Laboratory Evaluation of Bituminous Concrete Mix using Envirotac-Sc as a Chemical Additive

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Abstract— The economy of a nation is mainly governed by the transportation sector. In India, there has been a piercing upturn in the populace resulting in increased traffic which also increases the loading on the flexible pavement. Due to that demand for better pavement to withstand all the worse condition also increased. So additives are added to improve the properties of the bituminous concrete mix. In the present investigations Envirotac-Sc chemical is added to the bitumen and the bitumen’s physical and engineering properties are investigated with different percentages of chemical by the weight of the bitumen. As the result, the additives improve the bitumen’s performance. Then the bituminous concrete mix is prepared by using virgin bitumen VG-10 and also by addition of Envirotac-Sc to the bitumen and tested as per Marshall Method of mix design. As the conclusion, the existence of Envirotac Sc chemical in the bitumen improves the properties of the bitumen. Hence, the bitumen helps in resisting distress such as rutting and cracking. The decrease in the penetration with the increase in the Envirotac-SC further confirms the improvement of bitumen properties. The stability of the BC mix prepared by addition of Envirotac-Sc found little more than the conventional BC mix. However, some recommendations are commended in order to attain superior results.

Key words: Envirotac-Sc, VG-10, Marshall mix design

I. INTRODUCTION

The quality of the roads detects economy of a country. In India, there has been a piercing upturn in the populace and the development in industrialization resulting in increased traffic including large varieties of vehicles posing heavy load on the inadequate road space. This causes more stresses on roads. Due to this the life period of the roads get decreases. The pavements are suffering from the premature failures generally in terms of rutting and cracking. A number of elements affect the performance of the Pavement, mainly the constituents of mix (aggregates binder and additives). Effective, well-timed and speedy maintenance is the only solution to protect the huge capital investment linked to the road. Two important concerns in flexible pavement is – pavement design and mix design. The current study is related to the mix design concerns.

The deterioration of the pavement increases with the growth of traffic on roads and hence requires higher stability and long durability mix. To ease this process many measures such as use of better quality materials. The Conventional solution preferred for this is overlaying the deteriorated pavement but the persistent overlaying will increase the thickness of the pavement. So the invention of new binders containing polymers and reinforcement is given importance. There are several methods to develop the properties of the mix. One of the methods is constructing the pavement of higher thickness but this will costs high. The other method is modification of bitumen by the use various types of additives as modifiers. The additives can be added to asphalt in two ways. One way is wet process and the other is dry process. In first method the additives are added to the asphalt prior to mixing with the aggregates. In second method the additives are added directly to the mix. Polymers normally increase the stiffness of the bitumen and also enhance the temperature susceptibility. This in turn improves the rutting resistance of the mix. Use of chemical additives which can acts as adhesive between bitumen and aggregates is also one of the Options. In the present study a chemical additive by name ENVIROTAC-SC (Super concentrate) is used as additive to the bitumen.

A. Introduction to ENVIROTAC-SC

ENVIROTAC super concentrate contains environmentally safe chemicals which will work on the principles of Nano technology.

1) Physical Properties of Envirotac-Sc
   - Liquid in state ,
   - White in color ,Mild sweet in odor,
   - Specific gravity 1.080,
   - pH 5.0

2) Chemical Composition/ Ingredients
   - Polyethylene glycol octyl phenoxy ether 1 to 5%
   - Polyethylene glycol octyl phenyl ether 1 to 5%
   - It consists of 55 to 60% active solids.
   - This does not comprise controlled levels of carcinogens.

II. OBJECTIVES OF THE STUDY

- To determine the advantages of using ENVIROTAC-SC, as an improver with the bitumen
- Comparative study of the physical properties of the bitumen VG-10 with and without adding ENVIROTAC-SC
- To study the Marshall properties of the BC mix with Envirotac-SC.
- Comparison of Marshall Properties of BC mix with and without Envirotac-SC.

