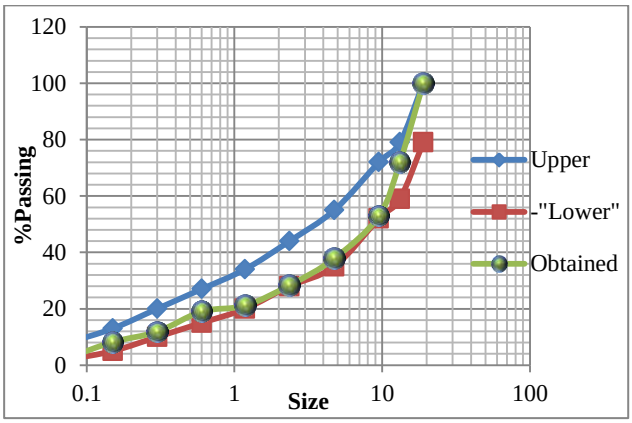

Fig.1 Gradation of aggregate chart

It is desirable for pavement design to have a workable, stable mix with resistance to water to attain the desired properties for the particular engineering application. From the plot of aggregate gradation chart as shown in figure 1, it shows specifically the obtained gradation line falls above the lower limit line which means that the selected aggregate proportion are classified as fine aggregate.

3. Laboratory Investigations to determine physical properties of PMB 40 with and without Rediset

4. Marshall Mix Design for Optimum Binder Content using PMB 40

The procedure and requirements of MoRTH section 508 is

Table 3 Marshall results showing properties of mix satisfying MoRTH section 508

Average Bitumen Content	Average Stability Kg	Average Flow Value mm	Average Bulk Sp. Gravity g/cc	Average Vv %	Average VFB %	VMA %
5	1819.67	3.37	2.32	5.83	64.61	16.34
5.5	2094.33	4.07	2.34	3.76	75.78	16.68
6	1974.67	5.30	2.32	4.12	75.42	16.75

taken into consideration for preparing 3 samples at different bitumen content at 5, 5.5 and 6% of gradation mix weight at mixing temperature of 160°C and a compaction temperature of 145°C.

