EVALUATION THE PROPERTIES OF VG 10 BITUMEN MODIFIED WITH WASTE THERMOCOL

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ABSTRACT

Bitumen is modified by adding thermoplastic or elastomeric virgin polymers. There is constant encouragement for the use of plastic waste in the road sector nowadays to reduce the impact on environment and health hazard. Thermocol waste is one of them. Thermocol is basically Polystyrene which is very slow to biodegrade and a big controversy among environmentalists. By comparing thermocol with plastic, thermocol is ecologically more harmful than other plastic as plastic recycled easily than thermocol. Worldwide disposal of thermocol waste is a serious problem. At the same time, finding proper use for the disposed plastics waste is the need of the hour. As the road traffic is increasing, there is a need to increase the load bearing capacities of the roads. The thermocol waste can be used to modify the bitumen to improve their physical characteristics for particular road mix and climatic conditions.

This paper focuses on the use of thermocol wastes which is mixed with VG 10 bitumen in proportions of 0.5%, 1% and 2% by weight of bitumen. The physical properties of neat bitumen are evaluated and compared with modified VG 10 bitumen having thermocol. An optimum dosage of selected thermocol modifier is determined. The morphological changes on the modified binder containing optimum thermocol quantity were studied by Field emission scanning electron microscopy (FESEM) to assess the compatibility of bitumen with thermocol.

KEY WORDS

Thermocol waste, VG 10 bitumen, optimum dosage, FE-SEM.

1. INTRODUCTION

High consumption of plastics leads towards the generation of huge quantity of plastic wastes. The plastic production industry has grown from INR 35,000 Cr. in year 2005 to INR 100,000 Cr. in year 2015 *(1)*. Plastic contains various toxic chemicals which pollutes the water, soil and air. One of the plastic wastes available in abundant quantity is in the form of thermocol wastes. Since thermocol is a non-biodegradable material, disposal of thermocol would lead to conservation of the toxic material permanently. There can be decrease in rate of rain water percolating in soil if it is mixed with soil.
The principal types of plastic materials found in refuse are High Density Polyethylene (HDPE), Low Density Polyethylene (LDPE), Poly(Vinyl Chloride) (PVC), Poly(Ethylene Terephthalate) (PETE), Polystyrene (PS) and Polypropylene (PP) *(2)*. The polymer modified bitumen used globally includes 75% elastomeric modified binder, 15% plastomeric and remaining 10% either rubber or other modification. Various factors like mixing technique, mixing temperature,

concentration of polymer, solvating power of base bitumen and molecular structure of polymer affect the viscoelastic behavior of polymer modified bitumen. PP offer better blend in comparison to HDPE and LLDPE *(3)*. Application of Polystyrene modified asphalt binders behaves hydrophobic in nature and has no tendency to react or absorb water *(4)*. A review study on applications of waste and virgin polymers in pavement has shown that waste polymers also improved the properties of pavement similar to that of using virgin polymers *(5)*. The effect of waste polystyrene on performance of asphalt binder was evaluated by conducting the basic properties on virgin bitumen: penetration grade (60/70) was mixed with various percentages of waste polystyrene at 2%, 3%, 4%, 5% and 6% and mechanical properties were evaluated through Marshall's tests. The morphology was examined by an Optical Microscope (OM). 5% waste polystyrene results were recorded as optimum as the workability was improving and enhances the resistance to deformation of asphalt concrete mixture *(6)*. The application of polymer coated aggregates in bituminous mix with 10-15% of plastic waste used was demonstrated *(7, 8)*. Sound absorbing property of roads can also be improved by any waste plastic in bituminous roads construction *(9)*. Rutting is one of the important evaluation parameter for flexible pavements. The bituminous mix designed using Poly (Vinyl Chloride) waste modified bitumen, shown improvement in rutting values of bituminous mix *(10)*. The viscoelastic behavior and rheological properties of bitumen get improved on addition of thermoplastic modifiers. Use of HDPE and PP improved softening point, reduced penetration and improved overall dynamic and absolute viscosities of binder *(11)*.