III. LITERATURE REVIEW

The Caltrans report on erosion control using new technology has briefly reported the facts of Envirotac-II in erosion control. Envirotac II is a hydraulic and acrylic copolymer soil stabilizer. The Envirotac chemical decreases the sediment run off by binding soil particles in place.

He Main, Cao dongi-Weyi, Zhang haii- yan, Soong zhaoi-rui, Wue Xiao-wyi have done a research on the performance of the bio-asphalt modification. They studied the properties including penetration, softening point and ductility of the modified asphalt with the bio asphalt in...
varying proportions. From the tests results they found that the penetration of the bio-asphalt decreased with the increase in the modified asphalt. The ductility of the bio-asphalt has also improved.

C.B. Mishra, Tirthakara Dam, Vinal Khambhayta, Dakesh Makwana, Sanjay Jadav, have presented a paper on “Utilization of Zycosoil as Additive for VG-10 Paving Mix”. This study involved in improving the technique for determining the optimum binder content with and without using the nanotech synthetic chemical by name Zycosoil. The Zycosoil is synthetic in structure hence it is water dissolvable. It changes the bond with the aggregates. This Zycosoil was added to bitumen in varying dosage and the marshmallow mix properties are compared. Additionally boiling point test has been conducted to emphasis on the dampness. From the study it was concluded that, with the expansion of Zycosoil the solidity and workability of bituminous blend has expanded. Only a marginal difference was seen in volumetric properties of the mix with and without the usage of Zycosoil. The dampness of bitumen get reduces with the addition of Zycosoil and expands the life of asphalt mix.

A study on warm mix asphalt (WMA) with the use of Zycotherm as an additive by Prof. Amith kumar A. Patel, Tushar A. kansagra. Warm mix asphalt is a new technology which allows the mixing placing and compaction of the mix at a low temperature. This decreased temperature is due to chemical modification of the virgin bitumen. There by there will be reduction in the fuel consumption, reduced wear and tear, less air pollution etc. In this study bituminous mix is prepared by using polymer modified bitumen (PMB) 40 with the chemical Zycotherm in optimum doses and is tested for their properties. The optimum binder content for different doses of chemical is found out.

E.R. Souaya. S.A. Elkholly, A.M.M. Abd El-Rehman, M, El-Shafie, I.M. and Ibrahim. Z.L. Abo-shamab have presented an article on Sulfur substituted asphalt mixture. Results shown has the optimum binder content reduced with the increase in the sulfur. Addition of 20% of modified sulfur gave almost same properties as normal mix. From the laboratory experiments they concluded that there will be increase in the stability with the increase in the sulfur content and illustrates that the modified sulfur will substitute asphalt partially with no effect on the performance and durability of the asphalt mix.

Liang Li, Huie yao, Zhanping Yu, Cheo Huei Lee, David wingaund, Yoke khein yap, Xianming Shei, Shuz wei Goh have studied the properties of bitumen modified which is modified by adding Nano silica. In their study the Nano silica was added to the bitumen in 4% and 5% the weight of bitumen. Then the properties of Nano-modified binder was estimated by Superpave mix tests.to analyze the rheological and chemical properties various test such as Dynamic shear rheometer, rotational viscosity test, asphalt pavement analyzer, flow test are used. After the tests they observed that the viscosity of the binder reduced. They concluded that by adding Nano silica to the bitumen, the anti-aging property, rutting and fatigue performance of the mix has improved which results in the increase in dynamic modulus, flow number and rutting resistance.

Huago Alexander Randon Quintana, Jesus Alfredo Fernandez Noguera and Carles Felipe Urazan Boells have studied the modified hot mix asphalt with Gilsonite. Bituminous mixes must be resistance against permanent deformation like rutting. Hence the authors added the Gilsonite to modify the asphalt and then tested by both wet and dry process. From laboratory results they concluded that the stiffness and performance of the binder improves after adding Gilsonite to the bitumen. The Gilsonite modified bituminous mix showed higher strength and stiffness.

