

## Study on EVA modified bitumen

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### ABSTRACT

The deterioration of the flexible pavements are also due to extreme climatic conditions prevailing in the country in addition to the heavy traffic. The polymer modification of the bitumen can improve the quality of binders and enhance the properties of binders used for the construction of pavements. Ageing of bitumen is one of the principal factors causing the failure of bituminous pavement components due to the prolonged exposure to air and environmental conditions. Ageing are of two types i.e. short term and long term. Short-term ageing occurs when binder is mixed with aggregates in a mixing plant. Long-term ageing occurs after pavement construction and is generally due to environmental exposure and loading. The properties of bitumen mainly depend on the age of bitumen. Therefore there is a need to study the properties of modified bitumen before and after ageing. In this paper the the physical properties of EVA (Ethyl Vinyl Acetate) modified bitumen is discussed, optimum dose is determined and the effect of ageing on the binder prepared using the optimum dose is evaluated.

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### Introduction

The ability of modified bituminous binders to reduce rutting at high temperatures and thermal cracking/fracture at low temperatures has made them popular in the recent past. The quality of bituminous road surfacing and its performance depends upon the properties of bitumen and these are controlled by composition of bitumen. Hence, properties of bitumen may be modified by certain binders such as polymer, crumb rubber, sulphur etc. Addition of polymers and rubbers in bitumen increases the life span of the road pavement considerably. Addition of natural or synthetic polymers to bitumen is known to impart enhanced service properties. The purpose of bitumen modification using polymers is to achieve desired engineering. This modification results in improvement of one or more properties of binder and (hence the mix) viz. fatigue resistance, stiffness modulus, rutting resistance, stripping potential, temperature susceptibility, oxidation potential etc.

The beneficial effects include decreased thermal susceptibility and permanent deformation under load and increased resistance to low temperature cracking. Binder modification is aiming to produce new binders with better rheological and mechanical properties. The improvement in the modified binders can be linked to the chemical change due to the interaction between the the molecular structure of the bitumen and modifier added

#### Some selected previous research work

Many researchers have studied the properties of the modified binders and evaluated their advantage over the conventional bitumen. The major studies carried out by different researchers using Ethyl Vinyl Acetate are discussed below:

Panda and Mazumdar (1999) reported that the penetration, ductility, and specific gravity of the EVA (Ethyl Vinyl Acetate) modified binders decreases as compared with the neat bitumen while the softening point temperature and viscosity increases. The temperature susceptibility of the modified binder is also improved. A small change in temperature and blending time does not affect binder properties. Like the conventional bitumen,

the modified binder is likely to retain its properties for a long time in storage. The use of EVA with bitumen results in Marshall Stabilities as high as 14 kN. Flow values and air voids are also satisfactory i.e. the use of EVA increases the stability and air voids and decreases the flow value and unit weight. For paving mixes, the optimum composition appears to be 5% EVA concentration in the binder and 6% binder content by weight of the total mix. EVA modification of bitumen increases tensile strength at the test temperatures (5°C to 50°C).[10]

Airey (2002) reported that the rheological properties of bitumen are improved by means of EVA polymer modification. The semi crystalline EVA copolymer provides the modification of bitumen through the crystallisation of rigid three-dimensional networks within the bitumen. Conventional penetration, softening point, Fraass, ductility and high temperature viscosity tests have demonstrated the increased stiffness (hardness) and improved temperature susceptibility of the EVA PMBs.[1]

Morales and Partal (2004) reported that the viscous properties of bitumen, at high temperature, are improved by adding recycled EVA copolymer in amounts that depend on bitumen penetration grade. Moreover, significant microstructural changes, related to the development of a polymer-rich phase, tend to occur in the bitumen as polymer concentration increased. These changes in microstructure have a significant influence on the flow behaviour of the binder and on its in-service performance.[9]

Gonzalez et al. (2004) revealed that the viscoelastic properties of a 60/70 penetration grade bitumen are improved when either a virgin EVA or a recycled EVA copolymer of similar vinyl acetate content are mixed with it. Risk of cracking at low temperatures and rutting at high temperatures, are both reduced. Better viscoelastic features are obtained with the bitumen modified with recycled EVA, probably due to the presence of carbon black, which acts like a filler in this material. Stability tests performed combining oscillatory flow and microscopy results disclose that blends with the higher polymer proportion (3%) are susceptible of phase separation

after 24 h of storage at 165 C, but 1% blends are stable for at least 4 days. A general evaluation of the results indicates that the performance of this bitumen as a binder for road pavement is particularly improved when 1% of recycled EVA or virgin EVA is added. [4]

#### EXPERIMENTAL PROGRAMME

##### Materials

The materials which are used in this work are as follows

##### 1) Bitumen

The 60/70 grade bitumen supplied by the Mathura Refinery is used in this study.