This study focuses mainly on evaluating the properties of virgin VG 10 bitumen and comparing its properties with thermocol modified bitumen. The dosage of thermocol used is 0.5%, 1.0% and 2.0%. The wet mix process adopted and optimum dosage of thermocol is determined.

2. MATERIALS AND METHODOLOGY

2.1. Materials

2.1.1. Bitumen

VG 10 grade paving bitumen from Tikitar Industries, Halol, Vadodara was used for this study. The physical properties of VG 10 bitumen are described in Table 1.

TABLE 1 Physical Properties of VG 10 Bitumen

Properties	Values	Limit as per IS 73:2013	Code
Penetration (dmm), 25ºC, 100g, 5sec	75	80-100	IS 1203
Softening point (°C)	46	Min. 40	IS 1205
Ductility (cm)	75+	Min. 75	IS 1208
Absolute Viscosity at 60 (°C), Poise	976	Min 800	IS 1206 (part 2)
Kinematic Viscosity ,135 (°C), cSt	323	Min 250	IS 1206 (part 3)

2.1.2. Waste Thermocol

Waste thermocol is a Polystyrene (PS) which is made of styrene monomers obtained from the liquid petrochemical. Polystyrene consists of a CH_2 group and a substituted benzene ring in its single unit structure as shown in Figure 1. Its IUPAC name is Poly (1-phenylethene) and chemical formula is $(C_8H_8)_n$. Polystyrene is a thermoplastic polymer and non-biodegradable.

Waste thermocol used in this study was the catering waste obtained from nearby residential areas.

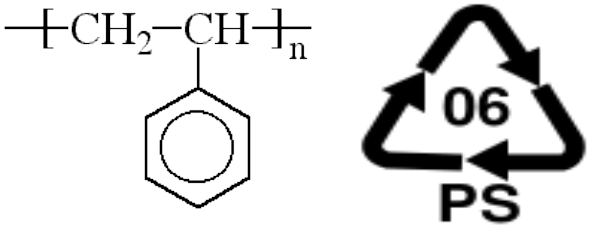

FIGURE 1 Chemical Structure and ISI Code of Polystyrene *(6)*

2.2. Preparation of Modified bitumen

VG 10 Bitumen of 500gm was heated in oven till fluid condition and small pieces of waste thermocol in different quantities (0.5%, 1.0%, and 2.0% by weight of bitumen) were mixed with hot VG 10 bitumen. The two were stirred for 2-3 hours at 160-180 ºC and 250-300 rpm to produce homogenous modified binder. The standards for the properties of modified bitumen are as per IRC SP 53 (2010). Empirical tests like penetration and softening were conducted on VG 10 bitumen and thermocol modified binder containing different percentages of thermocol waste. Viscosity test was conducted using DV-II + Pro BrookField Viscometer on bitumen and thermocol modified bitumen. The absolute and kinematic viscosity measurements were made at 60 °C and 135°C respectively for VG-10. The viscosity test was carried out on all thermocol modified binder up to the dosages of 2% thermocol waste at 135 °C only for comparison purpose.

2.2.1. Characterization of VG-10 and modified binders

The binder properties were found to be improved on addition of waste thermocol to VG 10. The results of penetration, softening point and viscosity of thermocol modified bitumen with different percentages of thermocol are presented in Figure 2, Figure 3 and Figure 4 respectively.

