INFLUENCE OF VG 30 GRADE BITUMEN WITH AND WITHOUT ADDITIVE (EVA) ON SHORT TERM AGING

Tanuj Parmar[1], Thummar Milan[2], Sohaliya Kaushik[3], Shiyani Dhaval[4], Rothod Rohit[5], Kakadiya Jigar[6]

[1] Assistant Professor, Civil Engineering Department, Government Engineering College Surat, Gujarat, India
[2] BE Student Civil Engineering Department, Government Engineering College Surat, Gujarat, India
[3] BE Student Civil Engineering Department, Government Engineering College Surat, Gujarat, India
[4] BE Student Civil Engineering Department, Government Engineering College Surat, Gujarat, India
[5]BE Student Civil Engineering Department, Government Engineering College Surat, Gujarat, India
[6]BE Student Civil Engineering Department, Government Engineering College Surat, Gujarat, India

ABSTRACT

In the developing country like India, growth of urbanization is a vital process ultimately leads to the vehicle growth and thus the load on the pavement increases which leads to distress of the pavement. Major problem in pavement seen is the aging of the pavement and to overcome such problem an attempt is made formed polymer modified bitumen using different type of polymer. Age solidifying of bitumen is induced by chemical and/or physical changes and is usually accompanied by hardening of the binder. In road applications, binder is exposed to aging at three different stages: storage, mixing, transport and laying, as well as during service life. India is a country having varied climate and excessive stress and strains on the road in a limited road space is there. India is distinctive among developing countries for its fast-growing service sector and road transport is vital to India's economy, social integration and security needs of the country. Hence roads infrastructure from long run point of view with respect to quality in terms of load carrying capacity, performance, durability and economy is needed. But the aging of bituminous binders is one of the key factors determining the lifetime of an asphalt pavement. Aging in bitumen normally resulted from the weathering of the binder due to oxidation. Bitumen hardening occurs progressively during asphalt production, transportation, paving operation and thereafter during its service life. Gradual loss of visco-elastic properties of bitumen is due to hardening of asphalt material, consequently an increasing traffic loading will hasten performance failure of the pavement, frequency of traffic and changing environment. In the present study Ethylene Vinyl Acetate (EVA), a plastomer were used in various percentages (2 to 4%) as modifiers in VG30 grade bitumen for determine short term aging. The changing effects on physical properties in terms of the bituminous binders with and without EVA were measured before aging and after aging were measured. The results show that after ageing softening point increases, penetration decreases and elastic recovery increases with increasing percentage of EVA. The losses of volatile fractions recorded are within permissible limits of codal provision. Utilization of such modifier can be beneficial to road projects.

Keyword: **-** *Bitumen, aging, oxidation, viscosity, EVA*

1. INTRODUCTION

Bitumen is one of the most important ingredients in the construction of the flexible pavement due to its good adhesive and viscoelastic property, but with the lapse of time due to atmospheric changes and increasing the traffic load on the pavement this property of the bitumen gets erode which badly affects the life of pavement. Majorly this type of problem is seen in the developing countries due increase in the population with which traffic volume is also increasing leading to the increment of axle load on the pavement. This all factors leads the bitumen to undergo aging phenomenon, in which the bitumen become stiff and fragile due oxidation process which ultimately hardens the bitumen and thus affect the service life of the pavement. Transport infrastructure is the lifeblood of modern society,

but often struggles to meet demands and expectations on reliability, availability, maintainability, safety, environment, health and cost is there. India is a very vast country, having widely varying climate, terrain, construction materials and mixed traffic both in terms of loads and volume. Road performance is determined by properties of bitumen. Ageing or hardening of bituminous binder occurs during mixing and lay down process and during service life of pavement. Bitumen ageing is one of the principal factors causing negative change of physical structures and chemical compositions gradually with time due to heat, oxidation, ultra violet radiation and loss of volatile constituents resulting in the deterioration of its physical behaviors.
The durability and the satisfactory performance of pavements demand the right type of bitumen with and without the addition of additives to cope up with the special problems of short term aging under extreme climatic conditions and increased traffic density. In the present study, an attempt is made to focus on evaluating the physical properties in the laboratory of VG 30 grade bitumen with and without additive (ethylene vinyl acetate copolymer). Also the impact of short term aging is carried out using thin film oven test (TFOT) for bitumen with and without additives. The outcomes of results are compared between the un-aged bitumen with and without modifier and aged modified bitumen samples (with and without EVA).

