Surveying the Impact of VG-10 Bitumen with & Without Additive on Short Term Transient Maturing

Kishan K.Vachhani[1], Prof. C.B. Mishra[2]

[1]*M.Tech Student, Transportation System Engineering, BVM Engineering College, V.V. Nagar, Anand, India,*

[2]*Associate Professor, Civil Engineering Department, BVM Engineering College, V.V. Nagar, Anand, India*

***Abstract*—With the quickly extending Indian road transportation foundation, the road system is experiencing a testing advancement. The adaptable asphalts, which have bituminous layers in top, are more favored in India as these are less extravagant with respect to both beginning and support costs. But the exponential increment in activity, over-burdening of business vehicles and huge varieties in every day and occasional temperatures have demonstrated a few constraints of customary bitumen execution. This requires the interest of changing the property of bitumens with utilization of compound added substances so as to give more durability to asphalt under extreme climatic conditions. In the present study, an endeavor is made to study the precise orderly examination of the properties of VG 10 evaluation bitumen with and without utilizing ethylene vinyl acetate (2%,3% and 4%) and reactive ethylene ter polymer (Elvaloy® 4170) in suitable measurements of 1.5%, 1.8% and 2% by weight of bitumen. To center the effect of high temperature (163°C) and air on developing, proliferation or is finished in the exploration office in the research facility utilizing thin film oven test for reenactment of transient maturing.**

I. INTRODUCTION

India has the second biggest system of road beside USA on the planet. Foundation improvement is occurring quickly in India. This change has acquired build activity volume, burden conditions, and so forth, and subsequently bitumen needed for road development is essentially ought to have longer benefit life and better execution attributes. The improvement of superior bitumen fasteners has been a subject of unmistakable fascination to accomplish better road execution. India is presently at a discriminating point in the historical backdrop of base advancements since freedom, whereby road development and formative exercises are at the top.

The Aging of bituminous cover is one of the key variables deciding the lifetime of asphalt. Aging 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. Binder modification is a major breakthrough and the continuous research and is aiming to produce new binders with better rheological and mechanical characteristics which allow the manufacturing and application of road bituminous mixes with higher performance. The purpose of bitumen modification using polymers is to achieve desired engineering service properties.

A methodical examination work has been done to recognize the impact of procedure strategies using ethylene vinyl acetate (EVA) and reactive ethylene ter polymer (Elvaloy® 4170) in suitable doses with and without on properties of asphalt binder (VG 10) which incorporates penetration test, softening point test, elastic recovery test and viscosity test. To determine the effect of heat (163°C) test is carried out in the laboratory using thin film oven test for simulation of short term aging.

II. SOME SELECTED PREVIOUS RESEARCH WORK:

2.1 Biswanath Saha, Sonal Maheshwari, P. Senthivel, N. V. Choudary (2010) – In their paper on "Assessment of performance characteristics of Crumb Rubber Modified Bitumen using Dynamic Shear Rheometer" stated that in the post globalization era, India is witnessing significant growth in every sector which is evident by rapid growth in infrastructure developments. The country is building a huge network of expressways, national highways and rural roads. This momentous change has brought a continuous increase in traffic volume, load conditions, etc and therefore bitumen required for road construction requires upgradation which offers improved performance & higher service life. The performance of base bitumen is enhanced by a wide variety of additives, mainly with synthetic polymers, which increases the cost of the final product. Natural rubber latex and Crumb rubber are the cost effective additives for improving the quality of base bitumen. Natural rubber modified bitumen (NRMB) is usually made with VG 10 bitumen and by addition of latex solution. BPCL-Kochi Refinery is the only producer of NRMB in the country, which produces three grades (NRMB 120, 70 & 40) that are used for pavement construction. Similarly, crumb rubber modified bitumen (CRMB) is usually made with base bitumen VG 10 or 30 along with chemically treated crumb rubber modifier. Three grades of CRMB 50, 55 & 60 are used for pavement construction. At BPCL- R&D, a detailed work

has been carried out to study the rheological properties NRMB 70, CRMB 55 & 60 samples using dynamic shear rheometer (DSR). The analysis is primarily focused on binder gradation, apparent viscosity, and multi stress creep and recovery, etc. The results obtained from their study enable one to assess performance as well as aging characteristics of modified binders. In their paper, the results obtained on CRMB 55 & 60 are discussed. [1]