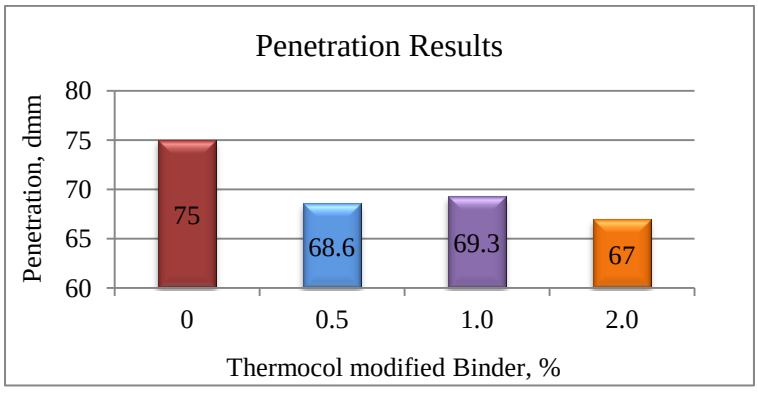

FIGURE 2 Penetration of VG-10 and Thermocol Modified Binder

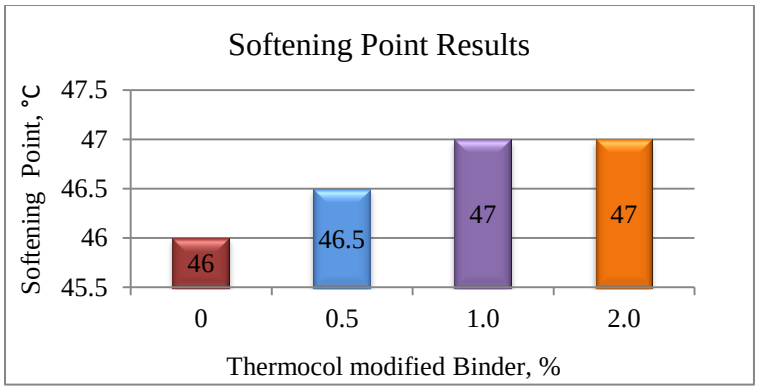

FIGURE 3 Softening Point of VG-10 and Thermocol Modified Binder

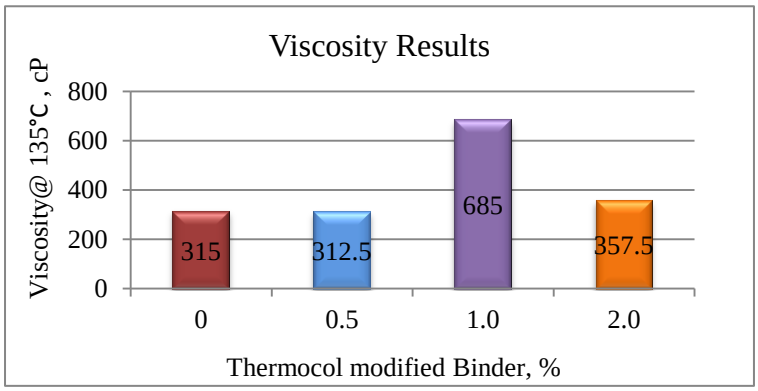

FIGURE 4 Viscosity of VG-10 and Thermocol Modified Binder

3. MORPHOLOGICAL ANALYSIS

Field emission scanning electron microscopy (FESEM) was used to study the internal morphology of the thermocol modified bitumen. Its automated advance features include focus, stigmator, gun saturation, gun alignment with very good contrast and brightness. Morphology of bitumen indicates the homogeneity of the modified bituminous binder. The morphology of thermocol modified bitumen usually investigated using Nova Nano SEM 450 which is a versatile high resolution low-vacuum Field Emission Gun Scanning Electron microscope capable of producing very high resolution images of the sample surface. The compatibility between the thermocol waste and bitumen is critical to the properties of thermocol modified bitumen. The compatibility of the bitumen with the polymer depends on molecular weight, as higher the molecular weight of polymers are incompatible with lower molecular weight bitumen *(12).* Field emission scanning electron microscope (FESEM) instrument was used for the study of the microscopic structure of VG 10 bitumen and 1% thermocol modified bitumen with a magnification of 500x. Figure 5 presents the FESEM image of VG 10 bitumen and Figure 6 presents FESEM image of bitumen modified with 1% thermocol. 1% thermocol modified bitumen shows better blend forming homogenous mix as shown from Figure 6 which reflects that lower the concentration of thermocol in mix, better blends can be achieved.

