THE EFFECT OF SHORT TERM AGING ON BITUMINOUS BINDER MODIFIED WITH ETHYLENE PROPYLENE COPOLYMER

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Abstract : The bituminous binder plays an important role in flexible pavement performance. Aging of the binder leads to the deterioration of the flexible pavement due to prolonged exposure to weather condition. Aging in bitumen binder normally resulted from the weathering of the binder due to oxidation. Physical and Chemical properties of the bituminous binder changes due to aging process and the binder becomes hardened. Due to hardening of the binder, gradual loss of visco-elastic properties of the binder occurs. Thus, the flexibility of the asphaltic pavement reduces as the bitumen binder ages. The polymer modification of the binder can improve the quality of binder and enhance the physical, chemical and rheological properties of the binders used for the pavement construction. In this paper, Ethylene Propylene Copolymer is used to modify bituminous binder. Thin Film Oven Test (TFOT) is conducted inthe laboratory to simulate short term aging at high temperature. The physical properties of VG-30 grade bitumen with and without Ethylene Propylene Copolymer are found for un-aged and TFOT aged sample. The results from the laboratory tests indicates that short term aging of the bitumen shows the physical hardness of the binder properties after simulating Thin Film Oven Test (TFOT), reducing binder penetration, increasing softening point and increasing elastic recovery.

IndexTerms: **Bitumen, Modifier, Aging, Ethylene Propylene Copolymer, TFOT**

I. INTRODUCTION

In developing Country like India, Transport plays an important role in Economic development. India has second largest road network in the world and majority of the Indian roads are flexible pavements, the ones having bituminous layer as wearing course. In flexible pavements, pre matured failures are observed. Flexible pavements are always prone to various distresses during its service life caused by loading and weather-induced stresses. High temperature rutting and low temperature cracking are examples of these distresses, the formation of which is highly dependent on performance of the bitumen of the asphalt mixtures.

The aging of bitumen is one of the principal factors causing the deterioration of flexible pavements. Aging is a phenomenon in which asphalt binder stiffness increases because of changes in temperature and oxidation. Aging in bitumen binder normally resulted from the weathering of the binder due to oxidation. The aging process changes the chemical and physical properties of bituminous binder which makes it brittle and increasing the risk of pavement failure. The problem needs to be solved as soon as possible by producing innovative binders with improved physical and chemical properties. The modified bitumen possesses high resistance to fatigue cracking and permanent deformation.

In the present study, Ethylene Propylene Copolymer is used to modify properties of bituminous binder (VG30). Short term aging is carried out using Thin Film Oven Test (TFOT). The physical properties of bituminous binder with and without Ethylene Propylene Copolymer are checked before and after TFOT. The results are compared between the unaged binder and aged binder.

II. EXPERIMENTAL PROGRAMME

- **Materials**

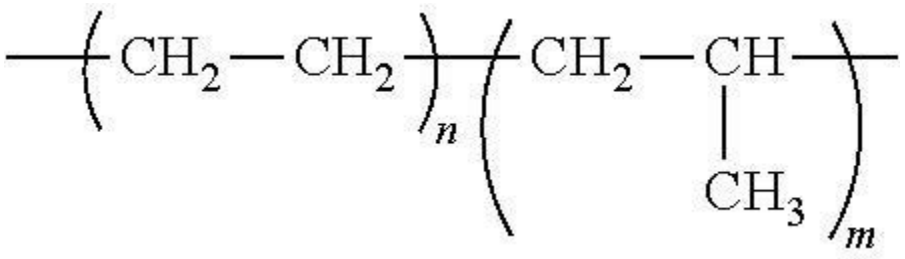
The materials which are used in the work are as follows:

- **Bitumen**

In this study, Viscosity Grade-30 Bitumen supplied by the Tikitar industries, Halol Vadodara district is used. Bitumen is a black, sticky and highly viscous liquid or semi solid form of petroleum and classified as a visco-elastic material.

- **Modifier**

Ethylene Propylene copolymer was used to modify VG-30 grade bitumen. Ethylene Propylene Copolymer is considered a valuable elastomer due to its useful chemical and physical properties. Ethylene Propylene Copolymer is resistant to heat, oxidation, ozone and weather. In this study, Ethylene Propylene Copolymer is added to un-aged bitumen in dosage of 1 %, 1.5 % and 2 % only by weight of bitumen. It has properties to improve long term resilience and weather resistance, better resistance to rutting and fatigue cracking. Structure of Ethylene Propylene Copolymer is shown below.



