

SOME STUDIES ON RHEOLOGICAL PROPERTIES OF PAVING BITUMEN

SUMMARY: Bitumen is processed through fractional distillation of crude oil and this unique production process makes it completely different when compared to other construction materials like cement, steel. The rheological properties of bitumen is significantly affected by crude sources and processing methods. This leads to the variability in rheological properties of bitumen which should be given due consideration for selection of bitumen for paving purposes. Studies relating the rheological properties of bitumen are marginal in India. Also very little work has also been conducted relating the rheological properties to the crude source and processing methods. The present study attempts to study the variation of rheological properties of bitumen with respect to crude sources, and processing methods. Simple rheological models are developed to capture some of the trends.

INTRODUCTION

Bitumen owes its origin from crude oil. Crude oil is a naturally deposited organic material in the crust of the earth. It is principally formed by a process called diagenesis, of marine algae having been deposited underwater with silt for 1 million to 1 billion years ago [1]. Petrochemicals, gasoline, diesel, jet fuels, and lubrication (lube) oil are the high valued refining products. The fractionation of crude oils in the atmospheric tower results in separation of the light and heavy gas oils and the left over is called Vacuum Tower Bottom (VTB) or Vacuum Residue which can be used as bitumen. Moreover other processing methods such as solvent deasphalting, residuum oil supercritical extraction (ROSE), blending, and continuous air blowing are carried out to meet the specifications of bitumen[2]. In case of cement and steel the manufacturer has full control on its raw material. In case of bitumen, as the source of crude keeps on changing, the bitumen produced also changes in quality due to the inherent changes in chemical composition. However the major application of bitumen is related to pavement construction and hence technical specification of bitumen is normally written catering to this specific application and not on its physical properties like in case of cement (fineness, etc). In addition it is subjected to wide variations of temperature in the road. Unlike other construction materials bitumen shows different mechanical behavior as the temperature is increased or decreased. Starting from a temperature of -40 °C to temperature above 100 °C bitumen also undergoes transitory behavior [3]. This is due to the fact that the internal structure of bitumen undergoes changes as it is heated or cooled. It is necessary that one understands the complexities of bitumen so that one can use it in a manner resulting in long lasting pavement.

SCOPE

Considering the recent shift in specifications of bitumen in India to viscosity grading and the fact that as of today very little data is available related to the rheological characteristics of bitumen processed in India there is a need to study and develop a data-base on the viscosity and other rheological characteristics of bitumen being produced in India.

SAMPLES AND TESTS PERFORMED

Various samples, all of them of same 60/70 penetration grade of bitumen, are collected from major refineries in India and are characterized. It is intended to study the how the test results vary between (i) refinery to refinery, (ii) same refinery but different crude sources, (iii) same refinery but different processes, (iv) same refinery but different blends and (v) same refinery but different dates of production. The tests conducted in this investigation include steady shear using Brookfield rotational viscometer in the temperature range of 60 – 150 °C and stress relaxation test using an Anton-Paar dynamic shear Rheometer in the temperature range of 20-30 °C. Various rheological parameters were calculated from these test

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measurements and the variability of each of these parameters with respect to the sample variables are discussed. The parameters include study of (i) variation of viscosity (η) with temperature (T), (ii) variation of torque relaxation behavior and (iii) variation of shear stress and normal stress behavior on these samples.

ANALYSIS

The analysis is to test for the variability between samples of same penetration grade made from different refineries, within samples of the same refinery however subjected to different processing conditions, by ANOVA analysis. Hypothesis testing has been performed by analyzing all the viscosity data (at all temperature), torque relaxation data of steady shear experiment (torque value at the end of test, time taken for the torque to relax completely), stress relaxation data (in terms of three numbers: peak stress, time to stress relax to 10% of initial peak stress and stress remaining at the end of 5 second). The present study attempts to study whether there is variability, and if variability exists, which parameter captures the variability more or in other words, which are more sensitive and least sensitive to the difference in crude source, processing method etc. Also comparison of the single point viscosity values may not really help in understanding the variability. Hence the samples are systematically sheared and the variability not only in terms of viscosity but also energy absorbed, peak shear stress, percentage of torque at the end of steady shear and percentage of torque after a specific period of time during relaxation is considered. The difference in the variability associated while comparing the steady shear data and DSR data for different samples is also addressed in this study. An attempt was made to co-relate the chemical composition of the bitumen samples with its rheological behavior. Simple rheological model has been developed to capture the steady shear state in rotational viscometer and stress relaxation in dynamic shear rheometer.

CONCLUSION

After detailed analysis it has been observed that even if all the samples are of the same penetration grade (60/70) there exists variability in rheological properties of bitumen due to variations in crude source, processing and blending methods and different time of sampling. Hence they will behave differently when used in road construction. As the material is extremely complex, extensive testing of the properties of bitumen as well its performance in the road must be evaluated before implementing in the specifications.

REFERENCE

- [1] *Chemical properties of asphalts and their effects on pavement performance*, Transportation Research Circular No. 499, Transportation Research Board, National Research Council, Washington, D. C., 2000.
- [2] Corbett, W., L., *Refinery processing of asphalt cement*, Transportation Research Record, No. 999, TRB, National research Council, Washington, D. C., 1984, pp.1-6.
- [3] Schweyer, H. E., Asphalt rheology in the near-transition temperature range, *Highway Research Record*, No. 468, 1973, pp. 1–15.