2. SOME SELECTED PREVIOUS RESEARCH WORK

- **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 crystallization of rigid three-dimensional networks within the bitumen. Conventional penetration, softening point, frass, ductility and high temperature viscosity tests have demonstrated the increased stiffness (hardness) and improved temperature susceptibility of the EVA PMBs.
- **Claudio Brovelli, LoicHilliou, YacineHemar, Jorge Pais, Paulo Pereira, Maurizio Crispino (2013)** stated EVA modified bitumen have the ability to provide improved resistance to rutting in hot-mix asphalt compared to conventional bitumen along with improved compatibility, safer handling and better workabilitycompared to the SBS and SBR modifiers. Some grades of EVA also increase the resistance to damage caused by fuel spillages and pose no problems with future recycling of the material. However, it should be noted that the properties of EVA vary for different grades depending on the chain length and molecular weight of the polymer, the vinyl acetate (VA) monomer content and the crystallinity. In terms of the EVAs the VA content and melt flow rate (MFR) are as important as the Styrene content and linear or radial structure in SBSs, when determining specific properties. EVA modified bitumen is also more heat stable and does not deteriorate at elevated temperatures during storage as fast as SBR and SBS modified bitumen products. Storage stability will therefore be better than that of SBS and SBR.
- **Gonzalez et al. (2004)** revealed that the visco-elastic 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 visco-elastic 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.
- **Praveen Kumar, M.R. Maurya, Manoj Gupta & Maninder Singh (2012)** stated that the challenge in physical property characterization is to develop physical tests that can satisfactorily characterize key asphalt binder parameters and how these parameters change throughout the life of an HMA pavement. In India, the methods for rheological characterization of bituminous binders are inadequate to characterize the bitumen. Hence a complete rheological study and characterization of bitumen using dynamic shear rheometer would be helpful. Also there is limited insight about the chemistry of modified bitumen. Ethylene Vinyl Acetate (EVA), a plastomer; Linear Styrene Butadiene Styrene (SBS), an elastomer and Crumb Rubber (CR) were used in the study. The changes in rheological and chemical properties of 60/70 and 80/100 grades bitumen modified with different percentage of CR, EVA and SBS (2 to 8 per cent) were studied. The rheological properties of the bituminous binders in terms of their complex modulus (G^*), stiffness and overall resistance to deformation, storage modulus (G’), binder elasticity, loss modulus (G”),viscous behavior and phase angle (δ), visco-elastic behavior were measured. Testing was performed at temperatures ranging from 46°Cto 82°C in increments of 6°C at a frequency of 10 rad/sec. The chemistry was studied using infrared spectroscopy.