- **Preparation of Modified Binders**

In preparing the modified binders, about 600 g of the bitumen was heated to fluid condition in a 1.5 litre capacity metal container. The mixing was performed in the laboratory using an oven fitted with a mechanical stirrer and rotated at 400 rpm for mixing the bitumen and modifiers. For preparation of Ethylene Propylene Copolymer blends, bitumen was heated to a temperature of 180 °C. As the bitumen attained a temperature of 180 °C, the different Ethylene Propylene Copolymer contents by mass (1 to 2%) were added to the bitumen. The temperature was maintained between 175 °C to 180 °C and mixing was then continued for 120 minutes.

- **Testing**

The following conventional tests were conducted on the modified and unmodified binders.

- **Penetration Test:**

The penetration of a bituminous binder is the distance in tenths of millimeter (mm) that a standard needle will penetrate vertically into a sample of the material under standard condition of temperature, time and load. The test is useful to grade the material in terms of its hardness. The penetration test is conducted as per IS: 1203- 1978. [7]

- **Softening Point Test**

The softening point is the temperature at which the material attains a particular degree of softening under specified condition of test. The softening point test is conducted as per IS: 1205-1978. [8]

- **Ductility Test**

The ductility of bitumen is expressed as the distance in centimeters (cm) to which the bitumen filled in a standard briquette elongates before the breaking of the thread of bitumen formed due to elongation under specified conditions. The ductility test is conducted as per IS: 1208-1978. [9]

- **Elastic Recovery Test**

The elastic recovery of the binder is determined by measuring the recovery of the binder thread formed by the elongation of binder specimen when it is cut down by a scissor at standard conditions. The elastic recovery test is conducted as per IRC: SP 53-2010 specifications. [6]

- **Viscosity Test**

Viscosity is a measure of the resistance to flow of a liquid. It is defined as the ratio between the applied shear stress and the rate of shear strain measured in units of Pascal second (Pa. S) Brookfield Viscometer is used to determine the kinematic viscosities of the samples at 135°C for 5 min. at 20 rpm. The rotational viscosity was determined by measuring the torque required to maintain a constant rotational speed of 20 rpm of a cylindrical spindle submerged in bitumen maintained at the test temperature through thermosel. [5]

- **Short Term Aging Test**

Ageing of the binders was carried out by thin film oven test (TFOT, ASTM D1754). Samples of VG30 with and without additive Ethylene Propylene Copolymer were placed on a rotating disc for 5 hr at 163ºC. The loss of volatile fractions contributes to the difference in weights between unaged and aged sample. The maximum loss in weight should be maximum 1 % as per IRC: SP: 53:2010. [4]

III. TEST RESULTSAND DISCUSSION

The physical properties of the bitumen modified with Ethylene Propylene Copolymer and the effect of aging on these properties are discussed below.

Table 1: Physical properties of un-aged bitumen

Binder type	Penetration @ 25 ^{0}C (mm)	Softening point (^{0}C)	Dynamic viscosity @ 135 ^{o}C (poise)	Ductility (mm)	Elastic Recovery @ 15 ^{0}C (%)
VG-30	49	52	2580	80	20
VG-30 + 1% EPC	40	53	2975	60	60
VG-30 + 1.5% EPC	39	54	3150	58	65
VG-30 + 2% EPC	38	55	3510	55	70

Table 2: Physical properties after TFOT aging

Binder type	Penetration @ 25 ^{0}C (mm)	Softening point (^{0}C)	Elastic Recovery @ 15 ^{0}C (%)	% Loss of weight after TFOT aging
VG-30	45	53	15	0.05
VG-30 + 1% EPC	37	55	58	0.05
VG-30 + 1.5% EPC	36	56	55	0.04
VG-30 + 2% EPC	35	58	53	0.03

- **Penetration Value**

The penetration values of the un-aged and aged binders are tabulated in the figure given below.

