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Laboratory Study on CRMB Modified Bitumen Mixes with Titan Polymer

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Abstract: **It has been established that strength as well as elastic properties of bitumen mixes increase considerably by addition of TITAN Polymer. The main objective of the study has been to evaluate the laboratory performance of Crumb Rubber Modified Bitumen (CRMB) and its comparative performance when a polymer Polyethylene wax i.e. "TITAN" is used in the already modified bitumen i.e. Crumb Rubber Modified Bitumen. Further study involves to synthesizing the laboratory test results of polymer modified binder, compare the laboratory test results of polymer modified bitumen i.e. CRMB with TITAN 7686 in terms of resistance to rutting, and evaluating the effects of measured viscoelastic properties of the bitumen layer. The addition of small amount of Crumb Rubber polymer dramatically changes the properties of the binder, but Crumb Rubber modified binder also requires high blending, mixing and placement temperatures. Therefore, for better stability, workability and elastic behaviour of bituminous mixes, they may be used in conjugation with other additives such as PE wax and PE Copolymer (7205 and 7686).**

Keywords: **Polymer Modified Bitumen (PMB), Copolymerization of Bitumen, Polyethylene wax TITAN, Dynamic Shear Rheometer (DSR).**

1. INTRODUCTION

Bitumen is predominantly used to construct pavements for roads, highways, and airports. Both bitumen binder and bitumen-aggregate mixture show temperature- and time-dependent behavior. Increasing traffic volumes, vehicle loads and tyre pressures are causing accelerated degradation of our road pavements. Improved materials, such as Polymer Modified Binders (PMBs), are being used as a means of better combating these effects. PMBs are generally considered to provide prolonged life or enhanced pavement performance. Elastomers and Plastomers are two basic types of polymers, used in modifying bitumen for road applications. Conventional bituminous mixes have performed satisfactorily well on a wide range of roads in the past, but, the performance of neat bituminous mixes is generally unsatisfactory for paving applications due to the increased magnitude of wheel loads and tyre pressures of current traffic. To cater to such situation the present study has been carried out using PE COPOLYMER WAX (HONEY WELL TITAN 7686) with Crumb Rubber Modified Bitumen which produced Bituminous mixes with enhanced properties.

The purpose of present work is to study the benefit of CRMB (crumb rubberised modified bitumen) with TITAN 7686 polymer modified bituminous mixes in terms of physical and mechanical properties.

This study has been conducted to explore the co-polymerization i.e. (addition of another polymer to already polymer modified bitumen) and its use in road construction. Detailed laboratory investigations have been carried out to find out whether it is viable to use in terms of suitability, economy and environmental standards.

2. METHODOLOGY

Modification of CRMB has been done by mixing 0.5% (by weight) of PE Wax i.e. TITAN in blender at 150^0C and 2000 rpm for one hour to produce homogeneous mixture.

2.1 Bitumen Tests

Bitumen used in the design of BC is plain CRMB and Modified CRMB with TITAN 7686. Before use of bitumen in design mix it has been tested for their physical properties. All these test should be performed as per provision of relevant IS codes. The tests to be performed are:

- Penetration test, IS: 1203-1978
- Softening Point test, IS: 1205-1978
- Elastic Recovery test, IS: 15462-2004
- Viscosity test (Brookfield Viscometer) ASTM 4404 / ASTM D 2983
- Specific Gravity test, IS: 1202-1978

2.2 Dynamic Shear Rheometer (DSR) test has been done as per ASTM D6373.

3. RESULTS INTERPRETATION

Laboratory test results have been evaluated to predict the behaviour of Warm mix and to determine the use of TITAN with CRMB in bituminous mixes, Analysis of all performance

evaluation tests results has been done of in terms of their engineering properties.

Additive 7686 is a PE copolymer; polyethylene which belongs to plastomer category gives rigidity to the binder and reduces the deformation under load. These additives, when mixed with bitumen, increase the viscosity and thus stiffness at service temperature.

3.1 Physical Properties of Plain CRMB and Modified CRMB

There are number of tests assess, the properties of paving grade bitumen. The commercially available CRM bitumen was tested for its suitability in bituminous mixes as per IS: 73-2013. The CRMB blended with PE copolymer waxes (7686) was also tested in the laboratory. The test results obtained for modified bitumen i.e. plain CRM bitumen and twice modified binder i.e. CRMB with TITAN 7686 are presented in Table 1.

