A Study on aging Behaviour of Paving Grade Bitumen using Filler Material

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Abstract—Bitumen aging is responsible principle factor for the deterioration of bitumen pavements. It is accountable for deterioration of physical and chemical properties of bitumen binder. In this present study cement is used in various percentages (0%, 1%, 1.5%, and 2%) as modifier in 60/70 grade bitumen. The effect on physical properties in terms of penetration, softening point and viscosity before and after aging are measured. The binders are aged using Thin Film Oven Test (TFOT). The results shows that before aging softening point, viscosity increases and penetration decreases with increasing percentage of filler material. After aging penetration of aged binders decreases than unaged binders but decrease in penetration value is more for binder having less amount of filler material. Decrease in penetration value is less for binder having 2% cement as filler than other binders after aging. Viscosity value is more for aged binders than unaged binders. Viscosity value is increases as percentage of filler increases for aged binders. For binder having 1% cement has less increase in viscosity value than other binders. Softening point increases of aged binders than unaged binders. Increase in softening value is less for binder having 2% cement as filler than other binders after aging.

Keywords: The Polymer Modified Bitumen, Aging, Stiffness, Dynamic Shear Rheometer, TFOT,RTFOT Aging, Penetration, Softening Point, Viscosity, Rheological Properties, Complex Modulus, Phase Angle, SBS, CR.

I. INTRODUCTION

Bitumen is manufactured from crude oil. Bitumen is obtained as the last residue in fractional distillation of crude petroleum. Crude petroleum is a different molecular weights. In the petroleum refineries the individual components like LPG, naphtha, Kerosene, Diesel etc. are separated through the process of fractional distillation. The heaviest material obtained from the fractional distillation process is further treated and blended to make different grades of paving grade bitumen. The actual bitumen output can be controlled not only by selecting the appropriate crude but also by adopting varying processes in the refinery. The choice of process would depend on the availability of suitable crude, demand of the end products and total commercial viability of the Complete refining process (H.P. Bitumen Handbook). For high volume roads, rutting resistance will be most important, especially to withstand wear from studded tires. These roads have to be resurfaced after few years due to rutting. Pavements on low volume roads will serve for many years before resurfacing, and important properties for these pavements are flexibility and low temperature capacity. The overall long term pavement performance is important for low volume roads.

In spite of the fact that binder content in asphalt pavement is about 5-7 percent by weight, the binder has a great influence on pavement performance. There are arguments for and against using hard or soft binders, and modified or unmodified binders. The choice is complicated due to the fact that binder properties are altered during production and with time in the pavement. This change is called aging. To be able to choose the right binder and asphalt mix, it is necessary to know how binder properties change under production and over time under real condition (traffic load, climate, temperatures, etc.). And over time under real condition (traffic load, climate, temperatures, etc.).

II. LITERATURE REVIEW

In year 1978 Craus et al. evaluated the influence that the type of filler had on durability of bituminous mixers. In year 1990, C.P.Valkering et al. have showed that elastic return in modified polymer bitumen using SBS has high than neat bitumen. In year 1998, Petersen et al. had carried out research work, using RTFOT named thin film accelerated aging test, Strained to enumerate how the addition of filler might benefit the reduction of hardening by age and improve the properties of flow at low temperatures. In year 2002, Chen et al. the effect of different quantity of SBS of bitumen has been considered and come to this result that rheology characters of bitumen by increasing SBS range will be improved. In year 2003, Mehraz et al. carried out experiments to study the effects of three different rubber concentrations (3%, 9%, and 15%). According to this study after a rolling thin film oven test, the unmodified bitumen showed an improvements of about 1.5 times in G* value, and in rubberized , the samples with 3% and 9% rubber showed an increase of about 2.5 times, the sample with 15% rubber showed an increase of about 1.5 times compared to their original unaged values. In year 2003, Mahrez et al. concluded that the use of CR reduced the aging effect on rheological properties of the bitumen binder. Aging index was considered for evaluating and characterising the aging properties of rubberised bitumen. It was found that in all binders the aging index is observed to be greater than one, which indicate hardening of this binders.