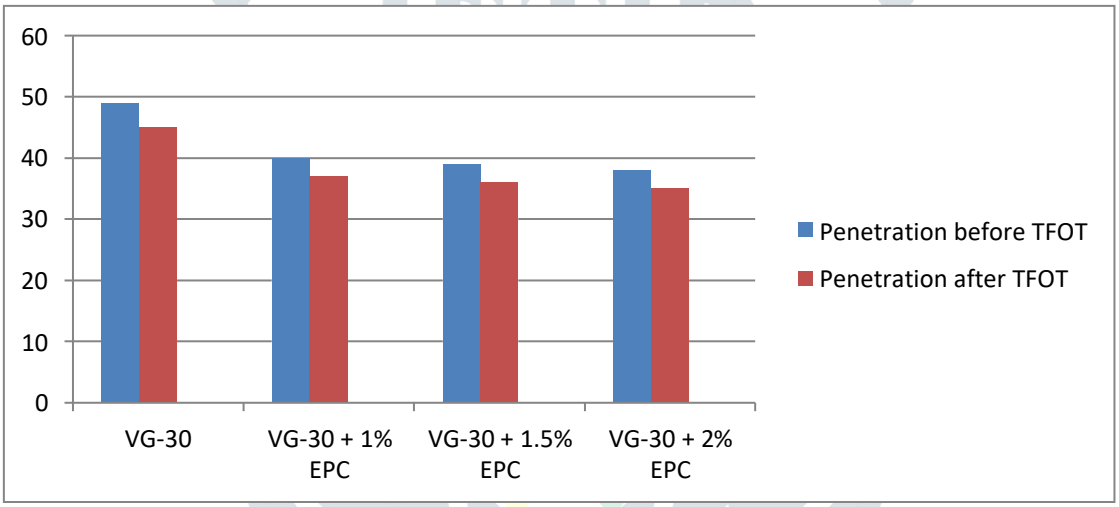


Figure 1 Penetration test results before and after TFOT

There is a significant decrease in penetration value for modified binder as the percentage is increased using Ethylene Propylene Copolymer, indicate that the binder becoming harder and more consistent. So, it may improve the rutting resistance of the mix. The binder becomes stiffer after aging due to evaporation of volatile compound.

- **Softening Point**

The softening point values of the un-aged and aged binders are tabulated in the figure given below.

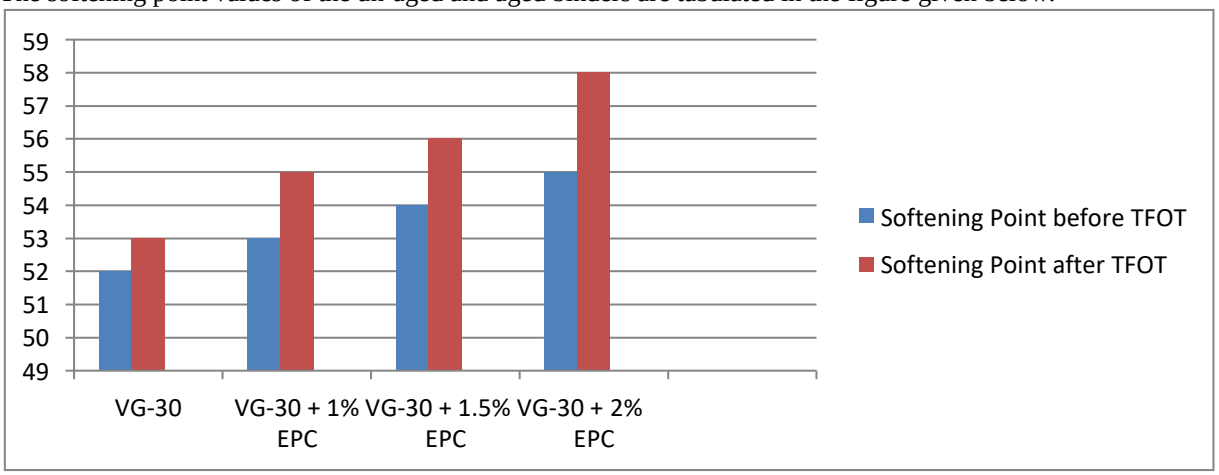


Figure 2 Softening Point test results before and after TFOT

The increase in softening point indicates stiffening effect with the addition of EPC in suitable dosage with VG-30 bitumen is favorable; this phenomenon indicates that resistance to binder against heat is increased and the binder will reduce its tendency to soften in hot weather. So, it is less susceptible to temperature changes. Hence, it is favorable to use bitumen modified with EPC at high traffic areas.

- **Elastic Recovery**

  The Elastic Recovery values of the un-aged and aged binders are tabulated in the figure given below.