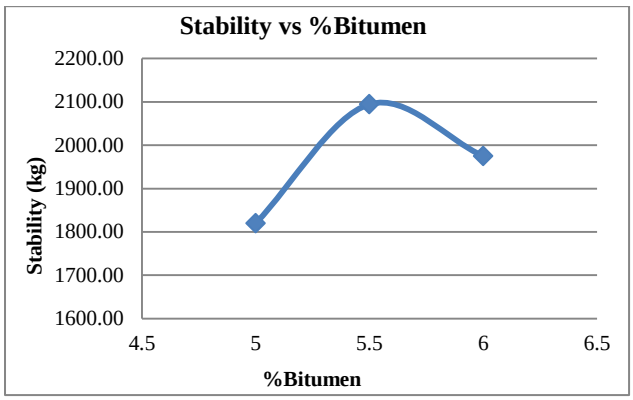

Figure 2 Stability Vs Bitumen

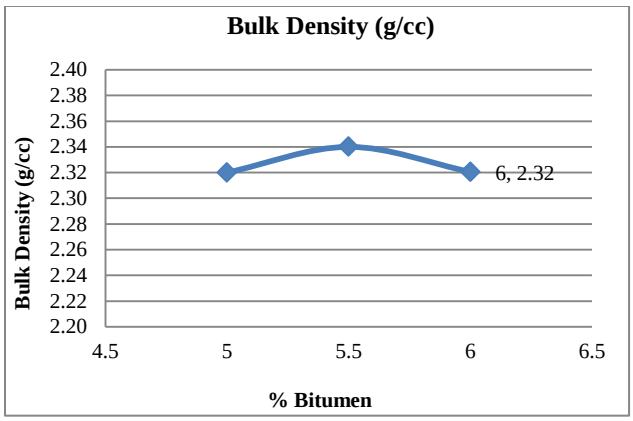

Figure 3 Bulk Density Vs Bitumen

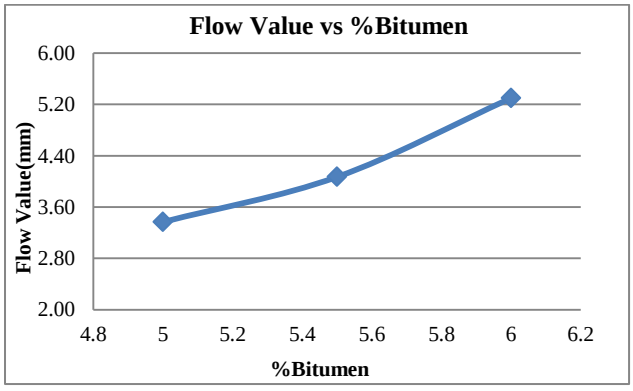

Figure 4 Bitumen Vs Flow Value

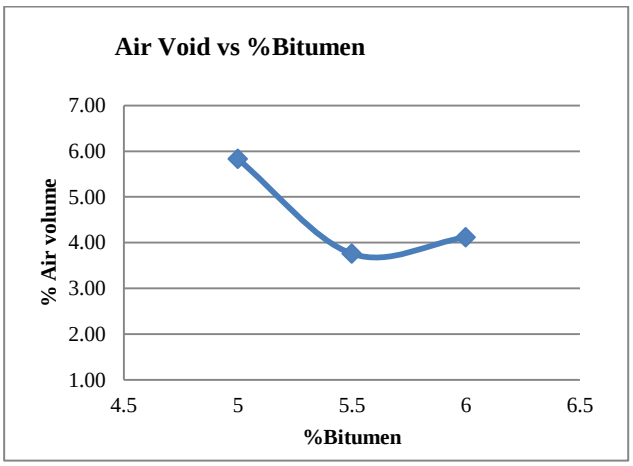

Figure 5 Air Voids Vs Bitumen

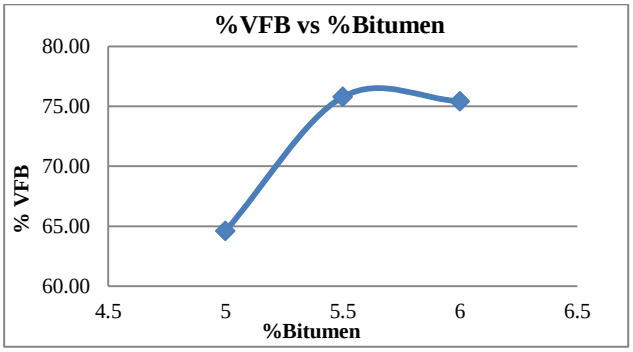

Figure 6 VFB Vs Bitumen

Volumetric and mechanical properties of Marshall Specimens, obtained at varying binder content are presented in figure 2, 3, 4, 5 and 6. Optimum binder content comes out to be 5.5% (by weight of aggregates) respectively. The Marshall mix satisfies the limit laid down in MoRTH section 508 with respect to maximum stability, flow value, bulk specific gravity, percentage air voids in compacted mix and voids filled with bitumen.

5. Marshall Mix design for PMB 40 (5.5 % optimum binder content) plus Rediset with optimum dosage and optimum temperature

In order to obtain homogeneous mix and to achieve the required standards for attaining the quality and characteristics for pavement construction, test results of Bituminous Concrete mix using PMB 40 with 5.5% optimum bitumen content is taken into consideration for mix design by addition of 1.5, 2 and 2.5% dosage of Rediset at temperature 110°C, 120°C and 130°C by weight

of PMB 40. PMB 40 plus rediset increases the elastic component of the bitumen and reduces visco-elastic component of the bitumen. Both modifications will result in increase stiffness of the as phalt, which will enhance the load spreading capability of material, increase in structural strength and lengthens the expected design life of the pavement. Graphs of all properties of each mix are plotted as shown in figure.