Table 1 Physical Properties of CRMB v/s CRMB modified with TITAN

S. No.	Test	As per IS	Result CRMB	Result CRMB+TITAN	Limit as per IRC SP53:2010
1.	Specific gravity (27^0C)	IS 1202	1.01	1.0	Minimum 0.99
2.	Ductility at 27^0C (cm)	IS 1208	86	90	Minimum 75
3.	Softening point, ^{0}C	IS 1205	62	65.5	Minimum 60
4.	Penetration at 25^0C, 100g, 5 sec, 1/10 mm	IS 1203	48.33	40.5	30-50
5.	Viscosity 150^0C, @ 20 rpm, (Brookfield Viscometer)	ASTM 4402 /ASTM D 2983	7.50	8.0	3-9
	Viscosity 150^0C, @ 100 rpm	ASTM 4402 / ASTM D 2983	7.20	7.45	3-9
6.	Elastic Recovery15^0 C	IS 15462	60	61	Minimum 60

3.2 Dynamic Shear Rheometer

This test method covers the determination of the dynamic shear modulus and phase angle of bitumen binders when tested in dynamic (oscillatory) shear using parallel plate geometry. This test method has been carried out for determining the linear viscoelastic properties of bitumen binders as required for specification testing. 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. Phase angle (δ) is directly proportional to viscosity. Phase angle (δ) limiting values are 0 degrees for purely elastic material and 90 degrees for purely viscous material. The complex shear modulus and the phase angle define the resistance to shear deformation of the bitumen binder in the linear viscoelastic region. The complex modulus and the phase angle are used to calculate performance-related criteria in accordance with Specification ASTM D6373 or AASHTO Standard M320. The comparison of results between plain CRMB and CRMB modified with TITAN are shown in Figure 1, Table 2 and 3.

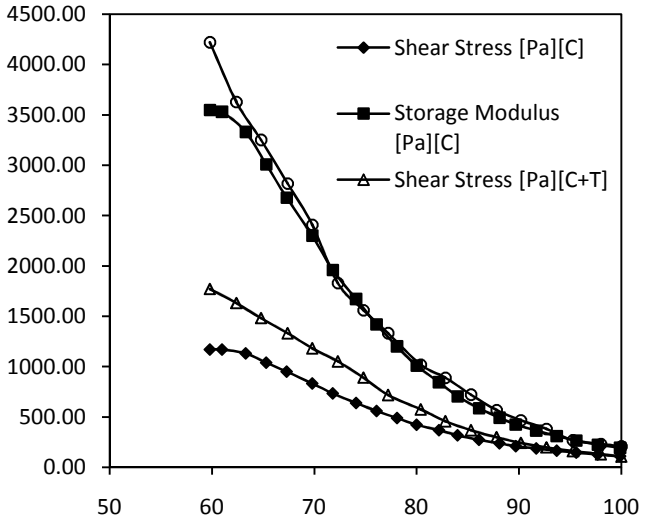

Fig. 1 DSR results showing the comparison of properties like Shear stress and storage modulus on plain CRMB [C] and CRMB modified with TITAN [C+T]

Table 2 DSR results showing the effect on various properties of plain CRMB sample w.r.t. change in temperature

Shear Stress	Storage Modulus	Phase Angle	Temp.	|G*|·sin δ	|G*|/sin δ	Deflection Angle
[Pa]	[Pa]	[°]	[°C]	[k Pa]	[k Pa]	[m rad]
127	226	77.4	97.7	1.01	1.06	9.78
111	192	77.8	99.9	0.887	0.929	9.8

Table 3 DSR results showing the effect on various properties of CRMB modified with TITAN sample w.r.t. change in temperature

Shear Stress	Storage Modulus	Phase Angle	Temp.	|G*|·sin δ	|G*|/sin δ	Deflection Angle
[Pa]	[Pa]	[°]	[°C]	[k Pa]	[k Pa]	[m rad]
128	232	81	98	1.02	1.05	9.92
104	196	81.6	100	0.838	0.856	9.82

4. CONCLUSIONS

The addition of PE Copolymer wax i.e. HONEYWELL TITAN (7686) to the bitumen i.e. plain CRMB has significantly affected the binder properties and viscosity profile of the base binder. The following conclusions can be drawn from the laboratory work that had been carried out at CSIR – CRRI; NEW DELHI.

Copolymerization of bitumen can bring real benefits to highway maintenance/construction in terms of better and longer lasting roads, and savings in total road life costing. PE Copolymer wax (7686) can be successfully used to enhance the properties of the binder and the mix as compared to conventional binder. Bituminous mixes with this additive are able to achieve the desired properties of mix like stability, durability, workability, compaction, resistance to deformation etc., but for better elastic behaviour they may be used in conjugation with other additives like CRMB, SBR or SBS etc. which can impart elastic properties to the mix also. Other properties of bitumen were also found to be improving with the addition of PE copolymer wax (7686). Incorporation of PE wax (7686) increased the viscosity of base binder to a greater extent.

5. RECOMMENDATIONS

The results obtained from laboratory study show that the use of PE Copolymer wax (7686) helps in improving the stability or strength, fatigue life and other desirable properties of bituminous concrete mix. Therefore, the life of the pavement surfacing course using the PE Copolymer wax (7686) is expected to increase substantially in comparison to the use of ordinary conventional bituminous mix or plain CRMB.

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