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Investigating the effects of nano Al_2O_3 on high and intermediate temperature performance properties of asphalt binder

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ABSTRACT

The present study explores the use of nano Al_2O_3 as a potential asphalt binder modifier. The study investigates the effects of different concentrations (0%,0.5%,1% and 2% by weight of the asphalt binder) of nano Al_2O_3 on various properties of the asphalt binders. XRD analysis is used to study the amorphous/crystalline nature of the base asphalt binder and nano Al_2O_3 modified asphalt binder. The influence of different temperatures and strain rates on the viscosity of the asphalt binder is evaluated. It was seen that the asphalt binder showed a shift from Newtonian behaviour to non-Newtonian behaviour upon the addition of nano Al_2O_3. The rutting evaluation of the asphalt binders was carried out by utilising different approaches like Superpave rutting parameter, multiple stress creep and recovery test, zero shear viscosity, and creep test. Furthermore, intermediate-temperature performance and aging resistivity of the modified asphalt binders was also evaluated. Results showed that the addition of nano Al_2O_3 enhances the stiffness of the asphalt binder and improves its recovery abilities. The modified asphalt binder was found to perform well under varying stresses and sustained loading and hence showed improved permanent deformation characteristics. Fatigue performance was evaluated utilising Superpave fatigue parameter and time sweep tests, and the nano Al_2O_3 modified asphalt binders showed improved fatigue life. The addition of nano Al_2O_3 also leads to an improvement in the aging resistance of the asphalt binder. The study shows an overall improvement in high temperature, intermediate temperature, and aging resistance of the asphalt binders using nano Al_2O_3 as an asphalt binder modifier.

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Introduction

Asphalt is a petroleum product obtained from crude oil during the refining process. It is a major component in the construction of flexible pavements. Asphalt binder is an organic substance in which most of the molecules are hydrocarbons with small proportions of Oxygen, Sulphur, Nitrogen, and traces of metals like nickel and vanadium. In its original form asphalt binder is capable of withstanding a wide range of stresses. However, with an increase in the traffic volumes and axle loads, asphalt binder in its pure form is found to be incapable of withstanding the increased stresses. Therefore there arises a need to enhance the physical properties of asphalt binders. Various types of modifiers like polymers, crumb rubber, waste materials, etc. are added to the asphalt binders to enhance their physical properties to make the pavements more durable (Airey, 2003; Behnood & Modiri Gharehveran, 2019; Isacsson & Xiaohu, 2000; Lo Presti, 2013; Martin Jasso, 2011; Munera & Ossa, 2014; Oliviero Rossi et al., 2015; Wang

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