Effect of Asphalt Binders Aging on Thermodynamic Parameter And Its Relationship With Moisture Sensitivity of Asphalt Mixes

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Abstract- *India is the fastest growing country among developing countries of the world, For Economic development of nation with infrastructural growth road development is also an essential for the country. But Aging of binder is the major draw-back of asphalt pavement for long service life point of view. Generally aging of binder is caused due to climatic condition which leads to the crack on pavement , rutting, fatigue cracks ,loss of visco-elasticity of binder resulting into hardening of binder which cannot cope-up the ever changing environment and increased traffic laden loads finally the pavement of failure takes place.*

To overcome this problem an attempt is made to modify the properties of VG-10 binder by the addition of sasobit and polypropylene in suitable dosages. Laboratory investigation are carried out to evaluate the properties of VG-10 binder with and without modifiers. Also, effect of Short term Aging is determined using TFOT respectively. Rheological properties is identified using DSR(

Keywords- Rutting , Fatigue , Sasobit , Polypropylene , Rheology

I. INTRODUCTION

Bitumen have been used for a millennia as waterproofing agent, sealant, adhesive and then gradually as a construction material. Bitumen is not only an important engineering material but also a vital material in pavement engineering whose properties changes with time. Even if the bituminous mix is made according to the specification though the durability is affected due to the age of hardening and damage due to water which weakens its rheological properties. Bitumen is a visco elastic material. Visco-elastic means it behaves partly like an elastic solid (deformation due to loading is recoverable) and partly like a viscous liquid (deformation due to loading is not recoverable) and its behaviour depends on the temperature and rate of loading. At the construction stage due to rapid oxidation the bitumen become stiffer but gradually the process slow down when the pavement is in service. This phenomenon is known as Aging.
Several researchers have performed chemical and mechanical aging tests but still aging is a poorly understood phenomenon.
A common practice in asphalt technology is that there is a continuous effort on modifying asphalt binders for improve properties by the researchers for improving the performance of bitumen pavement.

By considering the above problem, here the attempt is made to overcome from this problem by studying scientifically the performance related characteristics of unmodified bitumen (VG-10) with and without modifiers in the laboratory also simulating the effect of short term aging thereby changes in chemistry determined using morphological tests.

II. EXPERIMENT PROCEDURE

(Materials and Moulds Used)

BITUMEN :

As per IS 73:2006 VG 10 Bitumen i have used In my investigation.

Table : Elementary analysis of bitumen.

Component	Percentage(%)
Carbon	*82-88*
Hydrogen	*8-11*
Sulphur	*0-6*
Oxygen	*0-1.5*
Nitrogen	*0-1*

SASOBIT

it is an organic additive of warm-mix asphalt. It is also known as FT paraffin wax and asphalt flow improver. Sasobit is produced by sasol wax company , It is derived from

coal gasification process or natural gas. Based on guideline of Sasol wax, Sasobit is safe, easy to handle and can be used in food-grade applications such as adhesives and therefore holds in no health hazards for workers. According to Sasol guideline, Sasobit is existing in two forms: Pastille form (4mm diameter) and prill form (1mm diameter). Moreover, it is available in 2, 5, 20 and 25kg bags and 600 kg super sacks.

POLYPROPYLENE

Polypropylene is one of the most widely used polymers in the world because of the widespread availability and low manufacturing cost. The reactivity of propylene is a result of the double bond in methyl-ethylene ($H_2C=CHCH_2$), which gives rise to addition reactions. With respect to the regularity of the methyl group placement relative to the other methyl groups along the chain backbone otherwise called the stereo specificity of the polymerization.

III. TEST AND RESULT

1. SAMPLE PREPARATION :

Modified binder preparation required, about 500g of bitumen (VG-10) from the container after heating it to obtain it in a fluid state. Pour this in a vessel, now set this vessel beneath the stirring machine to get the bitumen stir and get heated up to 180°C. This stirring machine is oven fitted with setting of rpm of stirrer. This mix was prepared in a laboratory using this stirrer with 1200 rpm to heat the bitumen and modifier at 180°C. After attaining this temperature of bitumen, Modifier is then added into bitumen in accordance of predefined proportion. This mixture is then kept for stirring process, based on time taken by the modifier to dissolve in binder to formed homogenous mix of desired consistency. Then after this modified bitumen can be used for different testing.

CONVENTIONAL PHYSICAL TEST

The bitumen is available in a variety types and grades. To judge the suitability of these binders various physical tests conducted such as

1. Penetration test (IS:1203-1978)
2. Softening Point test (IS:1205-1978)
3. Elasticity Test (IS:1208-1978)
4. Rotational Viscosity test(IS:1206-1978)
5. Thin Film Oven Test (ASDM- D1754)

Result of Binder VG-10 with Sasobit , Before and After Short-term Aging (IS: 15462:2004):

Binder type	concentration (%)	softening point (°c)	penetration (dmm)	viscosity (150°c)	Elastic recovery (%)	Loss of weight (%)
VG-10	–	46	86	–	19	–
Before aging (VG-10+SB)	2.5	64	50	6.85	62	–
	3	68	47	7.5	76	–
	3.5	72	31	9.79	80	–
VG-10	–	47	82	–	15	0.07
After aging (VG-10+SB)	2.5	67	46	–	56	0.1
	3	70	40	–	70	0.07
	3.5	75	26	–	75	0.09

