A Study on Emulsion Based Half Warm Bituminous Mix

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Abstract— There is a lot of international pressure on the reduction of fossil fuels consumption and the emission of greenhouse effect gases (GHG), like CO2(carbon dioxide), SO2 (sulphur dioxide), NOx etc. Sadly, the production of hot-mix asphalt (HMA) for pavements is attributed towards a big proportion of the energy consumption and also the unharness of waste material gases This can be a consequence of drying and heating mineral aggregates, bitumen at temperatures higher than 150˚C, commixture of those ingredients to provide hot hydrocarbon mixtures. In this paper study of Hot Mix, Warm Mix & Cold Mix Asphalt mix is done & found effective.

Key words: Half Warm Bituminous Mix

I. Introduction

In terms of our modern civilization, it is proven fact that there are more people alive on our planet today (more than 6billion), than have ever perished within the history of humankind. Development of the global road infrastructure is equivalent to this situation with the majority of the necessary capacity of roads being presently in place. Due to this reason, road maintenance, rehabilitation and upgrading have become gradually important to pavement engineers.

In particular, cold recycling of existing pavements using bitumen emulsion is gaining popularity as a means of road rehabilitation. This directly implies that for existing high-level facilities enabled for upgrading of unpaved roads. Mainly due to environmental, economic and practical benefits in the use of cold bituminous mixes. Another benefit around this approach is static and mobile plant with the capability of performing stabilization with bitumen emulsion has become commercially available and globally utilized. This technology bears a disadvantage that it's not applicable over hotter regions. For this purpose a middle way in between to HMA and CMA is been developed known as Warm Mix Asphalt, whereas not much research has been done in this area to understand pros & cons of Warm Mix Asphalt approach. That should cover understanding of the behaviour and failure mechanism of these warm mixes. Also sound guidelines for the mix design procedures of warm mixes, especially emulsion based half warm bitumen mix & design guidelines for pavements structures incorporating these materials are lacking.

The enhancements in mix design procedures and related equipment for hot mix asphalt have overshadowed developments in cold mix design. Initiatives such as SHRP Superpave (1994) in the United States of America, as well as research produced at LCPC in France are two examples that have opened up new avenues in the hot mix asphalt design approach. Contemporary research undertaken on emulsion based mixes has been limited, by comparison. The volumetric considerations, mode of failure and critical mechanical properties that influence the performance of these materials require clarification for reliable and cost-effective pavement layers to be manufactured. These are areas that require more definition through research in order to provide pavement engineers with the tools to make judicious decisions.

For the road sector it costs about a crore rupee for construction and maintaining a section of one lane kilo meter road during its life span. India has about 46 lakh kilo meters of roads and still the infrastructure of roads is yet to be constructed and maintained. One of the challenges in India is to have quality roads in cities and villages to have better connectivity. Some of the villages have no roads and for that the inefficiency of the system prevailing, including the engineers is blamed. Most of the roads are being constructed using Hot Mix Plants contributing to carbon emissions in the air. According to environmentalists point of view the hot mix technology should be minimized to drop down the carbon emission and a new alternative is to be find out. But how this can be done on this fastest growing economy which is calling the urgency in road sector?

In addition to the global opportunities for advances in technology, India in particular, has a need for developing technologies in road construction that provide employment opportunities for local inhabitants in developing areas. Labour intensive construction requires technical soundness and economic competitiveness for these initiatives to be successful. Emulsion based Half Warm Asphalt Mixes is technology with the potential for utilization in labour intensive construction and in the process providing good quality services. Emulsion based technologies have to be fully exploited in this field and scope exists for the development of new construction processes that extract more benefits from the emulsion stabilized half warm mixes.

Against this backdrop of opportunity and challenge, research dissertations into half warm asphalt mixes have been structured. This chapter introduces the emulsion based half warm asphalt mix and explores some of the differences between foam bitumen mix, cold asphalt emulsion and conventional hot mix asphalt highlighting the advantages and disadvantages of each. In addition the chapter provides the background of mix design procedures for bituminous mixes in road engineering industry and their purpose, with emphasis on the emulsion based half warm asphalt mixes. Finally and most important, the objectives of the research dissertation are detailed.

II. Experimental Program

A. Materials Used

1) Aggregates: Naturally available aggregates were used as per MORT&H 2001 specification for SDBC and DBM. Results are as follow:

Property	Test Performed	Specification as per MoRTH 2013	Test Result

Cleanliness (dust)	Grain Size Analysis	Max. 5% passing 0.075mm sieve	2%
Particle Shape	Combined Flakiness and Elongation Test	Max 35%	25%
Strength	Aggregate Impact Test	Max 24%	18%
Soundness	Soundness in Sodium Sulphate	Max 12%	7%
Water Absorption	Water Absorption test	Max 2%	1.99%
Specific Gravity	Specific Gravity Test	-	2.69 (20 mm) 2.64 (10mm) 2.2(dust)
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum Retained Coating 95%	98%

2) Aggregates Gradation:

The grading of aggregates acquired for the preparation of BC Layer:

