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TECHNICAL PAPERS

Performance evaluation of nanosilica-modified asphalt binder

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Abstract
Continuous efforts are being made to enhance the performance of the pavements for which various modifiers and additives are being utilized. Lately, emphasis has been given to the use of sustainable materials to be used in pavement construction. The paper explores the use of nanosilica, which can be manufactured from industrial and agricultural wastes, as an asphalt modifier and evaluates its effect on high-temperature properties of VG-10 binder. The paper investigates the rutting potential of nanosilica-modified binders by using different rheological approaches. Nanosilica was used in three concentrations (0.5%, 1% and 3%). It was found that adding nanosilica to asphalt binder improves its rutting resistance. Results of all the rheological approaches showed that resistance to permanent deformation increases with the addition of nanosilica. Nanosilica-modified binders have high resistance to oxidative ageing. Nanosilica-modified binders exhibited good storage stability at high temperatures.

Keywords Rutting resistance · Superpave rutting parameter · Shenoy's parameter · Complex modulus · Phase angle · ZSV · LSV · MSCR · Nanosilica

Introduction

Rutting has been identified as major distress in asphalt pavements and is considered as one of the major design parameters considered in the design of flexible pavements. Rutting mainly results due to densification and/or shear deformation in the asphalt layers. However, the overall permanent deformation from the accumulation of the permanent strain in different layers of the pavement contributes significantly to rutting.

The permanent strain accumulation in the pavement layers is dependent upon the component materials and the pavement design. Properties of the binder play a significant part in resisting the permanent deformation. The intrinsic capability of the asphalt binder to resist the permanent deformation affects the overall rutting resistance of the asphalt mixes. Asphalt being a viscoelastic material is highly dependent on time and temperature and deforms with time due to load application. The ability of the binder to resist this deformation is highly desirable to obtain a mix with high rut resistance [1]. Asphalt on its own is incapable of resisting the excessive loads, stresses, temperature variations and oxidative processes. Therefore, different types of modifiers are used to improve various properties of the asphalt. Several categories of asphalt modifiers are used, which include polymers, rubbers, sulphur, fibres and various chemical agents [2–17].

Recently, the impetus has been on the use of nanomaterials in various construction fields. Nanomaterials due to their high strain resistance, high functional density and high specific surface area may provide solutions to various problems associated with the pavements. Various types of nanomaterials are being used in asphalt modification; nanoclay, carbon nanotubes, aluminium trioxide and nanosilica are few of them [18–27].

Earlier studies have shown that adding nanosilica to the asphalt binder improves its rutting resistance. Most of the studies to evaluate rutting resistance have concentrated on the use of Superpave rutting parameter $G^*/\sin\delta$ [28–38]. The studies have used different concentrations of nanosilica ranging from 1 to 6%; the authors selected lower and higher concentrations based on the study carried out by

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