2.2 Sonal Maheshwari, B. Saha, .P Senthivel, N. V. Choudary (2010) – The paper "Influence of process methods on quality of paving grade bitumen" mentions that paving grade bitumen is a key ingredient of the macadam and asphalt cement used in road constructions, which enable efficient transportation of all types. Though bitumen is the last and low value product from refinery; processing method, quality etc., it plays an important role for durable performance in pavement service. The main objective of any refinery is to maximize the recovery of valuable distillate and to reduce the energy consumption of the units. It is temperature which determines the amount of valuable streams and quality of end product. Due to paradigm shift in paving grade bitumen specification (IS 73:2006), it is necessary for every refinery to meet the required quality of bitumen. It may be a general practice to produce bitumen by one of the processes viz. "blending" to maximize the profit and to reduce process complexity along with energy saving, but it is essential that for better performance and high durability of road pavements, quality of bitumen shall not be compromised. Bitumen can be produced by various processing methods viz. straight run, blending and air blowing of short residue. In general, air blown bitumen is superior to bitumen processed by other methods in terms of high temperature susceptibility and performance characteristics. A systematic research work has been carried out to identify the influence of process methods on quality of air blown, straight run and blended bitumen. Samples of blended and air blown bitumen for this study were prepared in lab / pilot scale using SR (short residue) and slop of selected crudes. Products were evaluated as per VG specifications (IS 73:2006) and also tested for its performance characteristics before and after aging using advance instruments like Dynamic Shear Rheometer (DSR), Rolling Thin Film Oven Test (TFOT) and Pressure Aging Vessel (PAV), Bending Beam Rheometer (BBR) etc. The effect of processing methods on the quality of bitumen product in terms of performance properties is discussed in this paper.[2]

2.3 Maninder Singha, Praveen Kumara,, M. R. Mauryac, , Manoj Gupta (2012) in their research work on "Aging Effect on Modified Bitumen" states that the polymers are the most common modifiers currently being used to improve bitumen properties. The polymers increase the temperature range over which a binder resists both rutting and thermal cracking. In this paper VG10 bitumen and two polymers: Styrene Butadiene Styrene (SBS) block copolymer, Ethylene Vinyl Acetate (EVA) polymer and crumb rubber (CR) are used as modifiers with varying percentage of 2%, 5% and 8%. The SBS and EVA modified bitumen samples were prepared by means of high and low shear laboratory type mixer rotating at 3000 rpm and 1500 rpm, respectively at a temperature of 180oC whereas for the preparation of CR the modified samples are prepared at 1100 rpm. The ageing properties of polymer modified bitumen (PMB) have the main role in quality of PMB dispersions and solid PMB. For Short term aging the virgin bitumen and SBS/EVA and CR blends were aged by means of the Thin Film Oven Test (TFOT), at a temperature of 163oC for 5 hrs. The change in physical properties such as penetration, viscosity, softening point, elastic recovery and loss in weight were compared before and after short term ageing. [3]

2.4 Ms. Khusboo Arora, Mrs. Siksha Swaroopa Kar & Dr. P.K.Jain (2014) highlights in their paper on "Effect of vacuum residue on rheological properties of low viscosity bituminous binders for road construction" that effects of different dosage of a typical vacuum residue (VR) on rheological properties of low viscosity bituminous binder are investigated. Detailed rheological studies were performed using Dynamic Shear Rheometer (DSR). Four approaches were used to investigate the temperature susceptibility of binders. Temperature susceptibility decreases with increase in VR percentage in VG10 showing high penetration index (PI), low viscosity-temperature susceptibility (VTS) and high penetration-viscosity number (PVN). Isochronal and isothermal graphs are plotted for different blends. From this study, it has been concluded that with the incorporation of VR in VG10, resistance to rutting in bituminous roads increases. VR modified bitumen shall perform better in high temperature climate. [4]

2.5 Teltayev Bagdat, Izmailova, Galiya and Amirbayev Yerik (2014) has presented in his paper on "Rheological Properties of Oxidized Bitumen with Polymer Additive" 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. [5]

III. EXPERIMENTAL PROGRAMME

3.1 Materials:

In this study the accompanying materials are thought seriously about for doing investigations:

3.1.1 Bitumen:

VG-10 bitumen supplied by the Tiki Tar Industries, Halol Vadodara district is comprehensively used as a piece of spreading applications, for instance, surface-dressing and clearing in outstandingly cold air in lieu of old 80/100 Penetration grade. Vg10 grade bitumen containing 20 to

