HIGHLIGHTER

FATIGUE PERFORMANCE OF ASPHALT PAVEMENTS CONTAINING RAS AND RAP

January 2016

OVERVIEW Rising oil and gas prices spur development of methods and technologies for reducing fuel consumption and increasing use of recycled materials. With growing environmental awareness, using *reclaimed asphalt pavement* (RAP) and *reclaimed asphalt shingles* (RAS) in pavements have been gaining momentum nationally and globally. However, despite their advantages, there are concerns associated with fatigue and low-temperature cracking potential of pavements when including increased amounts of RAS and RAP. Therefore, this study evaluates the fatigue performance of hot-mix asphalt (HMA) containing RAS and RAP.

RESULTS In this study, a comprehensive survey was conducted among the state departments of transportation (DOTs) to determine current practices, including the methods and specifications associated with the use of RAS and RAP in pavements. Thirty agencies responded to this survey. The results revealed that about 50% of the DOTs use RAS in asphalt mixes. These agencies use both tear-off and manufacturer's waste; however, a majority of these agencies prefer using manufacturer's waste. Figure 1 shows processing tear-off RAS in a local asphalt plant.

Figure 1 Processing Tear-Off RAS

Additionally, the survey revealed the methods used for asphalt content determination of RAS include NCAT ignition oven and chemical methods; about 40% DOTs use NCAT ignition oven, and about 35% use chemical methods. NCAT ignition oven is used by all DOTs for asphalt binder content determination of RAP. Also, it was found that *indirect tensile strength ratio* (TSR), *Hamburg wheel tracking* (HWT) and in some cases *asphalt pavement analyzer* (APA) rut tests are the only tests conducted on the mixes containing RAS, RAP and both for screening mixes during mix design. No specific test was recommended for evaluation of these mixes for fatigue at the mix design stage. Only one DOT (New Mexico) uses *cyclic direct tension* (CDT) and *four-point beam fatigue* (FTG) tests for the cases where the RAP content exceeds 25% in base and 15% in surface course mixes. No specific regulations or specifications were used by DOTs to select RAP sources. More than 65% of the surveyed DOTs bump the PG grade of the virgin binder when RAS and/or RAP are used in the mix. More than 70% of the DOTs control the RAP quality in stockpiles and less than 50% of them control the RAS quality. Asphalt binder content and gradation are the most common measures applied for quality control of

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the RAP and RAS stockpiles. A majority of mixes containing RAS is used in city roads and sometimes in state highways. However, a majority of the mixes containing RAP is used in interstate highways. Most of the DOTs use Superpave® method for the design of mixes containing RAS and/or RAP.

The survey results also indicated that there are no widely-accepted fatigue tests recommended for the evaluation of mixes containing RAS and RAP. Eight fine surface course mixes (S4) with different types of asphalt binders (i.e., PG 64-22 OK and PG 70-28 OK) and different amounts of RAS and RAP were designed and tested in the laboratory. Although the amount of RAS and RAP in HMA mixes varied, the total amount of replaced binder was kept within certain specifications (i.e., RAP and/or RAS limited to 30% binder replacement). Changes in fatigue resistance and cycles to fatigue failure with changes in the amount of RAS and RAP were examined using flexural fatigue (four-point beam) test on laboratory compacted specimens (Figure 2a). Also, axial fatigue (cyclic direct tension (CDT)) tests were conducted on selected samples (Figure 2b). Effect of virgin binder grade on the fatigue performance was also examined. In addition, the effect of RAS and RAP in HMA on its creep compliance and dynamic modulus was investigated.

