Dynamic properties of stone mastic asphalt mixtures containing waste plastic bottles

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Introduction

Asphalt Concrete (AC) mixture is subject to many external forces during its service life which could eventually lead to failure. Different types of failures have been observed in asphalt mixtures such as permanent deformation (rutting), fatigue failure, and low temperature cracking. Fatigue failure is a common damage in AC mixtures which appears in the form of cracking (alligator cracking)

Fatigue resistance is the ability of the asphalt mixture to resist repeated bending forces without fracture and cracking. In asphalt concrete pavement fatigue cracking is caused by successive tensile strains due to repeated traffic loading. According to structural analysis fatigue cracks are produced at the bottom of asphalt layer where the maximum tensile strains accrue, thereafter these cracks propagate to the surface of asphalt mixtures. Fatigue life of AC mixtures has a negative correlation with the loads applied by vehicles on road pavements. Besides, fatigue life differs significantly among types of AC mixtures.

Stone Mastic Asphalt (SMA) is a type of asphaltic concrete which consists of more coarse aggregate content and filler, and has better characteristic against permanent deformation compared to the conventional dense graded mixture. SMA was developed in Germany in 1960s, and was used in Europe for years. Because of SMA success in Europe, it has been used in the United States since 1991 [1,2]. Previous studies showed that SMA mixture tends to have lower fatigue life in comparison with dense graded mixture because inherent structure of dense graded mixture provides better interlock between the aggregate particles [3,4].

Using additives is a common way to improve fatigue life of AC

mixtures. Different types of fibers and polymers can be used in AC mixtures. In a study, effects of adding polyester, polyacrylonitrile, lignin and asbestos fibers with different percentages were investigated by Xu et al. [5]. It was shown that fatigue life improved by adding fibers, and polyester and polyacrylonitrile which are considered as polymer fibers had the best effect on fatigue properties of AC mixtures. It is also reported that adding polypropylene fiber enhanced the fatigue resistance of asphalt mixtures, while fatigue life increased 27% by adding 1% polypropylene fiber [6].

Although utilization of virgin additives in asphalt mixture can improve fatigue properties of AC, in many cases road construction cost increases considerably. Thus, many investigations were conducted on the mixtures containing waste materials as additives to improve asphalt mixture characteristics and prevent from imposed additional charges due to usage of virgin materials. Furthermore, this would be an alternative solution for environmental pollution by utilizing waste materials as secondary materials in road construction projects. Waste glass, steel slag, tires and plastics (polymers) are examples of waste materials which have been used in AC mixtures in previous studies [7]. Among waste materials waste tire and recycled polymer have a prominent utilization [8-13]. The use of glass fiber has also been found to improve fatigue life of SMA mixes according to studies by Mahrez and Karim [14].

The main objective of this study is to investigate stiffness and fatigue properties of SMA mixtures containing different percentages of waste polyethylene terephthalate (PET).

Experimental procedure

Materials

SMA is gap-graded AC which is used in this study. Particle size distribution of the gradation is presented in Fig. 1. Granite-rich aggregate particles were obtained from Kajang Rock Quarry in Malaysia. Because of the importance of aggregate quality in SMA mixtures, several tests were done on coarse and fine aggregate particles, and the results are listed in Table 1. Furthermore, in SMA mixture amount of aggregate passing sieve 0.075 mm (filler) is higher than the amount used for conventional Hot Mix Asphalt, and is between 8% and 10% by weight of aggregate particles [1]. In this study 9% filler was used.

In order to prepare AC mixtures, 80-100 penetration-grade virgin asphalt has been utilized. Table 2 illustrates some properties of asphalt cement which is used in this research

PET is a type of polyester material, and is often used for packing in food and beverage industries. Waste PET was obtained from PET bottles. For utilization of PET bottles as additive in AC mixtures the bottles were cut to small parts, thereafter crushed by crushing machine. The crushed PET particles were sieved, and the particles passing sieve 2.36 mm were used for this investigation (see Fig. 2). Table 3 depicts some properties of PET material.