- **Szabolcs Biro-Bence Fazekas *et al*, (2005).***Asphalt rubber versus other modified bitumen* states that Asphalt rubber and rubberized asphalt samples were produced using various available, public recipes and their properties were compared to different laboratory and bitumen terminal / refinery produced linear and radial type of styrene-butadiene-styrene block copolymer (SBS), SBS-polyphosphoric acid (PPA), ethylene-vinyl-acetate (EVA) and Elvaloy modified bitumen. The aging characteristic of asphalt rubbers was found to be always better than the unsaturated polymer contained modified binders, however the confidence range of standards testing methods showed higher variability due to in homogeneity of the rubber modified binders. Asphalt rubber had the highest, while Elvaloy resulted the lowest viscosity at all tested temperatures. Elasticity of SBS modified bitumen's were found to be the best, while cold performance were significantly improved by rubber modified binders due to the presence of crumb rubber particles. It was found that an appropriately designed and manufactured asphalt rubber binder can replace SBS, SBS-PPA or EVA, Elvaloy modified bitumen. However it should be considered that the main objective is probably not this but to increase utilization of rubber modified bitumen versus common non-modified bitumen
- **S. Keyf, O. Ismail & B. D. Çorbacioğlu *et al*, (2007).** *Polymer-Modified Bitumen using Ethylene Terpolymers* highlights that polymer modified bitumen (PMB) is used in various construction applications, especially in motorways. The aim of this study is to improve features of 60/70 penetration grade, modified bitumen used on highways. Increasing the sensitivity to temperature and oxidation resistance are very important points for the modified bitumen. This condition was provided by reacting the carboxylic acid groups in asphaltene with the reactive ethylene terpolymer to form ester. Reactive ethylene terpolymer (RETP) and ethylene terpolymer (ETP) manufactured by DuPont USA were used as additives in this study. Infrared Spectrophotometer (IR) graphics and optical pictures of the modified bitumen have been examined. It has been observed that the softening point has increased on the other hand, the penetration and ductility values have decreased according to the test results
- **(Teltayev Bagdat, Izmailova, Galiya and Amirbayev Yerik et al, (2014)).** *Rheological Properties of Oxidized Bitumen with Polymer Additive* concludes that rheological properties of bitumen of grade BND-90/130 obtained from crude oil of Western Siberia (Russia) by the direct oxidation method and polymer binder, obtained by adding in pure bitumen the polymer Elvaloy 4170 are investigated. Binders in initial state and after short term aging at high and average temperatures were tested on Dynamic Shear Rheometer (DSR) and at low temperature after double aging-on the Bending Beam Rheometer (BBR). The obtained results showed that in all cases of testing operational properties of polymer-bitumen binder is significantly better than pure bitumen

3. EXPERIMENTAL PROGRAM

In this study the following materials are taken into consideration for carrying out experiments.

3.1 Bitumen

Viscosity Grade –30 bitumen supplied by the Tiki Tar Industries, Halol Vadodara district is used to construct extra heavy duty bitumen pavements in warmer climate to have greater mix of design, better road performance and load carrying capacity.

3.2 Modifier

Commercially available Elvaloy® 4170, the most chemically reactive grade of elastomeric terpolymer was chosen in the experiment for modifying asphalt. It had a density of 0.94 g/cm³, and melting point of 72°C. Its chemical structure provides both elastomeric and chemical stability to asphalt allowing no polymer separation and therefore it is called a stable and homogenous mixture PMB. In this study Elvaloy® 4170 is added to un-aged bitumen in dosages of 1.5%, 1.8% and 2% only by weight of bitumen. It has the properties to improve long term resilience and climate resistance, better resistance to rutting, reduced cracking and fatigue.

3.3 Preparation of Modified Binders:

In preparing the modified binders, about 500 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 1550 rpm for mixing the bitumen and modifiers. For preparation of EVA blends, bitumen was heated to a temperature of 180 °C. As the bitumen attained a temperature of 180 °C, the different EVA polymer contents by mass (2 to 4%) were added to the bitumen and vigorously agitated. The temperature was maintained between 175 °C to 180 °C and mixing was then continued for 80-90 minutes.

3.4 Testing:

Rotational Viscometer was used for determining the dynamic viscosities of the samples at 135 °C for 5 min at 20 rpm. Aging of the binders was performed by Thin Film Oven Test TFOT, as specified by IRC: SP 53-2002.

3.5 Test Results and Discussion:

Table 1: Physical properties of un-aged bitumen

Binder type	Penetration at 25 °C (mm)(IS: 1203-1978)	Softening point (°C) (IS: 1209-1978)	Elastic recovery at 15 °C, (%) (IRC-SP-53-2010)	Dynamic Viscosity in Poise (ASTM D4402-06) conducted at temperature	Specific gravity (IS: 1202-1978)
VG-30	54	51	24	@60°C = 2.8	1.49
2%EVA	36	55	48	@135°C = 6.4	1.034
3%EVA	31	61	54	@135°C = 6.9	1.031
4%EVA	28	65	62	@135°C = 7.8	1.029

4. PHYSICAL PROPERTIES OF UN-AGED BITUMEN:

4.1 Penetration test:

The penetration values of bitumen modified with different percentage of Ethylene vinyl acetate (EVA) and are shown in Table 1. The penetration values are decreasing significantly for VG30 bitumen mixed with EVA as the concentration of it increases. This is an indication that the chemistry has changed the property, as stiffness has increased; enhanced condition of temperature susceptible is noted thereby increasing the workability of bituminous mix.