Sieve Size, mm	Percentage of aggregates passing through sieve sizes				
	Nominal size of aggregates		Blending proportion by weight of aggregate Aggregate : Stone Dust 80:20	Specified limits for 50mm BC as per MoRTH 2013	
	Aggregate	Stone Dust		Upper Limit	Lower Limit
26.50	100.00	100.00	100.00	100.00	100.00
19.00	90.45	100.00	92.36	100.00	90.00
13.20	72.46	100.00	77.97	79.00	59.00
9.50	55.48	100.00	64.38	72.00	52.00
4.75	26.63	100.00	41.31	55.00	35.00
2.36	16.68	83.29	30.00	44.00	28.00
1.18	15.60	54.32	23.34	34.00	20.00
0.60	8.84	42.09	15.49	27.00	15.00
0.30	6.23	28.43	10.67	20.00	10.00
0.15	4.12	18.48	6.99	13.00	5.00
0.08	2.71	12.58	4.69	8.00	2.00
Proportion →	80 %	20 %	100%		

3) Binder:

Bitumen Emulsion SS-2 satisfying provisions as per IS: 8887-2004.

Property	Method of Test	Test specification as per IS:8887-2007	Test Result
Residue on 600micron IS sieve, % by mass	IS:8887-2007 Annex-B	Max 2	2
Viscosity by Saybolt furol viscometer, seconds @ 25˚C	IS:3117	30-150	108
Coagulation of emulsion at low temperature	IS:8887-2007 Annex-C	Nil	Nil
Particle Charge	IS:8887-2007 Annex-E	Positive	Positive
Residue by evaporation, %	IS:8887-2007 Annex-J	Min 60	61

4) Optimum Binder Content (OBC):

For finding of OBC for Marshall's sample were prepared at 90˚C temperature with different percentage of emulsion varying from 7%, 8%, 9% and 10%. Samples were prepared by mixing aggregates having temperature of about 90˚C with emulsion at room temperature and then compacted by applying 75blows. When these samples were tested for Indirect Tensile Strength it is found that optimum value for binder content at which maximum strength is 9% for SDBC and 8.33% for DBM.

5) Preparation of Test Specimens:

After finding of OBC Marshall's samples were prepared at OBC for performing different tests on the sample to compare the results of HWMA and CMA. Samples for CMA were prepared by mixing both aggregate and emulsion at room temperature and then left for 2hr and then compacted by applying 75 blows. While in case of HWMA the aggregates were heated at about 90˚C and emulsion is mixed and then compacted by applying 75 blows. The samples were unmolded after 2days.

6) Test Conducted:

The test conducted on the samples for determining different properties were Marshall's Stability Test, Indirect Tensile Strength Test, Modulus of Resilient value and Dynamic Creep Test.

III. Observations and Results

The results for different tests are as follows:

1) Marshall's Stability:

Properties	Test Result for HWMA			Specified Limits for BC layer using natural aggregates	
	Curing Time 1 day	Curing Time 3 days	Curing Time 30 days	For CMA as per MoRT&H 2013	For HWMA as per IRC SP:100-2014
Marshall Stability, kN @ 25 ˚C	4	7	15	2.2	Min. 9
Flow, mm	4.8	4.7	4.5	Min. 2	Max. 5
Air Voids, %	5	5	5.5	3-5	3-6
Specific Gravity	2.1	2.1	2.2	1.95	-

The Marshall's stability increases just about double in case of SDBC in HWMA when compared to CMA and about 50% increment in DBM in HWMA compared to CMA.

2) Indirect Tensile Strength:

Properties	Test Result for HWMA test			Specified Limits for BC layer using natural aggregates	
	Curing Time 1 day	Curing Time 3 days	Curing Time 30 days	For CMA as per MoRT&H 2013	For HWMA as per IRC SP:100-2014
Marshall Stability, kN @ 25 ˚C	4	7	15	2.2	Min. 9
Retained Stability, %	81	81	87	Min. 50	Min. 80
ITS @ 25 ˚C, kg/cm2	2.5	2.5	4.1	1.7	-
Tensile Strength Ratio, %	79	79	80	80	Min. 80

The ITS value also increases significantly for HWMA than CMA for DBM layers.

3) Modulus of Resilience:

Properties	Test Result for HWMA	
	Curing Time 3 days	Curing Time 30 days
Resilient Modulus, MPa @ 15 ˚C	3400	3750
Resilient Modulus, MPa @ 25 ˚C	2200	2400
Resilient Modulus, MPa @ 35 ˚C	800	900

The modulus of resilience comes greater for HWMA than CMA in case of DBM.

IV. CONCLUSIONS

Based on the study, following conclusions have been drawn:

– Among the mechanical properties, Marshall Stability is found to be curing and time dependent. The stability value of emulsion based HWMA increases with curing of samples.
– Mechanical properties such as Marshall Stability, indirect tensile strength and tensile strength ratio of emulsion based HWMA satisfied the requirements of HWMA as per IRC SP-100:2014.
– At present, there are no detailed guidelines available for emulsion based half warm mixes. Results of the laboratory studies carried out will facilitate the framing of guidelines.
– HWMA technology is an environment friendly technology which has advantages like cost savings, energy savings, reducing global warming that is reduction in pollutant and greenhouse gases emissions.

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