In year 2005, Recasens et al. concluded that the hydrated lime tends to stiffen the mixture less and make it less brittle than does calcium carbonate. The filler content proposed must be 20% or 30% less than the content recommended to minimize the effect of aging on bitumen in conditions where there is no aging. In year 2007, Bianchetto et al. concluded that the use of hydrated lime and calcium carbonate as filler reduced the aging effect on rheological properties of the bitumen binder. Pilat et al. (2008) concluded that
Viscoelastic properties of road bitumen are improved by means of SBS elastomers modification. It is good to replace a part of the elastomer with a linear particle for modifying road bitumen with a branched particle elastomer. It can be seen that Binders with a branched particle show increased resistance to the ageing processes. They have lower temperature sensitivity and lose the properties slower in comparison to bitumen modified with a linear particle polymer only. Mohamed et al. (2009) concluded that the use of CR30 reduced the aging effect on rheological properties of the bitumen binder than neat bitumen. In year 2012, Asim et al. concluded that the use of rubberised bitumen binder reduced the aging effect on rheological properties of the bitumen binder.

III. SCOPE AND OBJECTIVES
Following are the objectives of study:-

1. To study the effect of aging on softening point of neat bitumen and modified bitumen samples.
2. To study the effect of aging on viscosity of neat bitumen and modified bitumen samples.
3. To study the effect of aging on penetration value of neat bitumen and modified bitumen samples.
4. To compare the effect of aging on neat bitumen and modified bitumen samples.

The neat bitumen of viscosity grade 30 (equivalent to penetration grade 60/70) is used for this research study. Cement is used as filler material for this study. Cement is added at different percentages like 1%, 1.5% and 2%. The penetration test is conducted to measure the penetration value at 25ºC. Softening point test is conducted to get softening point value of different binders. Cannon-Manning vacuums viscometer is used to obtain viscosity values of different bitumen binders. Thin Film Oven test is conducted to obtain aging characteristics of mixers and in which way such pavements can be rapidly aged and evaluated in the laboratory. The comparison of aged and unaged modified bitumen samples are carried out.

IV. EXPERIMENTAL METHOD

A. Material
For this study, Bitumen of VG 30 grade (equivalent to penetration grade 60/70) is used for the study. Locally available cement is used as the filler material for the study.

B. Sample Preparation
In preparing the modified binders about 500g of bitumen is heated to fluid condition in 2 litre capacity metal container. The mixing is performed in the laboratory using an oven fitted with mechanical stirrer and rotated at 70 rpm for mixing bitumen and filler. A filler sample is placed in an oven at 110±5 C for drying to a constant weight. After preheating the bitumen and filler samples, each are removed from its respective oven. The correct quantities of the dried filler sample and the heated bitumen are placed into a sample container and heated it to approximately 160 C. The blend is mixed manually for about 3-4 minutes. The mixture is then stirred using a mechanical stirrer for about 10 minutes. The mortar is heated until the air bubbles escape, and stirred to mix the filler particles, which would otherwise settle at the bottom of the container. When the mortar appears visually homogeneous, the mortar would be ready for pouring into the testing mould. The modified bitumen is cooled to room temperature and suitably stored for testing. Four samples of modified bitumen containing cement (0%, 1%, 1.5% and 2%) are prepared.

C. Short Term Binder Aging
The different binders samples are artificially aged at 163 ºC for 5 hours using Thin Film Oven Test (TFOT) in accordance with IS: 9382-1979.

D. Penetration Test
The penetration values of different sample is evaluated at laboratory before and after aging in accordance with IS: 1203-1978.

E. Softening Point Test
The softening point of the various test samples is obtained using the ring and ball test in accordance to IS: 1205-1978, before and after aging.

F. Viscosity Test
The viscosity of samples is determined using Cannon-Manning vacuums viscometer before and after aging. The test was conducted at the temperature of 60ºC as per IS: 1206(part-2)-1978.

V. RESULTS
A. Before Aging:
The results shows that before aging softening point, viscosity increases and penetration decreases with increasing percentage of filler material, as presented in Table 1 below.