##### 2) Modifiers

Ethyl Vinyl Acetate is used to modify the conventional 60/70 bitumen.

##### Preparation of Modified Binders

For preparation of EVA blends, bitumen was heated to a temperature of 170°C. As the bitumen attained a temperature of 170°C, the different EVA polymer contents by mass (3 to 9%) were added to the bitumen. The temperature was maintained between 175°C to 180°C and mixing was then continued for 80-90 minutes depending upon the quantity of polymer to be added.

##### Tests Conducted

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

##### Penetration Test

The penetration of a bituminous material is the distance in tenths of millimetre that a standard needle will penetrate vertically into a sample of the material under standard condition of temperature, load and time. Penetration test is the most commonly adopted test on bitumen to grade the material in terms of its hardness. The test is conducted as per IS: 1203-1978. [6]

##### Softening point Test

The softening point is the temperature at which the substance attains a particular degree of softening under specified condition of test. The softening point of bitumen is determined as per IS: 1205-1978. [7]

##### Ductility Test

The ductility of bitumen is expressed as the distance in centimetres 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. [8]

##### Elastic Recovery

The elastic recovery of the binder is evaluated 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 carried out as per IRC: SP 53-2002 specifications. [5]

##### Viscosity Test

The ratio between the applied shear stress and the rate of shear is called the coefficient of viscosity. This coefficient is a measure of the resistance to flow of the liquid. It is commonly called the viscosity. The viscosity of a fluid is highly dependent on the temperature. It gets reduced with the increase in temperature. To determine the influence of temperature on the viscosity of bituminous binders we have to determine the viscosity at different temperatures. Brookfield viscometer is used for the purpose and the test is conducted as per ASTM D 4402- 2006. [3]

##### Rolling Thin-Film Oven Test(RTFOT)

Ageing or hardening of bituminous binder occurs during the mixing and during service. Short term ageing of the binders is

performed by two methods, Thin Film Oven test (TFOT, ASTM D 1754) and Rolling Thin Film Oven Test (RTFOT, ASTM D 2872), respectively. The TFOT and RTFOT are used to simulate the hardening which bitumen undergoes during mixing. In RTFOT, the glass jars were loaded with 35 gm of the sample. The jars with the samples are kept in an oven for about 15 minutes at 160°C. According to the standardized procedures, the samples are aged at 163°C and 1.5 hrs for RTFOT. [2]

#### TEST RESULTS AND DISCUSSION

The physical properties of the bitumen modified with the Ethyl Vinyl Acetate and the effect of aging on these properties are discussed ahead.

##### Penetration Value

The penetration values of the unmodified and modified binders are tabulated in the figure given below.

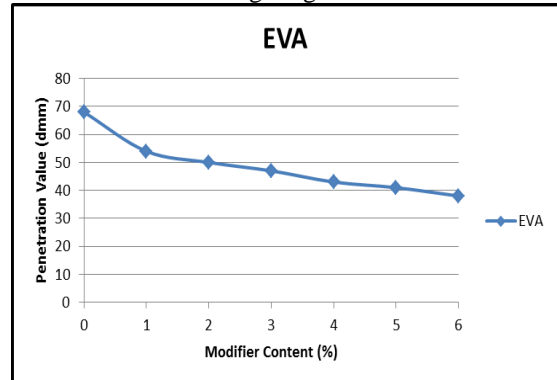


Fig.1 Variation in Penetration Values

##### Softening Point

The softening point values of the unmodified and modified binders are tabulated in the figure given below.

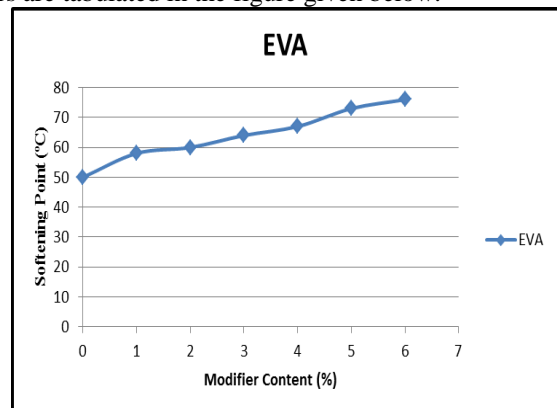


Fig. 2 Variation in Softening Point Value

##### Viscosity

The Viscosity values of the unmodified and modified binders are tabulated in the figure given below.

