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Original Research Paper

Testing and assessing the performance of a new warm mix asphalt with SMC

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ABSTRACT

Warm mix asphalt (WMA) is a new technology which asphalt mix is produced and placed at normal temperature. It has advantages including low cost, environmentally friendly, haul-convenience, and so on. WMA has been widely tested and applied in the USA in the last decade, but it has just started in China. Recently, a new WMA using a new plastic-macromolecule-normal temperature additive, which was called "SMC" by the production company, was introduced as asphalt modifier. Based on discussing the strength forming process of this new WMA with SMC, a series of laboratory tests, including Marshall stability test (MST), boiling test (BT), modified immersion Marshall test (MIMT), freeze-thaw splitting test (FTST), rutting test (RT), low-temperature bending test (LTBT), and abrasion loss test (ALT), were conducted in this study to assess the performance of this WMA and the capability of applying it on low volume roads in China. SMC modified asphalt mixed under normal temperature is used in testing samples. It was found that this WMA product exhibited merits on its strength, which was about 6.7 kN bigger than the requirement of 5.0 kN in the JTG F40-2004, on high-temperature stability, which is about 1100 times/mm greater than the requirement of 600–1000 times/mm in the JTG F40-2004, and on its storage stability. Based on these indicators, it is recommended that this product could be used for low volume low class roads construction. However, due to the relatively lower water resistance and low-temperature cracking resistance, this product is suggested to be applied first in the areas with warm weather and little rainfall. In order to improve the performance of this WMA with SMC, further research on this SMC asphalt modifier should be continued.

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1. Introduction

Warm mix asphalt (WMA) is a new kind of energy saving and environmental protection material, which has broad application prospects. D'Angelo et al. (2008), Federal Highway Administration (FHWA) (2013), CDR Staff (2014) pointed out that WMA has attracted a considerable amount of attention in the USA and Europe over the last decades. Hurley and Prowell (2006) found that warm mix is about 25% of the total asphalt production in the USA in 2012, more than 4 times of that of 2009. The key issue of applying WMA is the asphalt modifier, which allows lowering the producing and placing temperature of asphalt mix. Chen et al. (2009), Guo et al. (2010), Liu et al. (2011), Pei and Xing (2010), Pei et al. (2011), Qin et al. (2010), Zhang et al. (2011) and Zhou et al. (2010) studied the compaction properties, the construction technology and the road performance of WMA. According to their studies, the benefits of WMA are evident: low cost, less gas and particle emissions in paving process, and thereby more environment friendly, a longer time period for construction, longer hauling distance etc. Their study results also show that the construction temperature of WMA is lower than that of HMA. WMA has better high-temperature stability as well, but some other researches done by Li et al. (2010), Sun et al. (2011), Xiao et al. (2010), Yu et al. (2011) found that WMA's cracking resistance at low temperatures, fatigue resistance and water stability would be changed slightly. In order to improve the performance of WMA, some additives should be mixed into this mixture, and the SBS asphalt modifier is commonly used in the USA as the WMA's additive. The SBS asphalt modifier presents stability in engineering practice. However, due to its expensiveness, the SBS based WMA has been widely used for pavement surface repair, but seldom used in new pavement construction in China. Recently, a new plastic-macromolecule-normal temperature additive, which was called "SMC" by the production company, was invented by a Chinese company, and a new WMA technology using this SMC as asphalt modifier was put into some roads construction practice, and this modifier is about 30% of the price of SBS asphalt modifier. Although, the price of the SMC asphalt modifier is significantly lower, this SMC asphalt modifier is not suitable for high volume roadways, since the strength of the materials is questionable (Ai et al., 2014). In contrast, experiment results indicate that this SMC asphalt modifier is a satisfactory choice for low volume and low class pavement construction.

To conduct this research, the strength forming process of this new WMA with SMC is first discussed, and followed by detailed description of properties of testing materials. Then the laboratory testing methods are described in detail and results are presented. Conclusions and discussions are addressed at the end of this paper.

2. Strength forming process of WMA with SMC

It is important to understand the strength forming process in this research. Similar to HMA, the cohesion of the material C and internal friction φ are the 2 factors affecting the strength of the WMA. However, the WMA is differing from the HMA because the cohesion of the material C and internal friction φ are prone to change. The material strengths at early and late stages of the paving are different. In general, the forming of the strength of WMA is comprised of the following four phases, as illustrated in Fig. 1.

First, in the storage phase, since the mixture is not yet subject to external forces, the WMA is still loose, and the aggregates are separated from each other. In this phase, the strength is not yet formed, and both C value and φ value are small.

In the construction phase, under the influence of compaction machinery and vehicle load, mineral aggregate particles begin to form embedded structure. Forces generated within the frictional resistance are a major source of strength. In this phase, C value retains small while φ value increases.

In the initial use phase, the heavily-loaded traffic should be restricted during this phase. With the volatilization of the organic solvents in the WMA, the asphalt gradually becomes denser, making them bond to aggregates even tighter. Meanwhile, the mixture is compacted by repeated traffic load, the air voids are reduced and the strength is significantly increased. During this phase, the C value is increasing while φ value stays large.

In the use phase, this pavement should be completely open to traffic at this time. With the effect of natural environment and vehicle loads, the final strength of the mixture is formed when all the organic solvent are volatilized. Thus, both the C value and φ value are large.

According to the above described process, the WMA shows a distinguishing property in terms of strength form comparing to HMA. Therefore, the evaluation of WMA performance must be implemented based on these properties.

3. Determining testing materials

The newly developed SMC asphalt modifier is a type of solvent bitumen which is made of a special oil dilution. The major lab

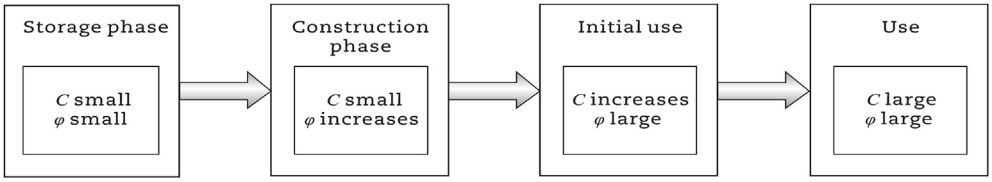

Fig. 1 – Strength forming process of WMA.

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