IV. MATERIALS AND METHODOLOGY

A. Raw Materials

The bituminous concrete is composed of aggregate as primary material and bitumen as binder. Representative hot mix asphalt is about 85% of the aggregates, 10% of the bitumen binder, 5% of the air voids. To progress the performance of the BC mix, Additives such as crumbled rubber, fly ash and even the chemical additives are added.

B. Materials Used

1) Aggregates

For the present study the virgin aggregates are obtained from Hoskote Quarry. These aggregates are tested for their basic properties.

2) Bituminous binder

In this study VG 10 is used as the binder to determine the properties of the bituminous mix. Bitumen is obtained from the suppliers to the Govt. S K S J T I laboratory.

3) Chemical Envirotac SC

The chemical by name Envirotac Super concentrate is obtained from our collage laboratory sponsored by EP&A ENVIROTAC.

C. Laboratory Investigation of Basic Properties of the Materials

The materials used for the study has to satisfy the specifications given in the MORTH V Revision.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Tests</th>
<th>Aggregates</th>
<th>Permissible Limits As Per Morth V Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aggregate Impact value</td>
<td>13.66%</td>
<td>24%</td>
</tr>
<tr>
<td>2</td>
<td>Combined index</td>
<td>22.50%</td>
<td>35%</td>
</tr>
</tbody>
</table>
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Table 1: Properties of the virgin aggregates

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Tests</th>
<th>Bitumen VG 10</th>
<th>Permissible Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific Gravity</td>
<td>0.965</td>
<td>0.99</td>
</tr>
<tr>
<td>2</td>
<td>Penetration @25°C, 5 sec</td>
<td>95</td>
<td>Min 80</td>
</tr>
<tr>
<td>4</td>
<td>Ductility</td>
<td>77.5</td>
<td>Min 75</td>
</tr>
<tr>
<td>5</td>
<td>Softening Point</td>
<td>44</td>
<td>Min 40</td>
</tr>
<tr>
<td>6</td>
<td>Flash Point</td>
<td>250</td>
<td>Min 220</td>
</tr>
</tbody>
</table>

Table 2: Properties of the bitumen VG-10

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Tests</th>
<th>Bitumen VG-10</th>
<th>Permissible Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific gravity</td>
<td>2.6</td>
<td>2.5-3</td>
</tr>
<tr>
<td>4</td>
<td>Water absorption</td>
<td>0.33%</td>
<td>2%</td>
</tr>
<tr>
<td>5</td>
<td>Abrasion value</td>
<td>14.05%</td>
<td>30%</td>
</tr>
</tbody>
</table>

D. Marshall Method of Mix Design
In Marshall Method the resistance to plastic deformation of a compacted specimen of bituminous mix, when it is loaded at a constant deformation rate of 50 mm/min is measured. The marshal stability of a mix is well defined as maximum load carried by the compacted specimen at a temperature of 60°C. The flow is the measure of deformation of the specimen under maximum load. The features of this method are the Density-Voids analysis and the stability flow tests. In this study this method is used to determine the OBC for the BC mix. The Marshall test is conducted as per ASTM-D1559-96.

- Preparation of marshal samples
- Testing of samples
- Volumetric analysis

The specimens prepared by the Marshall method are used for the volumetric analysis. The maximum theoretical specific gravity, maximum bulk specific gravity, percentage of air voids and other volumetric properties are determined using the following equations.

\[
G_t = 100\left(\frac{W_1}{G_1} + \frac{W_2}{G_2} + \frac{W_3}{G_3} + \frac{W_4}{G_4}\right)
\]

\[
V_v = \left(\frac{G_t - G_b}{G_t}\right) \times 100
\]

\[
V_b = \left(\frac{W_4}{G_4}\right) G_b
\]

\[
V_{MA} = \frac{V_v + V_b}{100}
\]

\[
V_{FB} = \left(\frac{V_b}{V_{MA}}\right) \times 100
\]

Where, \(G_t\) = Theoretical specific gravity of the mix
\(G_b\) = Bulk specific gravity of the mix
\(V_v\) = Percent of Air Voids.
\(V_b\) = Volume of Bitumen.
\(V_{MA}\) = Percent Voids in Mineral Aggregates.
\(V_{FB}\) = Percent Voids filled by Bitumen.

