Comparative Study of Emulsion Based Half Warm Mix and Cold Mix for Construction of SDBC and DBM

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Abstract—There is increase in pollution due to increase in the use of vehicles which leads for upgrading of roads to withstand more load. CMA is a technology which does not impart more pollution as compared to traditional HMA but it wears less load. Using new technology known as Emulsion based Half Warm Mix Asphalt not only increase load bearing capacity of roads but is also cost effective and environmentally friendly. In this paper study of HWMA with comparison to CMA is done for SDBC and DBM layer of flexible pavement and is found to be effective over use of CMA.

Key words: CMA, SDBC, DBM

I. INTRODUCTION

Bitumen is the basic ingredient of flexible pavement construction. Bitumen came to us from the fractional distillation of tar. It is a viscous material, which is to be liquefied while using as a binder in flexible pavement construction.

In our day to day life we all are familiar with the construction procedure for flexible pavement. There are three basic technologies which are known today in flexible pavement construction namely: Hot Mix Asphalt (HMA), Warm Mix Asphalt (WMA) and Cold Mix Asphalt (CMA). All the three have the advantages and disadvantages.

For instance the advantage of HMA is that it is meant to be constructed where road has to wear more load and it can resist high temperature of range about 70°C. But it has a disadvantage of about 150°C to 170°C as working temperature which is quite higher which has to sustain by the labors while laying of the HMA based roads. To maintain this temperature it requires a large energy leading to wasting a lot of cost towards liquefying bitumen so that it can strip to the aggregate easily.

Secondly for CMA has an advantage that it does not require high working temperature, it requires about 60°C-70°C operating temperature, means cost saving for fuel. But it has a disadvantage that it cannot withstand in hot climatic regions. Similarly we talk about WMA it is subdivided into two categories one with additive and second without additive. WMA prepared with the additives such Evotherm, Sasobit, Redisat etc. requires a working temperature of 110°C-150°C. But the cost of these additives is much higher so the overall cost is approximately equal to that of HMA.

While WMA prepared without additives called as foamed bitumen requires mainly the cost to make the foam of bitumen and then laid it which also requires laying temperature of about 120°C thus the cost saving is not much more. And also its life span is not confirming towards that with HMA.

We have developed a new technology known as Emulsion based Half Warm Mix Technology (HWMA). In this technology emulsion is taken as a binder and mixed with aggregates at a lower temperature of about 90°C. The main figure for this technology is that the labor can work for the flexible pavement construction easily. The fumes evolved during mixing of binder with aggregate are less. This new technology saves the cost for fuel consumption w.r.t. HMA and WMA. It can be used also at the places where the ventilation is less.

Although it is not good enough than HMA but it is best than the conventional CMA. It can withstand more temperature than CMA. Its binding property of binder and aggregate is good as compared to CMA without heating. This new technology is good to be used at colder regions as compared to CMA.

This Emulsion based Half Warm Asphalt Mix technology has been compared with the conventionally used CMA for preparation Semi-Dense Bituminous Macadam (SDBC) and Dense Bituminous Macadam (DBM) layers by making various Marshall’s samples for different types of tests and the results were better than conventional CMA for design of SDBC and DBM.

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:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Test</th>
<th>Result</th>
<th>MORTH Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aggregate Impact value</td>
<td>11.30%</td>
<td>25% max</td>
</tr>
<tr>
<td>2</td>
<td>Water absorption</td>
<td>0.30% (20 mm)</td>
<td>2% max</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.66% (10mm)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Specific Gravity</td>
<td>2.69 (20 mm)</td>
<td>2.6-2.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.64 (10mm)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.61(dust)</td>
<td></td>
</tr>
</tbody>
</table>

2) Aggregates Gradation:

The grading of aggregates acquired for the preparation of SDBC test specimens is as follow:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage of aggregates passing through sieve size</th>
<th>Blend Proportion by wt. of aggregate</th>
<th>Specified Limits for 25 mm SDBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 mm</td>
<td>45:20:32:3</td>
<td>A:B:C:D</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nominal size of aggregates (mm)</th>
<th>Specified Proportion by wt. of aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>45:20:32:3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>6</td>
<td>Stone Dust</td>
<td>Lime</td>
</tr>
<tr>
<td>13.2</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
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( IJSRD/Vol. 3/Issue 03/2015/727)

IV. OBSERVATION AND RESULTS

The results for different tests are as follows:

A. Marshall’s Stability:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Marshall’s Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMA</td>
<td>8.93</td>
</tr>
<tr>
<td>SDBC</td>
<td>12.95</td>
</tr>
<tr>
<td>DBM</td>
<td>11.4</td>
</tr>
<tr>
<td></td>
<td>15.36</td>
</tr>
</tbody>
</table>

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.

B. Indirect Tensile Strength:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>ITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMA</td>
<td>4.4</td>
</tr>
<tr>
<td>HWMA</td>
<td>6.2</td>
</tr>
<tr>
<td>DBM</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td>6.9</td>
</tr>
</tbody>
</table>

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

C. Modulus of Resilience @ 25˚C:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Modulus of Resilience @25˚C</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMA</td>
<td>1600</td>
</tr>
<tr>
<td>SDBC</td>
<td>2400</td>
</tr>
<tr>
<td>DBM</td>
<td>1900</td>
</tr>
<tr>
<td></td>
<td>2500</td>
</tr>
</tbody>
</table>

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

D. Dynamic Creep Test @ 35˚C:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Dynamic Creep @35˚C</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMA</td>
<td>0.726</td>
</tr>
<tr>
<td>SDBC</td>
<td>1.155</td>
</tr>
<tr>
<td>DBM</td>
<td>0.279</td>
</tr>
<tr>
<td></td>
<td>1.542</td>
</tr>
</tbody>
</table>

The total permanent strain comes greater in both SDBC and DBM for HWMA than CMA.

IV. CONCLUSION

- From the results it has been concluded that the HWMA technology is more effective than CMA as it gives higher stability values.
- Both Cold mix and Half Warm mix technologies helps in reducing environment degradation and Global Warming. Use of such kind of technologies in Pavement layers allowed to reducing the mixing and compaction temperature.
- The use of Emulsion based HWMA increases the bearing capacity of pavement layers more as compared to CMA.
- We can use half warm mixes as a green bituminous mix in road construction as it is environment friendly and conserves energy. It uses 50% less energy as compared to the traditional HMA.
- Addition of bitumen emulsion in Cold and Warm mix technologies reduces the environment degradation, global warming and fuel cost.
- For curing of pavement layers with using bitumen emulsion in road construction gives higher stability value with increasing curing periods.

The grading of aggregates acquired for the preparation of DBM test specimens is as follows:

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<td>A:B:C:D</td>
<td>Specified Limits for 25mm DBM</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>3.75</td>
<td>3.61</td>
</tr>
<tr>
<td>2.36</td>
<td>0.8</td>
</tr>
<tr>
<td>0.72</td>
<td>0.49</td>
</tr>
<tr>
<td>0.30</td>
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</tr>
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<td>0.075</td>
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</tbody>
</table>

3) Binder:

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

4) Optimum Binder Content (OBC):

For finding of OBC for HWMA 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 75 blows. 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 2hrs 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:
ACKNOWLEDGMENT
Authors are thankful to Director, CSIR-CRRI New Delhi for granting permission to carry out this research of national importance.

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