4.2. Softening point test

Results shows the softening point increases with increase in percentage of modifiers as the bitumen becomes increasingly viscous and increases better rutting resistance.

4.3 Elastic recovery results

The elastic recovery test was performed as per IRC: SP: 53-2002 and was found to increase with increase in percentage of modifiers thereby improving binder resistance to rutting.

4.4 Specific gravity test results

The results show that the specific gravity values decreases significantly by modifying the bitumen. The density of bitumen is greatly influenced by its chemical composition. The reduction signifies the decrease in aromatic type mineral impurities with reduction in density thereby maintains stiffer bitumen in hotter temperatures. It substantially reduces rutting and increases stability.

4.5 Viscosity results

The viscosity is a fundamental engineering parameter which shows increases on introduction of EVA and this contributes to easily pump the material into the HMA plant for mixing and can be placed to the site for roadwork.

4.5 Physical properties after aging (table 2):

Table 2: Physical properties after TFOT ageing

Binder type	Penetration at 25 °C (mm) (IS: 1203-1978)	Softening point, (°C) (IS: 1209-1978)	Elastic recovery at 15°C, (%) (IRC-SP-53-2010)	%Loss of weight after TFOT (ASTM -D1754)
VG-30	49	52	18	0.06
2%EVA	33	56	37	0.055
3%EVA	31	62	45	0.04
4%EVA	28	65	56	0.03

4.6 Penetration test

The material becomes stiffer after evaporation of volatile, material ageing hardens and thus penetration value decreases and the value decreases as the percentage of modifier.

4.7 Softening point test

There is an increase in softening point noted with increasing modifier content.

4.8 Elastic recovery test

The result obtained shows an increasing pattern which indicates the material as more flexible to binder.

4.9 Loss in weight

The loss of volatile fractions contributes 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%.

5. CONCLUSIONS:

The laboratory investigations indicates that short-term aging of the bitumen shows the physical hardness of the binder properties changing after simulating the base bitumen to aging using TFOT, reducing binder penetration , increasing softening points, increasing elastic recovery and the loss of volatile fractions contributes to the difference in weights between un-aged and aged sample. Aging increases the binder hardness; this could be attributed to the increase stiffness of the binder after the TFOT. The elastic recovery increases with increase in percentage of EVA and is observed at 4%. Higher value of elastic recovery indicates more flexibility to the binder and will increase the life of pavement at low temperature. EVA modified binders can be used in very high temperature and heavy traffic areas and states the climatic conditions in which each one should be used beneficially. It has got opportunities for road sector engineering companies.

6. REFERENCES:

[1]. Airey, G.D. (2002). “Rheological Evaluation of Ethylene Vinyl Acetate Polymer Modified Bitumens”, Journal of Construction and Building Materials, Elsevier Science Ltd, 16, 473-487.

[2]. Claudio Brovelli, LoicHilliou, YacineHemar, Jorge Pais, Paulo Pereira, Maurizio Crispino (2013), “Rheological characteristics of EVA modified bitumen and their correlations with bitumen concrete properties” / Construction and Building Materials 48 (2013) 1202–1208, Elsevier Science Direct.

[3]. Gonzalez, O., Muno, M. and Santama, A. (2004). “Rheology and Stability of Bitumen-EVA Blends”, European Polymer Journal, Elsevier Science Ltd, 40, 2365-2372.

[4]. Morales, M. and Partal, P. (2004). “Viscous properties and microstructure of recycled EVA modified bitumen”, Fuel, Elsevier Science Ltd, 83, 31-38.

[5]. Praveen Kumar, M.R. Maurya, Manoj Gupta &Maninder Singh(2012) “Lab study on chemical and rheological changes in modified binders” Highway Research Journal, January – June 2012

6]. Praveen Kumar, Tanveer, Khan and Maninder Singh (2013), “Study on EVA modified bitumen” Elixir Chem. Engg. 54A (2013) 12616-12618

[7]. ASTM D4402 – 06 “Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer”.

[8]. ASTM D1754, “Test Method for Effect of Heat and Air on Thin Film of Asphalt (TFOT)”.