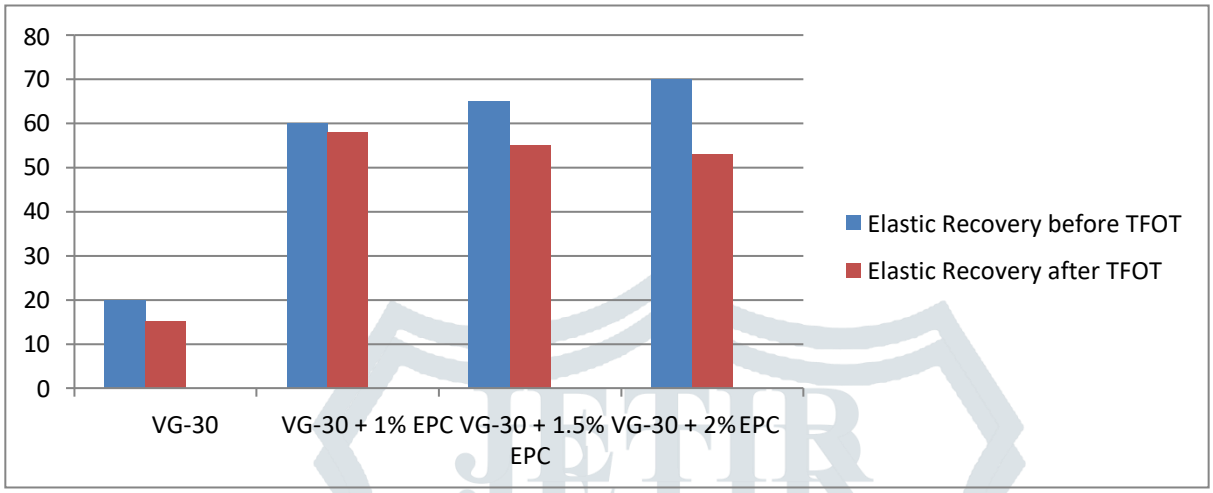


Figure 3 Elastic Recovery test results before and after TFOT

Elastic Recovery increases with increase in modifier content. Thus, binder becomes more flexible and will increase the life of pavement at low temperature.

- **Loss in weight**

  The loss of volatile fractions present to the difference in weights between un-aged and aged sample. The maximum loss in weight is within the permissible limit as laid down in codal provision i.e. less than 1%.

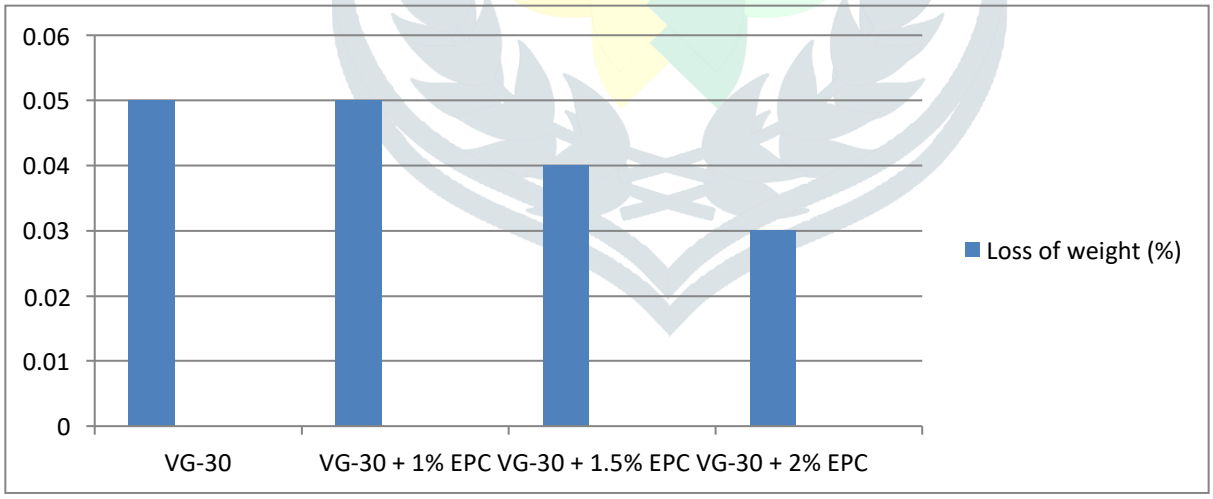


Figure 4 % weight loss results before and after TFOT

CONCLUSIONS

The results from the laboratory tests indicates that short term aging of the bitumen shows the physical hardness of the binder properties after simulating Thin Film Oven Test (TFOT), reducing binder penetration, increasing softening point and increasing elastic recovery. The elastic recovery increases with increase in percentage of Ethylene Propylene Copolymer and is observed at 2 %. Higher value of elastic recovery implies more flexibility to the binder. The loss of volatile compound contributes to the difference in weight of un-aged and aged sample. Effect of aging on EPC modified bitumen is within permissible limit.

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