Comparison of SBS, Crumbled Rubber and Zycotherm on VG-20 Grade Bitumen

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Abstract

This paper presents the comparison between three modifiers used in bitumen. The commonly used SBS and Crumbled Rubber has been compared against Zycotherm, which is a new generation silane additive. The paper presents a comparison between the modifications in penetration and softening point values of modified bitumen. The complex modulus variations obtained from DSR testing were also compared. The prices of the modifier used, per kilogram of bitumen has also been assessed.
Keywords- SBS- Styrene-Butadiene-Styrene, Crumbled Rubber, Zycotherm, Dynamic Shear Rheometer, Complex Modulus

I. INTRODUCTION

The performance of asphalt pavements are largely determined by the stiffness and strength of mixtures. Numerous studies recently, have found that the modifications imparted to the bitumen improves the performance of asphalt mixtures.

Antistripping additives and polymer modifications are the two commonly used modifiers used to improve the fundamental properties of asphalt binders, as the performance of asphalt mixtures are closely related to these properties. According to these studies, the overall performance of polymer-modified mixtures is more desirable than those of unmodified mixtures or of mixtures modified with antistripping additives. Polymers were found to improve the rutting performance, adhesion, and cohesion of an asphalt binder.

Currently, styrene–butadiene–styrene (SBS) is the most commonly used polymer for bitumen modification. The SBS block copolymers are classified as elastomers, which increase the elasticity of bitumen, and these are probably the most appropriate polymers for bitumen modification. Previous studies have shown that SBS-modified mixtures exhibited good performance in both asphalt cements and mixtures.

Somehow, it was found that in some cases the modifiers not only decreased the workability of HMA but it also failed to provide a cost-effective solution. This problem of escalating cost of bitumen and polymer modifiers and the lack of available resources have motivated highway engineers to explore alternatives for the construction of new roads. Hence, the usage of waste materials has thus become an important issue in this respect.

Reclaimed rubber obtained from waste tires has been used for paving as an elastic binder additive. Using this waste material may contribute to the solution of a waste disposal-problem and will also facilitate economic sustainability by reducing the construction cost of roads. Asphalt-rubber binder results from the chemical reaction of a mixture of liquid asphalt binder with 5–22% crumb rubber obtained from used tires and added to liquid asphalt.

Asphalt-rubber is mixed and applied to roads mainly using either of two techniques: the dry and wet processes. In a dry process, crumb rubber is used as a part of the aggregate in the hot mixture to replace some of the solid fraction [8]. In a wet process, crumb rubber is added to the asphalt cement mix.

Zycotherm is an advance generation silane additive with multiple benefits. Zycotherm gives chemical bonding for extended moisture resistance, enables 100% coating of bitumen on aggregates and allows wider temperature zone for compaction, resulting in a pavement with extended life cycle.

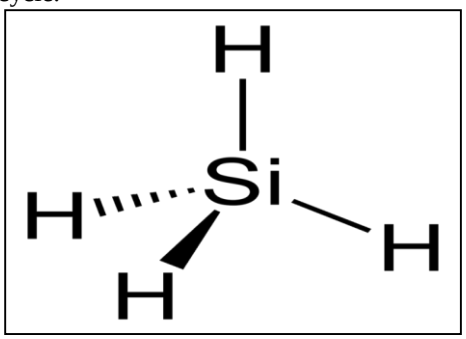

Fig. 1: Silane structure

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Zycotherm chemically modifies the aggregate from water loving to bitumen loving, gives strong permanent bonding of bitumen on the aggregate and extended life confirmed by extending current specification.

Zycotherm modified bitumen achieves complete coating faster due to improved wetting. It also helps to saturate the finest pores and crevices of aggregate surface. Fines are completely coated in the mixing time of 45-60 seconds and ensure pinhole free surface.

II. MATERIALS AND METHOD

VG 20 grade bitumen was used to compare the properties of modifiers used which were Styrene Butadiene Styrene (SBS), Crumb Rubber and Zycotherm.

The virgin binder and the modified binder were taken and tested for their penetration value, softening point etc and was also subjected to testing under Dynamic Shear Rheometer.