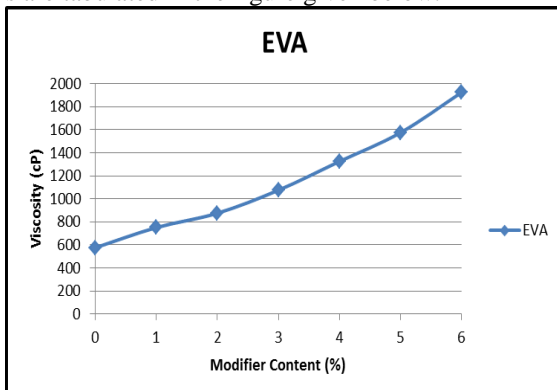
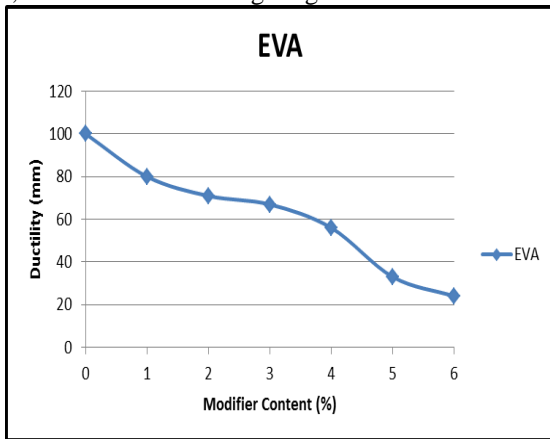


Fig.3 Variation in Viscosity Values

**Ductility**

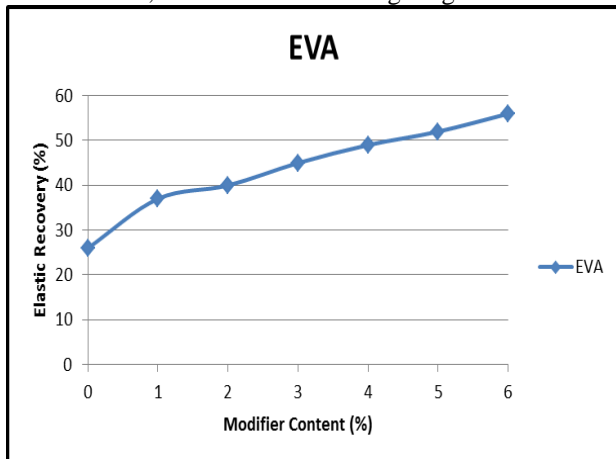
The Ductility values of the unmodified and modified binders, are tabulated in the figure given below



**Fig. 4 Variation in Ductility**

**Elastic Recovery**

The Elastic Recovery values of the unmodified and modified binders, are tabulated in the figure given below



**Fig. 5 Variation in Elastic Recovery**

**Penetration Index**

The values of penetration Index are tabulated in the table below.

**TABLE I  
PENETRATION INDEX VALUES**

Binder Type	Modifier Content (%)	Penetration Index
VG 30	0	-0.4488
VG30+EVA	1	0.8161
	2	1.0292
	3	1.6365
	4	1.9457
	5	2.7987
	6	3.0589

**DETERMINATION OF OPTIMUM DOSE**

The requirement of penetration, softening point and ductility is satisfied at 4% of EVA as per IRC: SP: 53-2002 and IS 15462-2004. From penetration index point of view also, up to 4% EVA can be used in paving bitumen as the PI value lies between +2 to -2 as indicated in the Table 6

**EFFECT OF AGEING**

The effect of ageing is depicted by the changes in the physical properties of the different modified binders after RTFOT. The changes in physical properties are shown in Table 7.

**Table II**

**THE CHANGES IN PHYSICAL PROPERTIES AFTER RTFOT**

Designation	Binder Type	Test Results	Permissible Results as per IRC:SP:53-2002
Loss in Weight (%)	VG 30 + 4% EVA	0.11	1.0 , max
Increase in Softening Point (°C)	VG 30 + 4% EVA	3.23	5.0 , max
Reduction in Penetration of Residue at 25°C (%)	VG 30 + 4% EVA	21	35 , max
Elastic Recovery at 25°C (%)	VG 30 + 4% EVA	43	35 , min

**CONCLUSIONS**

The following conclusions are drawn based on the results obtained in the present study:

1. The physical properties of bitumen such as penetration and softening point are improved with addition of polymers.
2. EVA modified binder gives lower Penetration value as compared to neat bitumen
3. EVA modified binder gives Higher Softening point value as compared to neat bitumen
4. EVA modified binder gives Higher Viscosity as compared to neat bitumen.
5. Effect of Aging on EVA modified binder is within permissible limits.

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