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Laboratory evaluation of rutting and moisture damage resistance of glass fiber modified warm mix asphalt incorporating high RAP proportion

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HIGHLIGHTS

- The moisture susceptibility of GFM-WMA mixtures containing RAP was evaluated.
- The rutting resistance of GFM-WMA containing RAP was evaluated.
- The effect of short term aging on performance of mixtures was evaluated.

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ABSTRACT

In one hand, increasing pollution and global warming as one of the most important environmental concerns, increasing the price of asphalt, and on the other hand, the introduction of the transportation industry as one of the most common contaminant of environment raise the popularity of the use of warm mix asphalt (WMA) mixtures containing high percent of recycle asphalt pavement (RAP) in the construction of the asphalt pavement. This paper describes a laboratory effort that studied glass fiber modified warm mix asphalt mixtures with RAP contents of 0, 20, 40 and 50% to enhance resistance of mixture to rutting and moisture susceptibility. Parameters obtained from KNTU Wheel track test including the post compaction, stripping inflection point, dynamic stability and final cycles for 20 mm and 12.5 mm rutting depth were employed to evaluate rutting resistance and moisture sensitivity of the aged as well as the unaged samples. The results showed the improving impact of glass fiber and RAP percent on the performance of the WMA mixture.

1. Introduction

The increase of pollution and consequently the concerns about global warming are considered as one of the most important environmental preoccupations. The number of vehicles are also highly increasing. Moreover, the introduction of transportation industry was considered as one of the most important environmental pollutants in Rio de Janeiro conference in 1992. These problems have all encouraged the asphalt industry towards making efforts to reduce the pollutants. One of the most important solutions to resolve these problems is the reduction of temperature degree of mixing and compaction of asphalt mixture without any noticeable diminish in mechanical performance of the mixture and consequently the production of WMA mixture [1]. Moreover, the production of asphalt mixtures in lower temperatures and also greater use of RAP materials in the construction of asphalt pavements are considered as transportation industry approaches in achieving sustainable development [2,3]. Environmental and economic benefits are the most important impact factors to delivery of pavement industry in the use of RAP materials in construction of asphalt pavement [4].

Three main groups of WMA additives in the literature have been denoted as organic additives, chemical additives and foaming technologies. WMA technology causes the reduction of asphalt viscosity. Some palpable benefits of this viscosity reduction are the reduction of production temperature, energy consumption, hazardous emission at the asphalt plant, greenhouse gas emission and also provision of better work condition for the staffs. WMA technology will provide possibility to reduce 18–54 °C of production temperature of the WMA mixture prepared with Sasobit as compared with the HMA mixture [5]. Although the mentioned advantages show promising results, there are also some concerns about long-term performance of this technology due to its short life in comparison of life of asphalt pavement. In addition, the

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Fig. 1. KNTU wheel track machine.

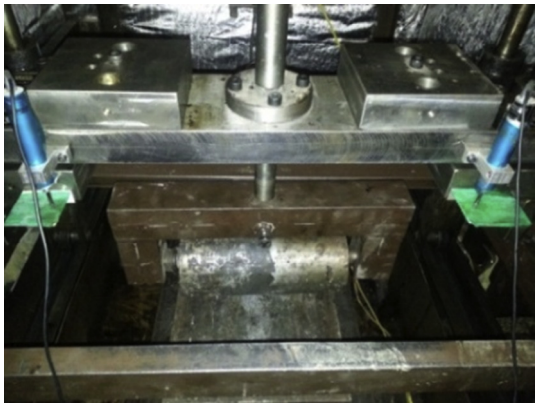

Fig. 2. Roller compactor of KNTU wheel.

moisture susceptibility and rutting resistance, due to the reduction of production and laying temperature have been introduced as the main concerns for WMA performance [6–9].

One of the salient definitions of moisture damage in the literature is provided by Kiggundu and Roberts as "the progressive functional deterioration of a pavement mixture by loss of the adhesive bond between the asphalt and the aggregate surface and/or loss of the cohesive resistance within the asphalt principally from the action of water" [10].

The consolidation or lateral movement of the pavement under traffic causes the accumulation of small amounts of unrecoverable strain on pavement. This deformation is defined permanent deformation or rutting that remains one of the main defects and obstacles in the performance of flexible pavements [11]. Thus, the study of rutting and moisture susceptibility of the WMA mixtures is vital. The less tensile strength of asphalt mixtures as compared with their compressive strength has given rise to the introduction of using fiber with high tensile resistance as a solution to transfer the existing tensile stresses in the mixture through fiber and also the increase of absorbed strain energy during fatigue and fracture process [12]. The salient benefits for the use of fibers in asphalt mixtures are the increase of tensile strength, fatigue resistance, resistance against rutting [13] and also the improvement of moisture susceptibility [14,15]. Fibers stabilize and maintain the asphalt on fibers surface and increase the asphalt resistance against the fluidity in high temperatures [16] and also formation of three dimensional networks in asphalt mixture and reinforcement of the mixture to resist against the shear forces and reduction of mixture fluidity [16]. Furthermore, glass fibers with a high tensile module, high elastic recovery and high softness point have been introduced as the improving additives for the performance of asphalt mixtures [17].

Most of the available literatures highlight the recycling of RAP advantages, which include the following [3,4,18,19]: reduction in energy consumption and greenhouse gas (GHG) emissions, reducing the required new asphalt content (virgin binder), preservation of nonrenewable natural resources such as virgin aggregate and asphalt, reducing waste production, and reduction of landfill use.

Some researches show that the addition of RAP material can have a detrimental effect on moisture damage resistance of mixtures [20,21]. On the contrary, other studies reported an increase of moisture damage resistance [22–26]. On the basis of the main researches done so far and their findings, it appears that the addition of high percent of RAP material has a substantial improvement in resistance to permanent deformation of the WMA mixtures [21,27,29,30].

(a) **(b)**

Fig. 3. (a) Rutting test in dry condition, (b) asphalt concrete slab after rutting test in dry condition.