For the testing we used bitumen which was mixed with 4% SBS, 12% CR and 0.1% Zycotherm was used.

A. Penetration Test

It measures the hardness or softness of bitumen by measuring the depth in tenths of a millimetre to which a standard loaded needle will penetrate vertically in 5 seconds under the standard conditions of load and temperature. It is the measure of consistency of bitumen and the most commonly adopted test on bitumen so that they can be classified into standard grades. It is conducted according to IS: 1203:1978.

B. Softening Point Test.

Softening point is defined as the temperature at which the substance obtains a desired degree of softening under the specified conditions of testing. It is conducted as per IS: 1205:1978. This is conducted using the ring and the ball apparatus.

C. Dynamic Frequency Sweep Tests

It applies a sinusoidal stress of a constant peak over a range of frequencies. One measurement is taken over each selected frequency. The peak amplitude of the stress is determined by the stress command. Upon completing the stress sweep tests and establishing the target stresses or strains, frequency sweep tests are performed on all the samples at the following test conditions:

- Mode of loading: Controlled stress,
- Temperatures: 10, 20, 30, 40, 60 and 70˚C, and
- Frequencies: from 0.1 to 20 Hz.

III. RESULTS AND DISCUSSIONS

A. Conventional Test Results

The penetration and softening point test results has been tabulated below.

Table 1: Comparison of test results

	VG 20	*SBS*	*CR*	*Zycotherm*
Penetration	*75*	*78*	*70*	*59*
Softening Point	*42*	*52*	*54*	*45*

It was observed that on adding the modifiers there were considerable modification to the VG 20 bitumen. On adding SBS it was observed that the penetration value was increased along with the softening point values. The addition of CR was found to decrease both the penetration as well as softening point value. The addition of zycotherm showed a drastic decrease in penetration value but the change in softening point was not as large as compared with the other two additives.

B. DSR tests

The complex modulus of the four samples were noted down and the graph was plotted to draw comparison between the rigidity of the samples which also in turn gave an idea about the fatigue cracking of the samples before and after modification.

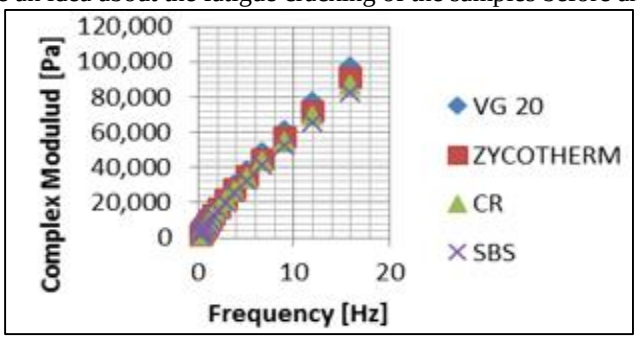

Fig. 2: Plot of complex modulus Vs Frequency

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C. Cost Comparison

It is essential that the modifier that is used does not largely affect the overall cost of the mix. The comparison in cost has been tabulated in Table 2.

Table 2: Cost comparison of modifier

	% in mix	*Cost (/Kg) (in **Rs**)*	*Cost of modifier for 1 kg bitumen(**Rs**)*
Zycotherm	*0.1*	*1000*	*10*
SBS	*4*	*250*	*10*
CR	*12*	*100*	*12*

It can be seen that the modifiers are all having almost equal cost w.r.t the quantity used per kg of bitumen.

IV. CONCLUSIONS

Tests showed that the addition of Styrene-Butadiene-Styrene, Crumbled Rubber and Zycotherm has a positive effect on the bitumen. The penetration and softening point was modified so that it can be used at a region having a higher temperature range during the performance in an asphalt matrix. The analysis pertaining to the complex modulus values showed that the fatigue properties were supported. The mix was found to show more resistance against fatigue cracking as the complex modulus value was found to decrease on the addition of modifiers which in turn relates to the decrease in rigidity at low temperatures. The costs of all the three modifiers were found to fall almost in the same range.

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