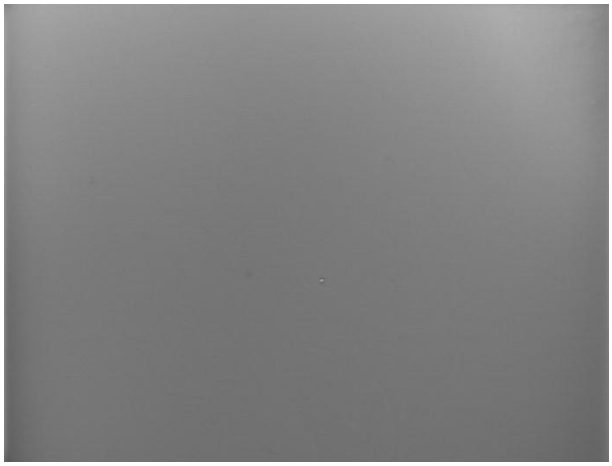

FIGURE 5 FE-SEM of VG 10

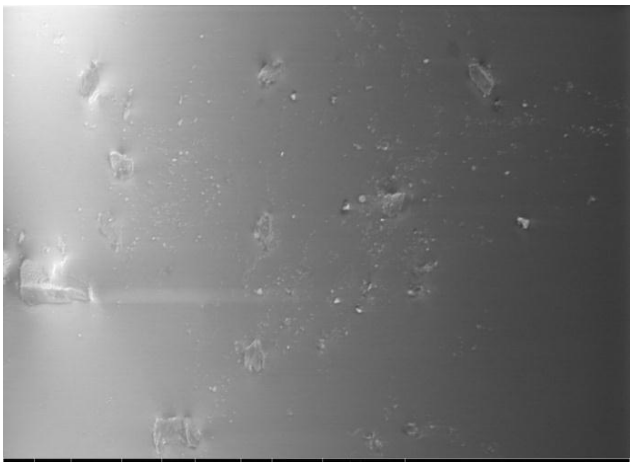

FIGURE 6 FE-SEM of 1% Thermocol Modified Bitumen

4. RESULTS AND DISCUSSION

VG- 10 binder met the requirements of IS-73, 2013. The effects of thermocol wastes content on physical characteristics of VG-10 bitumen were evaluated to assess the optimum dose of thermocol to be added to meet the requirements of IRC SP 53, 2010. The physical properties as shown in Figure 2, Figure3 and Figure 4 indicated marginal changes in softening point and penetration of VG-10. From the Figure 2 it was observed that there is a decrease in the penetration value of VG 10 bitumen from 75 to 68.6 dmm for 0.5%, 69.3 dmm for 1.0% and 67 dmm for 2.0% of thermocol modified bitumen which shows that there is a resistance in modified binder to become hard due to higher molecular weight of Polystyrene present in thermocol From the Figure 3 it was observed that there is slight increase in the softening point for thermocol modified binder as compared with virgin bitumen. The softening point linearly increased for modified binders containing upto 1% thermocol after softening point did not further improved even after adding 2% thermocol in VG-10 binder.

From Figure 4, base bitumen with viscosity of 323 cSt at 135 °C shows increase in viscosity at 1.0% thermocol modified binder. However, the decrease behavior in viscosity shows Non-Newtonian behavior which indicates that it is influenced by the internal structure of the thermocol modified binder. Viscosity is higher at 1% thermocol modified bitumen compared with virgin bitumen and modified binder containing 0.5% and 2% thermocol.

Based on the said physical properties it is concluded that upto 1% quantity of the thermocol waste can be used for the modification of VG-10. The viscosity of bitumen binders at high temperatures is an important property as it is a good indicator of the binder's ability of pumping through bitumen plant *(13)*.

4. CONCLUSIONS

Based on the preliminary laboratory studies, it can be concluded that thermocol waste can be successfully used in road applications. The addition of thermocol wastes to virgin bitumen improved the binder properties. Best results within the limitation of the study for thermocol modified binder suitable for road making purpose were obtained with 1% thermocol modified binder. This study shows that thermocol modified binder carries great promise as an alternative use to minimize or to recycle the thermocol waste for waste management. Apart from this the

problem of environment pollution caused by the huge generation of thermocol wastes in municipal solid waste stream is resolved by using thermocol waste in road construction. Further studies to investigate the behavior of thermocol with aggregates, rheological behavior, long term performance, it's rutting, fatigue properties are in progress.

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