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Review

Recent trends and laboratory performance studies on FAM mixtures: A state-of-the-art review

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HIGHLIGHTS

- Review focuses on characterisation of FAM mixtures.
- An overview of FAM sample fabrication methods is presented.
- Discussed fundamental assessment of viscoelastic, fatigue and healing properties.
- FAM sample test using DSR is an innovative technique for assessment of asphalt mixtures.
- Complex shear modulus and dynamic modulus of FAM and full asphalt mixtures.

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ABSTRACT

In recent years, the testing and evaluation of Fine Aggregate Matrix (FAM) mixtures using Dynamic Shear Rheometer (DSR) which has drawn a growing interest because of its simplicity, reproducibility, and flexibility. However, several research studies have employed various sets of test methods for performance evaluation of FAM mixtures that calls for a critical review of the procedures that have been followed to date. This state-of-the-art review article presents the current work regarding material selection, sample fabrication methods and test methods to evaluate viscoelastic, fracture and healing properties of FAM mixtures.

Contents

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1. Introduction

Fatigue damage is one of the major distresses in the flexible pavement during its service life due to repeated application of traffic loading. Laboratory tests have revealed that the pavement not only experience the fatigue damage during traffic loading but also have the capacity to recover from this damage during no traffic loads [1]. Fatigue life is defined as number of loading cycles to failure. Researchers have evaluated the fatigue life at 50% loss in initial stiffness [2,3]. Many studies have been carried out to characterise the fatigue damage distresses in order to know the factors that influences the fatigue resistance of HMA (full asphalt mixture). In addition, there are many different methods to measure and quantify fatigue cracking resistance of full asphalt mixtures [4–8]. Typically these mixtures are made up of binder, coarse aggregates, fine aggregates, fillers and air voids. Further, these mixtures compose of four different phases such as asphalt binder, mastic (binder and filler), FAM mixtures excluding coarse aggregates and HMA mixtures including coarse aggregates [9]. Fracture and healing performance of asphalt mixtures have been evaluated in laboratory by considering field conditions. Currently, fracture and healing performance of asphalt mixtures are being evaluated in the laboratory using, triaxial test, Semi-Circular Bend test (SCB) [50]. The characterisation of these asphalt mixtures is difficult and complex as these mixtures consumes lot of materials, expensive and time consuming. To overcome this, researchers proposed a new test method to characterise the FAM mixtures. This is only because of researchers found that fatigue cracks grow within the mortar or Fine Aggregate Matrix (FAM) of the asphalt mixture.

FAM mixtures composes of asphalt binder, fine aggregates lesser than the 4.75 mm sieve sizes, filler less than 0.075 mm sieve size and air voids excluding coarse aggregates. This term was initially coined by Kim et al. [10] in his studies with sand asphalt mixtures. FAM mixture represents the fine portion of full asphalt mixture is suited to evaluate the different material factors as an indicator for the fatigue resistance of asphalt mixtures. The advantage of using FAM mixtures is that it provides a very convenient technique to examine the influence of material related aspects i.e., binder type, additives and ageing on the fatigue, healing and moisture damage properties. The significance of characterising the FAM mixture is that most of the damage due to fatigue cracking is believed to be concentrated in this phase of the HMA. Recently the researchers used FAM samples to characterise the fatigue damage and healing properties of FAM mixtures [11,12]. FAM test has several benefits such as consistency, repeatability, reproducibility and simplicity in terms of sample preparation, testing and evaluation of fracture and healing properties of FAM mixtures using DSR.

HMA and FAM mixtures have different geometry, gradation, material type requirement and testing procedures. However, FAM test has gained more attention by summary on the various test specifications used in conducting FAM test and its application is needed worldwide to characterise the fracture and healing properties of asphalt mixtures. Thus, this review will help researchers and practitioners in road construction industry to understand the importance of the test technique to assess both fracture and healing behaviour of FAM mixtures.

The main purpose of this review article was to present the current knowledge about the various test procedures adopted by different researchers to evaluate the fracture and healing properties of FAM mixtures. Although there are less research available regarding the FAM test and findings on FAM mixture properties, it is found that FAM samples testing using DSR methodology turn out to be promising test method. This review article is divided into three major heads as shown in Fig. 1, which includes i) FAM Material Characterisation; ii) Sample Fabrication for FAM Mixtures; and iii) Performance evaluation of FAM mixtures. A summary regarding the current review is provided at the end of the review discussion on FAM mixtures.

2. FAM material characterisation

2.1. Materials

The materials used in FAM mixtures are, asphalt binder, aggregates, and fillers. Many studies have been carried out using different type of asphalt binders and aggregates. The studies also have been evaluated the FAM mixtures containing recycled asphalt pavement/shingles (RAP/RAS) [8,13,36]. In addition, different WMA additives such as Aspha- Min, Evotherm, Sasobit, Advera and Rediset have been incorporated in FAM mixtures to improve the healing and fracture properties [2,5]. There are different methods adopted by researchers to select and finalise the quantity of materials required to prepare FAM mixtures. The details of materials (aggregates and asphalt binders), aggregate gradation and air voids studied are explained in the following sections.

2.2. Different aggregate gradations

The maximum aggregate sizes used for the studies of FAM mixtures are 0.6 mm, 1.18 mm, 2.00 mm, 2.36 mm, 4.00 mm and 4.75 mm have been studied [14,15,16,17,18]. Freire et al. [19] studied the FAM mixture with three different NMAS (4.00, 2.00, and 1.18 mm). Aggregate size less than 0.075 mm acts as fillers (Hydrated lime and Limestone) [1]. There are different gradations for preparation of FAM mixtures and asphalt mastics. However, there are inconsistencies in the review of literature with respect to the FAM being used as a technique for HMA characterisation. One of these inconsistencies is related to the choice of the sieve that limits the NMAS used in these mixtures. Some authors defined the sieve (1.18 mm) as the upper limit for designing FAM samples [4,5,20–27,51]. Dai and You and Aragao et al. [28,14] used a different sieve to separate the coarse portion from the fine portion of the asphalt mixture, 2.36 mm, and 0.6 mm, respectively. The details of the different aggregate gradations studied are shown in Fig. 2(a) and (b).

2.3. Selection of asphalt content

Many studies have been carried out for the selection of asphalt content by trial and error methods for the preparation of FAM mixtures. While selecting the asphalt content, it should not be very high or very low as it causes flow and stiff mixtures respectively.