W1, W2, W3, W4 are weights of the materials
G1, G2, G3, G4 are Specific gravity of the materials

E. Optimum Binder Content
In order to evaluate the optimum binder content graphs are plotted by taking Bitumen percentage on X –Axis and the following properties on Y –Axis.
- Bulk density (Gb) or Unit weight
- Marshal Stability
- Percentage of Air voids (Vv)
- Flow value
- Percentage of Volume filled with bitumen (VFB)

Optimum binder content is calculated as the mean of three bitumen contents which are obtained from the graphs plotted.
- Bitumen content at maximum Unit weight
- Bitumen content at Maximum Stability
- Bitumen content conforming to the design limit of percent air voids in total mix.

V. RESULTS AND DISCUSSION

<table>
<thead>
<tr>
<th>Envirotac-Sc Properties</th>
<th>0%</th>
<th>0.1%</th>
<th>0.2%</th>
<th>0.3%</th>
<th>0.4%</th>
<th>0.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>0.96</td>
<td>0.98</td>
<td>0.982</td>
<td>0.994</td>
<td>0.99</td>
<td>1.03</td>
</tr>
<tr>
<td>Penetration</td>
<td>95</td>
<td>92.5</td>
<td>89</td>
<td>86.3</td>
<td>85</td>
<td>82.3</td>
</tr>
<tr>
<td>Ductility</td>
<td>77.5</td>
<td>72</td>
<td>65</td>
<td>59.5</td>
<td>54.5</td>
<td>49.5</td>
</tr>
<tr>
<td>Viscosity</td>
<td>92</td>
<td>133</td>
<td>195</td>
<td>216</td>
<td>260</td>
<td>300</td>
</tr>
<tr>
<td>Softening Point</td>
<td>44</td>
<td>46</td>
<td>49</td>
<td>51</td>
<td>52</td>
<td>53</td>
</tr>
</tbody>
</table>

Table 3: Comparison of Properties of Bitumen VG-10 with and without Envirotac-Sc.
Relationship Curves for Determining the Optimum Binder Content For Bituminous Mix with VG-10 are shown in the following graphs.

**Fig. 5:** Graph showing curve for unit weight v/s bitumen content

**Fig. 6:** Graph showing curve for Stability v/s bitumen content

**Fig. 7:** Graph showing curve for Voids v/s bitumen content

**Table 5:** Comparison of Marshall Properties for BC with VG-10 And with VG-10 + 0.5% Envirotac-Sc

<table>
<thead>
<tr>
<th>Sl no</th>
<th>Properties</th>
<th>BC with VG-10</th>
<th>BC with VG-10 + 0.5% Envirotac-Sc</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OBC</td>
<td>3.37%</td>
<td>3.28%</td>
</tr>
<tr>
<td>2</td>
<td>Unit weight (g/cc)</td>
<td>2.35</td>
<td>2.3</td>
</tr>
<tr>
<td>3</td>
<td>Marshall stability (Kg)</td>
<td>1368.32</td>
<td>1427.99</td>
</tr>
<tr>
<td>4</td>
<td>Flow value (mm)</td>
<td>3.15</td>
<td>3.57</td>
</tr>
<tr>
<td>5</td>
<td>Air voids (%)</td>
<td>3.79</td>
<td>3.99</td>
</tr>
<tr>
<td>6</td>
<td>VFB (%)</td>
<td>76.67</td>
<td>75.48</td>
</tr>
</tbody>
</table>

**VI. CONCLUSION**

Based on the extensive laboratory investigation the conclusions drawn are as follows:

The basic properties of the VG-10 bitumen and the Marshall properties of the BC mix improves with the addition of 0.5% Envirotac-SC by weight of bitumen and hence reduces the rutting and fatigue cracks. The optimum binder content is less than that required for the conventional mix hence decreases the cost needed for the bitumen.

**REFERENCES**