40 wt% of sweet-inhaling enhanced deasphalted oil concentrate division and having a base kinematic consistency of 250 cst at 135° C, a base by and large thickness of 800 poise at 60° C, a penetration point heading off from 80/100 at 25° C and a base softening motivation behind 40° C. Milder thickness grades VG-10 are proposed for areas with most raised consistently mean air temperatures of 30° C and lower, (for instance, cool climatic high stature zones of North India). The slightest step by step mean air temperatures (which are also truly close to bitumen temperature) happen in India in January. They run from -2°C to 21°C from Kashmir to kanya Kumari. At temperatures lower than -10° C we can use gentler grades

3.1.2 Type of modifiers and its preparation:

Dupont™ Elvaloy® 4170 supplied by Tiki Tar Industries, Halol, Vadodara is a Reactive Elastomeric Ter polymer (RET) and is most sensitive that can be utilized to change the properties of bitumen utilized as a part of clearing. Its warm Melting Point (DSC) typically is 72°C. The Elvaloy® changed bitumen was delivered by including concentration weight (1.5%, 1.8% and 2%) of to the virgin bitumen at a temperature of 180°C using grill fitted with a mechanical stirrer and rotated at 1550 rpm. Maker of the modifier prescribes a mixing system which takes 120 minutes curing time, at 180°C extent, utilizing a colloid process. . It has the properties to improve long term durability. Ethyl Vinyl Acetate (EVA) copolymer, accessible as pellets 4 to 5 mm in measurement supplied by Tiki Tar Industries, Halol, Vadodara area was utilized to change the ordinary Vg10 grade bitumen. EVA is a polymeric plastomer which comprises of two monomers ethylene and vinyl-acetic acid derivation (VA). The copolymers are polar and together with the maltenes from the bitumen will manage the similarity and glue properties of the bitumen. EVA adjusted bitumen can give enhanced imperviousness to rutting in hot-blend bitumen contrasted with routine bitumen alongside enhanced similarity, more secure taking care of and better workability. EVA have enhanced clarity, low temperature adaptability, anxiety split safety, and effect quality. To 1.5 liter limit metal compartment around 500 g of the bitumen was warmed to fluid condition. The mixing was performed in the exploration focus using a grill fitted with a mechanical stirrer and rotated at 1550 rpm for mixing the bitumen and modifiers. The EVA modified bitumen was produced by adding Concentration, weight (2%, 3% and 4%) ethylene – vinyl acetate copolymer to the heated bitumen at 180°C for 80 to 90 minutes.

3.2 Testing :

3.2.1 Brookfield Viscometer test was done according to ASTM D4402 with thermocel temperature control system. The spindle was selected for 135°C and is equilibrated in the clean thermocel chamber for 5 minute at 20 rpm to determine the kinematic viscosity of the samples to simulate binder workability at mixing and lay down temperatures for pavement construction. Test results were used to compare the viscosity of all VG 10 with and without Reactive Elastomeric Ter polymer (RET) & Ethyl Vinyl Acetate (EVA) of un-aged samples to the viscosity of all aged samples. [8]

3.2.2 Short term aging test:

Maturing of the bitumen was performed by short term aging test (TFOT, ASTM D1754). Samples of 50 gm of VG10 bitumen was weighed (with and without added substance modifiers) and poured into cylindrical pans with 140 mm dia. and 10 mm depth and having a thickness of 3.2 mm. The pans were placed on a circular shelf rotating at a speed of 6 rpm. The whole assembly is fixed in an oven for 5 hr at 163ºc. The impact of high temperature and air are dead set from changes brought about in physical properties measured previously, then after the fact the broiler treatment. Loss of unpredictable divisions helps the distinction in weights in the middle of unique and matured example. The most extreme misfortune in weight ought to be 1 every percent according to IRC: SP: 53:2002. [9]

IV. TEST RESULTS AND DISCUSSION:

4.1 Before aging

Table 1: Physical properties of VG-10 bitumen before aging.