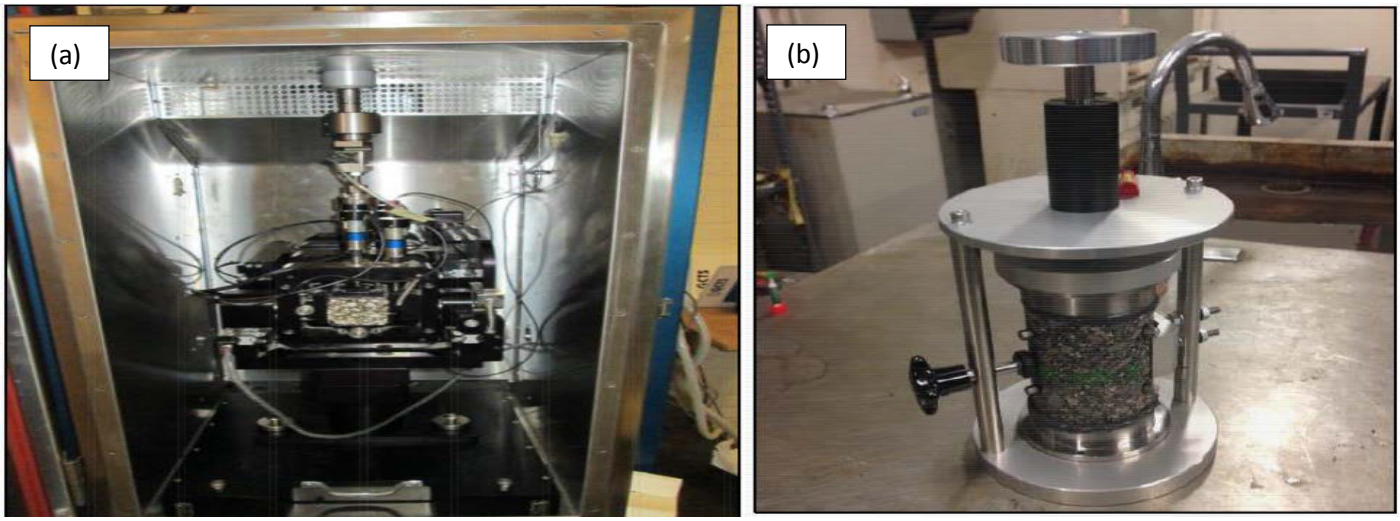

Figure 2 (a) Flexural Fatigue (Four-Point Beam), (b) Axial Fatigue Test (Cyclic Direct Tension) (right)

The results showed that the fatigue life of asphalt mixes containing a PG 64-22 OK binder increased with the use of RAP or a blend of RAP and RAS. Using a blend of 5% RAP and 5% RAS in a mix led to the maximum increase in fatigue life. However, the fatigue life of the mix was found to decrease when 6% RAS was used compared to that of the virgin mix with the same type of asphalt binder (PG 64-22). When a PG 70-28 OK asphalt binder was used, addition of RAP and/or RAS in a mix resulted in a decrease in the fatigue life. Using 6% RAS resulted in the maximum decrease in fatigue life, compared to that of the virgin mix with the same type of asphalt binder (PG 70-28 OK). Use of a polymer-modified asphalt binder (PG 70-28 OK) was found to be an effective way to increase the fatigue life of mixes. A high coefficient of variation for the results obtained from the four-point beam fatigue test show that the repeatability of this method was not very good. The dynamic modulus and creep compliance test results revealed that addition of RAP and/or RAS to asphalt mixes increased their stiffness for cases in which PG 64-22 OK or PG 70-28 OK asphalt binders were used. Thus, mixes containing RAP and/or RAS may result in a better rutting performance, but such mixes may exhibit a higher low-temperature cracking potential compared to the virgin mixes. Finally, the results showed that indirect tensile strength (IDT) of the asphalt mixes increased with use of RAP and/or RAS compared to their virgin counterparts. Use of 6% RAS resulted in the maximum increase in the IDT values.

BENEFITS This study provided the current state-of-the-practice for the evaluation of fatigue performance of asphalt mixes containing RAP and RAS. Additionally, the laboratory test results can be used to develop or update guidelines/special provisions for design of asphalt mixes containing RAP and RAS for paving applications in Oklahoma.