Table 1: Physical Properties of unaged Bitumen

<table>
<thead>
<tr>
<th>Binder Type</th>
<th>Penetration, (1/10th mm)</th>
<th>Softening Point, (ºC)</th>
<th>Viscosity, (Poises)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% Cement</td>
<td>66</td>
<td>49</td>
<td>1636</td>
</tr>
<tr>
<td>1% Cement</td>
<td>63</td>
<td>49.5</td>
<td>1730</td>
</tr>
<tr>
<td>1.5% Cement</td>
<td>63</td>
<td>51</td>
<td>1986</td>
</tr>
<tr>
<td>2% Cement</td>
<td>60</td>
<td>52</td>
<td>2058</td>
</tr>
</tbody>
</table>

B. Penetration Test
The penetration values of bitumen modified with different percentages of cement are shown in Fig. 1. The Penetration values are decreasing significantly for 60/70 bitumen mixed with 0% cement to 2% cement. For cement added 1.5% has the equal value to 1% cement added. It is observed that the penetration value decreasing as the concentration of modifiers increasing.
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C. Softening Point Test
As shown in Fig. 2, the softening point increases with increase in percentage of filler as bitumen becomes increasingly viscous. Softening Point of cement added 2% is more than other sample containing different percentages of cement.

D. Viscosity Test
The viscosity values of bitumen modified with different percentages of cement are shown in Fig. 3. The viscosity values are increasing with increasing of percentages of filler in binder. It indicates the greater resistance to flow. Viscosity of cement added 2% is more than other sample containing different percentages of cement.

E. After Aging:
Thin Film Oven Test was carried out to obtain aging of samples, the values after aging are shown in below Table 2.

Table: 2 Physical Properties of aged Bitumen

<table>
<thead>
<tr>
<th>Binder Type</th>
<th>Penetration, (1/10th mm)</th>
<th>Softening Point, (ºC)</th>
<th>Viscosity, (Poises)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% Cement</td>
<td>35</td>
<td>54</td>
<td>1805</td>
</tr>
<tr>
<td>1% Cement</td>
<td>36</td>
<td>55</td>
<td>1842</td>
</tr>
<tr>
<td>1.5% Cement</td>
<td>43</td>
<td>54</td>
<td>2367</td>
</tr>
<tr>
<td>2% Cement</td>
<td>47</td>
<td>53</td>
<td>2700</td>
</tr>
</tbody>
</table>

F. Penetration Test
The penetration values of bitumen modified with different percentages of cement are shown in below Fig. 4. The penetration values are decreasing significantly for 60/70 bitumen mixed with 2% cement to 0% cement. It is observed that the penetration value increasing as the concentration of modifiers increasing.

G. Softening Point Test
As shown in Fig. 5, the softening point increases with increase in percentage of filler as bitumen becomes increasingly viscous. Softening Point of cement added 1% is more than other sample containing different percentages of cement.

H. Viscosity Test
The viscosity values of bitumen modified with different percentages of cement are shown in below Fig. 6. The
viscosity values are increasing with increasing of percentages of filler in binder. It indicates the greater resistance to flow. Viscosity of cement added 2% is more than other sample containing different percentages of cement.

VI. COMPARISON OF AGED AND UNAGED BITUMEN SAMPLES

Comparison of aged and unaged bitumen samples containing different percentages of cement is carried out before and after aging.

A. Penetration Value

The Comparison of Penetration values of aged and unaged Samples are shown in below Fig. 7.For binder containing 0% cement, the difference in penetration value before and after aging is more compare to other binders of varying percentages of cement. It is less for binder containing 2% cement than other binders.

B. Softening Point

The Comparison of Softening Point values of aged and unaged Samples are shown in below Fig. 8.For binder containing 2% cement, the difference in Softening Point value before and after aging is more compare to other binders of varying percentages of cement. The difference in Softening Point value is less for binder containing 1% cement than other binders.

C. Viscosity

The Comparison of Softening Point values of aged and unaged Samples are shown in below Fig. 9.For binder containing 2% cement, the difference in Viscosity value before and after aging is more compare to other binders of varying percentages of cement. The difference in Viscosity value is less for binder containing 1% cement than other binders.

CONCLUSIONS:

The physical properties of bitumen such as penetration, softening point and viscosity are improved with addition of cement. From results of penetration, cement added at 2% shows maximum stability against aging effect. The difference in penetration value before and after aging is less for binder containing 2% cement, which shows good resistance against aging. The Stability against aging decreases from 2% to 0% added cement binder. The difference in softening point value before and after aging is less for binder containing 2% cement, which shows good resistance against aging. The difference in softening point value before and after aging decreases as filler contain increases. The difference in viscosity value before and after aging is less for binder containing 1% cement, which shows good resistance against aging, it is more for binder containing 2% cement. So in terms of aging it is better to use cement added at 2% as filler material for 60/70 grade bitumen binder.
REFERENCES