Binder type	Penetration at 25 °C (mm)	Softening point, (°C)	Elastic recovery at 15 °C, (%)	Viscosity in Poise	Specific gravity
VG-10	86	46	19	@60°C = 1.1	1.00
1.5%RET	65	60	68	@135°C = 5.75	1.020
1.8%RET	62	63	72	@135°C = 6.0	1.023
2%RET	60	65	76	@135°C = 6.4	1.0265
2%EVA	50	52	38	@135°C = 4.2	1.010
3%EVA	45	57	44.5	@135°C = 5.3	1.011
4%EVA	38	62.5	50	@135°C = 5.95	1.020

4.2 Physical properties of VG-10 bitumen before aging(table 1):

*4.2.1 Penetration test result (*IS: 1203-1978*)*: Penetration measures the bitumen consistency. The infiltration qualities are diminishing essentially for VG10 bitumen blended with both added substances as the convergence of it increments. This is evidence that the science has changed the property, as solidness has expanded;

upgraded state of temperature helpless is noted accordingly expanding the workability of bituminous blend. This is great in one sense since it may enhance the rutting safety of the mix. [11]

*4.2.2 Softening point result(*IS: 1209-1978*)*: The results show the stiffening effect with the addition of EVA and reactive Elvaloy (®RET) in suitable dosages with VG 10 bitumen; this phenomenon indicates that the resistance of the binder to the effect of heat is increased and it will reduce its tendency to soften in weather. This shows that better rutting resistance property. [12]

4.2.3 Elastic recovery results (IRC-SP-53-2010): Results indicate improved homogeneity increasing flexibility of the binder to recover after stretching depending on the modification additive. This will contribute to increasing the life of pavement at low temperature. It is clearly shown in table - 1 that the VG 10 bitumen modified with 2%Elvaloy® (RET) gives the maximum elastic recovery than that of bitumen modified with EVA. [10]

4.2.4 Specific gravity test(IS: 1202-1978): The results demonstrate that the particular gravity quality minor increase is noted. This is due to slight changing the chemistry of bitumen by addition of both agents. [13]

4.2.5 Viscosity Test (ASTM D4402-06): It is used for determining the kinematic viscosities of the samples at 135°C for 5 min at 20 rpm. The viscosity increases on introduction of EVA and reactive Elvaloy (®RET) in suitable dosages with VG 10 bitumen, but the change is more pronounced in case Elvaloy® (RET) as compared to EVA. [8]

4.3 After aging:

Table 2: Physical properties of VG-10 bitumen after aging (TFOT)

Binder type	Penetration at 25 °C (mm)	Softening point, (°C)	Elastic recovery at 15°C, (%)	%Loss of weight after TFOT
VG-10	82	46.5	12	0.07
1.5%RET	59	61	65	0.07
1.8%RET	57	65	70	0.05
2%RET	55	66	73	0.04
2%EVA	45	53	35	0.03
3%EVA	40	57.5	42	0.04
4%EVA	33	62.5	45	0.025

4.4 Physical properties after aging (table 2):

4.4.1 Penetration test (IS: 1203-1978)
Table shows considerable decrease in penetration value by the addition of additives as per codal practice. It indicates that the chemistry has changed showing signs of stiffness. [11]

4.4.2 Softening point test (IS: 1209-1978)

Table 2 shows there is an augmentation in softening point noted with growing modifier substance bringing about hardening of bitumen which will decrease the rutting issues since the road surface temperature is relied upon to be less than the softening point of road surface. [12]

4.4.3 Elastic recovery test (IRC-SP-53-2010)

The result got exhibits an effect of modifier on VG 10 bitumen i.e. increment of elastic recovery value which demonstrates the material enhancing bitumen resistance to rutting. [10]

4.4.4 Loss in weight (ASTM -D1754)

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%. [9]

V. CONCLUSIONS

Maturing is not a deformity without anyone else's input, yet a few asphalt properties are affected by the maturing methodology. Among these properties, the properties of bitumen picked up consideration since the bitumen is matured; it gets to be more vulnerable to advancement of splits and raveling. It will be more delicate to improvement of breaks because of rutting, low temperature and mishapening. Based on the results of this study, the addition of EVA and reactive Elvaloy (®RET) in suitable dosages with VG 10 bitumen to the bitumen binder enhance the physical properties of bitumen binder as indicated by the reduction in penetration value, increase in softening point and elastic recovery, thus enhancing binder elasticity and increase its ability to resist rutting deformation. It is established that in initial state and after short term aging at high temperature of 163°C for 5 hours shows that 2%Elvaloy® (RET) is having excellent properties compared to EVA additives, also the % Loss of weight as per ASTM -D1754 is reducing and is within permissible limits of codes. Study states the climatic conditions in which VG 10 grade bitumen with 2% Elvaloy® (RET) can be beneficial to the road contractors

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