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Linear viscous approach to predict rut depth in asphalt mixtures

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HIGHLIGHTS

- Six different asphaltic mixtures were selected for the study.
- Wheel track rut depth can be predicted using BISAR.
- Field rut depth also could be predicted.

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ABSTRACT

Rutting in asphalt mixtures is a very common type of distress. It occurs due to the heavy load applied and slow movement of traffic. Rutting needs to be predicted to avoid major deformation to the pavement. A simple linear viscous method is used in this paper to predict the rutting in asphalt mixtures by using a multi-layer linear computer programme (BISAR). The material properties were derived from the Repeated Load Axial Test (RLAT) and represented by a strain-dependent axial viscosity. The axial viscosity was used in an incremental multi-layer linear viscous analysis to calculate the deformation rate during each increment, and therefore the overall development of rutting. The method has been applied for six mixtures and at different temperatures. Finally, field data has also been used to check the applicability of the approach in real pavement design.

1. Introduction

The main form of permanent deformation in asphalt mixtures is rutting. Many studies have investigated the mechanism of rutting formation and how to optimise material proportions to avoid it. Permanent deformation is a key issue in asphalt pavement design especially in places with high temperatures, and it can be determined by using triaxial testing [1–3]. Rutting needs to be predicted to avoid major deformation to the pavement.

Generally, it is well known that the response of an asphaltic mixture depends on loading time and temperature. Asphalt concrete mixtures behave as linear visco-elastic materials under low temperature conditions (or short loading times), while they behave as non-linear elasto-viscoplastic materials under high temperature conditions (or long loading times), [4]. When asphaltic mixtures behave as linear visco-elastic materials, they can be modelled using one of the physical models in which the model components are arranged as springs and dashpots either in parallel or in series to best fit test results.

There are two main approaches for predicting asphalt mixture rutting: the layer-strain method and the visco-elastic approach, [5]. The layer-strain method can predict the life until rutting failure in asphalt mixtures by assuming a linear or non-linear relationship between the elastic stress field and vertical permanent deformation in each selected layer. This approach is only dependent on the elastic properties of the mixture and does not directly use the material viscosity [6].

Romain (1972) [7] developed a computer programme for prediction of permanent deformation based on the layer-strain method. The layers of the pavement were divided into sublayers, and the produced model elements were sufficiently thin to be considered as homogeneous in terms of vertical stress state. The stresses in each element were calculated by elastic theory and were

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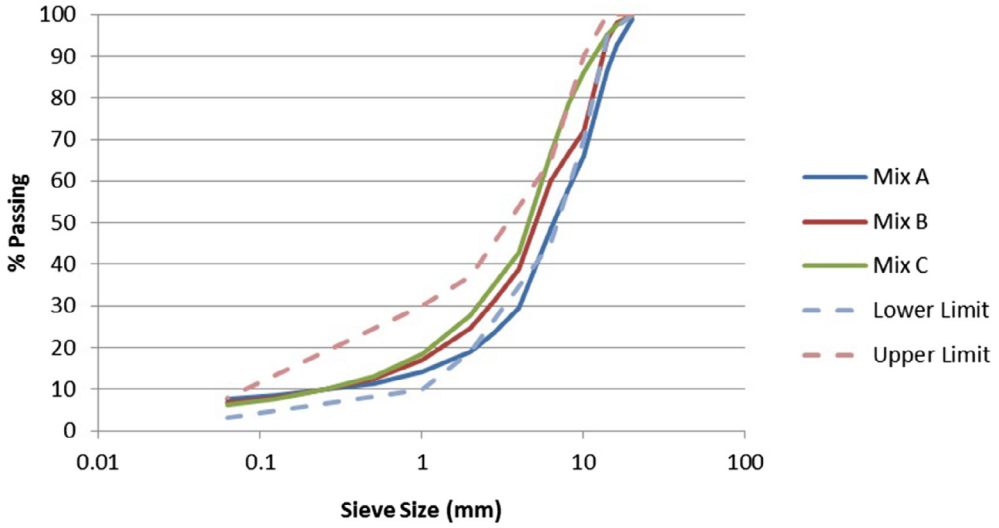
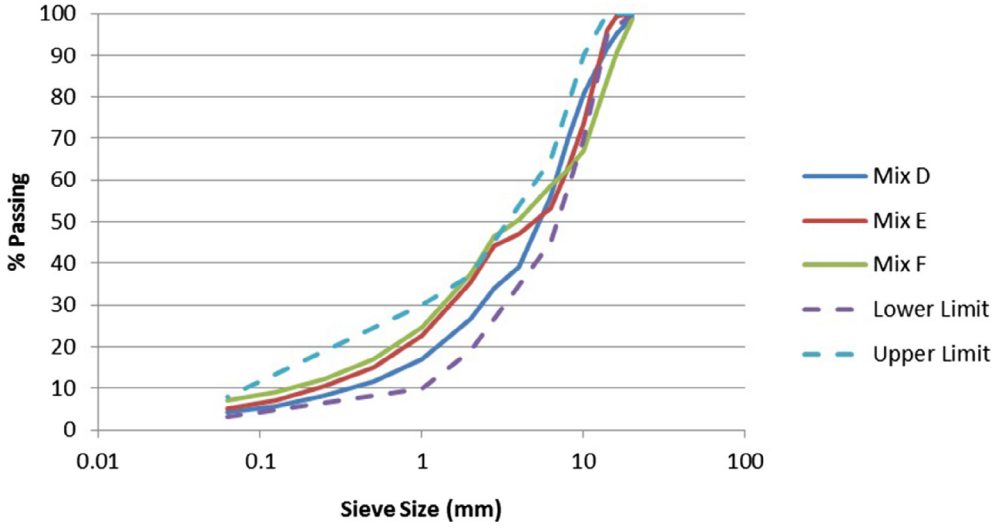


(a) Mix A, B, and C



(b) Mix D, E, and F

Fig. 1. Aggregate gradations for asphalt mixtures.

then used with experimental stress-strain data to calculate the deformation in each element by applying a number of vehicle passages. The elemental deformation was summed up to produce the total surface deformation.

Morris et al. (1974) [8] developed a rutting model for the asphaltic layers where the characteristics of permanent deformation were determined from triaxial tests. Tension and compression stress modes were applied to the samples to evaluate the behaviour of the bituminous material. Comparison of the predicted rut depths with real measured values from Brampton Test Road in Canada were carried out by plotting a relationship between the total yearly permanent deformations over a period of 7 years. The model predicted that the permanent deformation occurred in the tension zone due to the lateral distortion of the material, which was the same as in the test section. Based on their model prediction they concluded that if the tensile stresses exist in the field the mechanism of rutting is due to the lateral

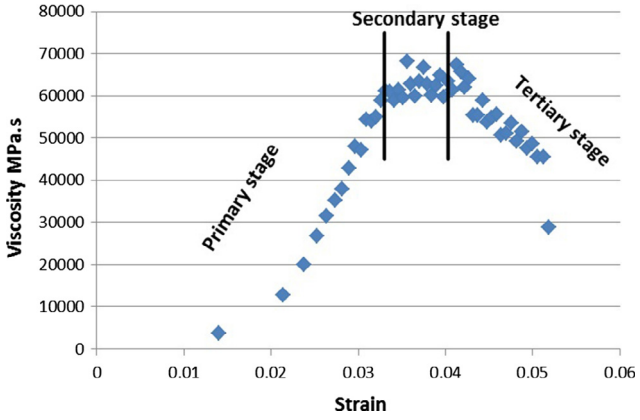


Fig. 2. Typical plot of viscosity vs strain for an asphalt mixture.