Result of Binder VG-10 with Polypropylene, Before and After Short-term Aging (IS:15462:'04)

Binder type	Polymer concentration (%)	softening point (°c)	penetration (dmm)	viscosity (150°c)	Elastic recovery (%)	Loss of weight (%)
VG-10	–	46	86	–	19	–
Before aging (VG-10+PP)	1.6	63	52	7.0	70	–
	1.8	65	49	7.4	77	–
	2	67	47	7.6	85	–
VG-10	–	47	82	–	15	0.07
After aging (VG-10+PP)	1.6	65	50	–	66	0.1
	1.8	67	44	–	74	0.06

IV. STUDY ON RHEOLOGICAL TEST OF BINDER

DYNAMIC SHEAR RHEOMETER (DSR)

The Dynamic shear rheometer is used to test the viscous and elastic property of the binder at medium to high temperature. The basic DSR test uses the binder sample sandwich between the two circular plates oscillates back and forth across the sample at 10rad/sec to create shearing action. This test can be conducted on unaged, TFOT, RTFOT and PAV aged sample. This test is mainly the software controlled test. DSR is capable to quantify the viscous and elastic properties, which makes it suitable for defining the temperature range when pavement is in service.

The rheological parameter determine by the DSR test are complex shear modulus (G*) and phase angle (δ). The complex shear modulus (G*) can be considered the sample's total resistance to deformation when repeatedly sheared, while the phase angle (δ), is the lag between the applied shear stress and the resulting shear strain. The larger the phase angle (δ), The more viscous the material. Phase angle (δ) limiting values are:

- Purely elastic material: δ = 0 degrees
- Purely viscous material: δ = 90 degrees

SPECIMEN GEOMETRY

The specimen geometry was chosen according to the test type, condition and specification. The specimen geometry at high temperature should have big diameter (25mm) with small thickness (1mm) to save the specimen from melting. At intermediate temperature the specimen should have small diameter (8mm) with high thickness (2mm) to prevent It from brittle crack

Variation in Rheological Parameter Binder using DSR Test

Material	Tempe-rature (°C)	Phaseangle (rad)	Complex modulus (G*) (kPa)	Shear Modulus (G*/sinδ) (kPa)	Loss Modulus (G* × sinδ) (kPa)	Storage Modulus (kPa)
VG-10+ 2.5% Sasobit	40	1.18	86.27	78.2	84.2	84.2
	60	1.13	6.23	8.5	9.41	9.41
	90	1.1	0.84	0.92	0.51	0.51
VG-10+3% Sasobit	40	1.15	95.2	210	96.44	96.44
	60	1.13	5.84	10.2	8.69	8.69
	90	1.12	0.9	1.72	0.82	0.82
VG-10+ 3.5% Sasobit	40	1.32	105	88.9	95.73	95.73
	60	1.22	9.9	0.99	2.13	2.13
	90	1.19	0.764	0.84	0.92	0.92
VG-10+1.6% Polypropelene	40	1.25	81.4	89.4	75.1	75.1
	60	1.22	8.6	8.91	7.8	7.8
	90	1.14	0.658	0.871	0.685	0.685
VG-10+1.8% Polypropelene	40	1.27	85.4	94.8	80.1	80.1
	60	1.21	7.64	10	8.89	8.89
	90	1.19	0.779	0.78	0.821	0.821
VG-10+ 2% Polypropelene	40	1.42	106.4	105	70.23	70.23
	60	1.23	9.52	9.54	7.72	7.72
	90	1.18	0.238	1	0.657	0.657

V. CONCLUSION

- After addition of the modifiers SASOBIT and PP with different dosage in the bitumen VG-10 sudden physical change has been seen in the binder. As the concentration of modifier increases the properties such as softening point increases, penetration decreases and elastic recovery increases of modified bituminous binder respectively.
- After the TFOT test again there is increase in the softening point of modified bitumen which shows that there an expansion of the modifier in the bitumen content during oxidation process.
- Penetration of the binder is decreasing which indicaearchte that due to oxidation the binder is getting stiffer and maturely solidified, it can be seen that PP penetration remains 44 dmm at 1.8% of dosage while SASOBIT is having 40 dmm at 3% dosage thus PP is more suitable.
- After TFOT test loss in weight of modified binder should be less than 1% and which is in permissible limit of modified binders as shown in the table.
- Hence it can be said that both modifier SASOBIT at 3% and PP at 1.8% work well as far as the physical properties are concern as all the values are as per the IS specified limit.
- Three major rheological properties of modified bitumen are characterized from this DSR test that is complex modulus(G*), shear modulus (G*/sinδ) and loss modulus (G* sin δ) which performance are predicted at the high temperature.
- Shear modulus which is known as a rutting factor and characterized the stiffness parameter is also decreasing with increment of temperature thus help to prevent rutting effect on the pavement and also it is able to with stand against high temperature during summer due to decrease in stiffness of bitumen thus prolong the life of pavement.
- From the temperature failed analysis after short-term aging of modified binder it can be seen that VG-10+ 3% SASOBIT and VG-10+1.8% PP both are can be used in high temperature climate as they are stiff binder also elastic in nature.

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