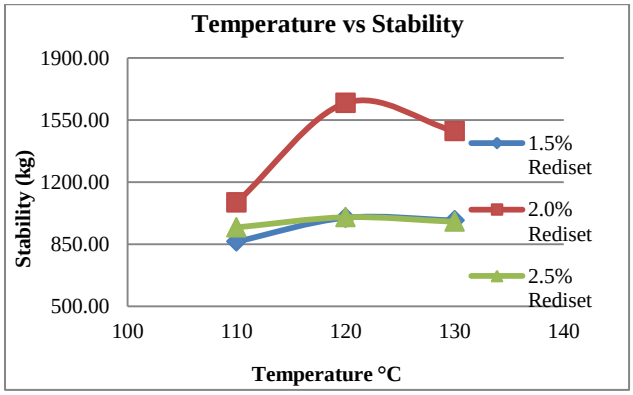

Figure 7 Temperature Vs Stability

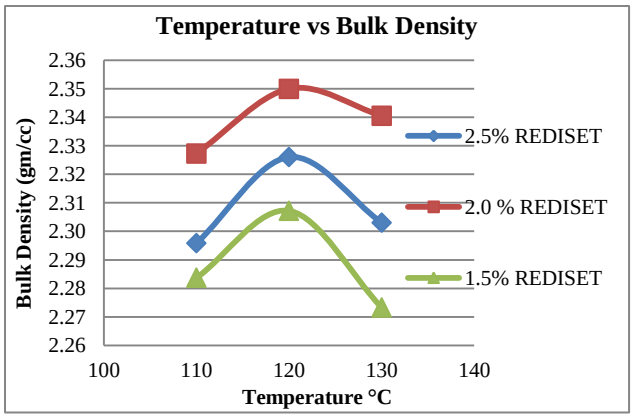

Figure 8 Temperature Vs Bulk Sp. Gravity

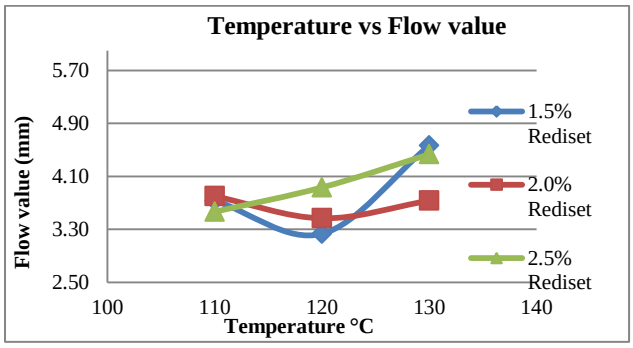

Figure 9 Temperature Vs Flow Value

The analysis of study, looking to the graphs clearly shows that optimum temperature is 120°C for warm mix design at 2% addition of Rediset. The MoRTH requirements are fulfilled at this temperature. This shows a remarkable decrease in temperature of mix design compared to PMB 40 grade without rediset. The addition of rediset in PMB 40 is obviously clear that the binder properties allows sufficient coating of the aggregates and has potential to enhance workability of mix and can therefore remain compatible for a longer period of time, with decrease in their air voids. Also reduction in temperature causes reduction in the smoke and odor and may thus result in improved working conditions.

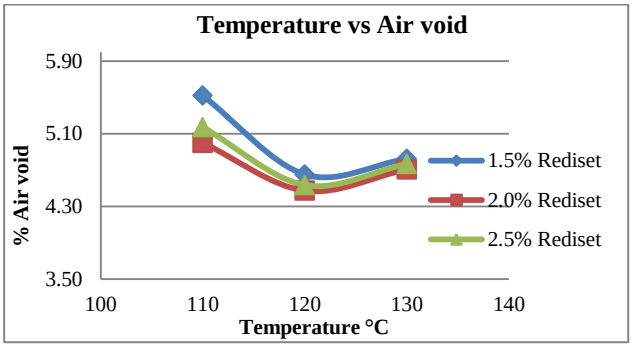

Figure10. Temperature Vs Air void

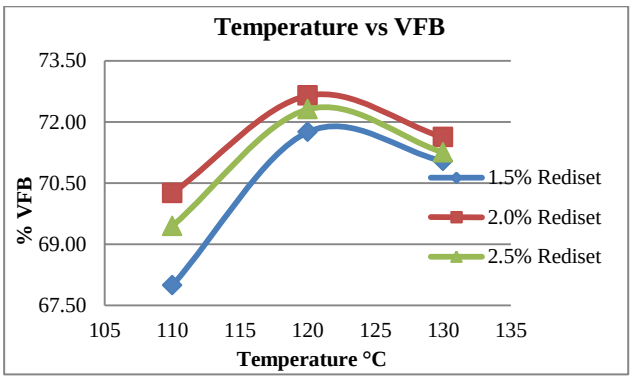

Figure11. Temperature Vs VFB

Reduction in air voids up to temperature 120° C shows rise in stability and bulk specific gravity. After 120°C decreasing trend in stability, bulk density, volume filled with bitumen is seen with the rise in air voids is seen.

4. Conclusion

By this study it is possible to prepare PMB 40 mixes at 120 ºC temperature using Warm mix - Adhesion Promoter. Warm Mix Asphalt (WMA) is an innovation in paving technology which offers reduced mixing temperatures, when compared to traditional Hot Mix Asphalt (HMA) mixed at 150 to 160° C. A reduction in mixing temperatures results in reduced CO_2 emissions, increased sustainability, improved working conditions for construction and maintenance crews, extended paving season and financial benefits derived through lower production costs. Hence Warm Mix is the Future of Asphalt Mixtures.

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