Study on the Durability of Stabilized Base Course Material Containing RAP in Japanese Expressways

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I. INTRODUCTION

Reclaimed asphalt pavement (RAP) is an alternative to virgin mixtures in road construction. This material is commonly used in the surface layer of pavement structures. This flexible layer require a high content of asphalt binder, making it expensive. Since RAP is a source of less expensive binder, it can replace a portion of the more expensive asphalt binder.

The handling of RAP as a common material in the pavement industry dates back to the early 1970s. Economical and environmental benefits are a motivation for highway transportation agencies to look for ways to use RAP not only as a substitution for new material in the surface course, but also in the base course of pavement structures.

However, one company that is late in the application of RAP is NEXCO. For instance, the company is working on a road widening project that is taking place in a section of an expressway that goes through Niigata and Nagano Prefecture. This is the first time the private company is using RAP in one of its expressways. The road base of the new lanes will contain 15% of RAP. If using RAP does not have a negative impact on the lifetime of the base course and the whole pavement structure, the company will procede to use the material in surface courses of future projects.

II. OBJECTIVE

Road construction practices in Japan only require assessing the quality of the base course materials with routine testing. These tests only measure resistance to plastic deformation of compacted specimens and the hardness of asphalt binder. That is to say, tests that evaluate the durability of the 15% RAP mixture were not conducted.

It is important to emphasis that the winter season in the Niigata and Nagano region causes pavement to go through freeze-thaw cycles and rain is present almost every day. For such reasons, an study on the resistance to moisture of the stabilized base course mixture containing RAP is desired. Concretely, the objective of this research is to evaluate the durability of base course mixtures containing RAP with a focus on the effects of moisture and fracture behavior at low temperature in Japanese expressways. This is the first case study to focus on the durability of materials used in Japanese expressways

III. MATERIALS

To better understand the effects of RAP as a component of base courses, the materials used in the lane expansion project were obtained and the same mix design was followed to prepare the mixtures as they were initially tested. In the design stage of the project, NEXCO considered the possibility of using mixtures containing 15%, 20% and 25% of RAP in the base course. Marshall test results indicate that in all cases the minimum requirement was satisfied. However, the 15% RAP mixture proved to be closest in quality to the virgin mixture (0% RAP). With these results and the available stock, it was decided to use 15% of RAP as a stabilized base course material.

IV. CURRENT WORK AND RESULTS

In addition to looking into the durability of the mixtures considered by NEXCO, in this study, emphasis was also given to finding the maximum acceptable amount of RAP that could be used in road base without compromising durability. To do so, a 40% RAP mixture was also evaluated, for a total of five mixtures (0%, 15%, 20%, 25% and 40%). Previous researchers have proved that mixtures containing more than 30% of RAP has a negative impact in moisture resistance and cracking at low temperature (X. Yu et al., 2010).

Modified Lottman tests (AASHTO T-283 and IDOT modified procedures) and two boiling tests were used to asses moisture susceptibility. Additionally, to predict the performance of the base course after years of on-field service, RAP was aged at 110ºC for 24, 48 and 58 hrs. The three mixtures were prepared with 15% of RAP and tested using the AASHTO T-283 procedure. Finally, the Three-Point Bending test (3PBT) was conducted to compare the fracture resistance of a mixture composed of 15% and 40% of RAP.

The boiling tests cover a rapid procedure for visually identifing the loss of adhesion in uncompacted bituminous coated aggregate mixtures due to the action of boiling water. After both experiments, all mixtures remained fully covered with binder. These tests do not consider the void structure of compacted pavements, and results were only considered to be preliminary.

To assess the moisture susceptibility of all mixtures, the IDOT and AASHTO T-283 modified Lottman tests were selected. In these tests, 6 samples are to be prepared: a set of 3 dry samples and a set of 3 wet

samples. After conditioning and an indirect tensile strength, the tensile strength ratio is calculated. The TSR is a numerical index that expresses the resistance of asphalt mixtures to the attack of moisture. However, the IDOT test underestimates the detrimental effects of moisture by not including freeze-thaw cycles, contrary to the AASHTO test. **Figure 1** shows that the IDOT results of 0%, 15%, 20% and 25% RAP mixtures exhibit TSR values that are 9%, 48%, 46% and 34% greater than the AASHTO test results, respectively.

A different study focused on comparing the AASHTO and IDOT method using virgin mixtures, and TSRs from the IDOT were 13% greater than the AASHTO results (Maziar Moaveni et al., 2012). The dissertation paper provides further insight on how eliminating conditioning steps caused the mixture to become excesively stiffer, affecting TSR results and providing misleading data that does not represent the performance of RAP mixtures against moisture attack.

To correctly assess moisture susceptibility, the AASHTO T-283 test was conducted. This test is used to evaluate surface courses and requires specimens to be compacted to a degree of 7.0%. However, to make results representative of base courses, the compaction degree was set to 10.5 %. This is the first study to make such modification. Test results demonstrated how the addition of RAP to the base course mixture caused an initial decrease in stiffness (ITS), which later recovereded gradually when RAP content was increased up to 25%. Consistent with different research studies that explain how the performance of asphalt mixtures decrease when more than 30% of RAP is added, the 40% RAP mixture exhibited a decrease on stiffness, with the lowest ITS values of all mixtures (See **Figure 2**).

Mixtures with RAP aged at different periods were also tested using the AASHTO T-283 method. The three stabilized base course mixtures with 15% of RAP exhibited higher TSR values with the longer time RAP was aged. This results may be considered as a promising aspect of resistance to the attack of moisture even after years of field service under the winter conditions of the Niigata region.

3PB test results indicate that the stabilized base course mixture containing 15% of RAP is more resistant to cracking at low temperatures than the mixture with 40% of RAP. A drop of 30% in fracture energy (σ) and a slight decrease in tensile strain (ε) was observed with the increase in RAP content from 15% to 40% (See **Figure 3**).

V. CONCLUSIONS

1. The mixture with 15% of RAP is resistant to moisture. Conversely, the addition of 40% of RAP to the base course mixture has a negative impact on moisture resistance.

2. Aging RAP simulated 1, 5 and 9 years of field aging. Results revealed that the 15% RAP mixture increased in TSR values with the longer aging times.

3. The 3PB test results indicate that the stabilized base course mixture containing 15% of RAP will exhibit more resistance to cracking at low temperatures than the mixture with 40%.

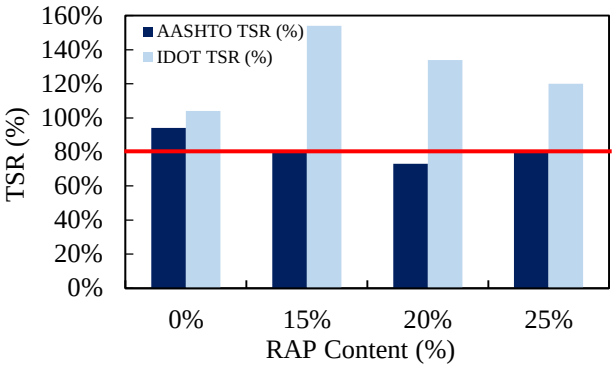

Figure 1 *TSR Comparison of Different Conditioning Methods*

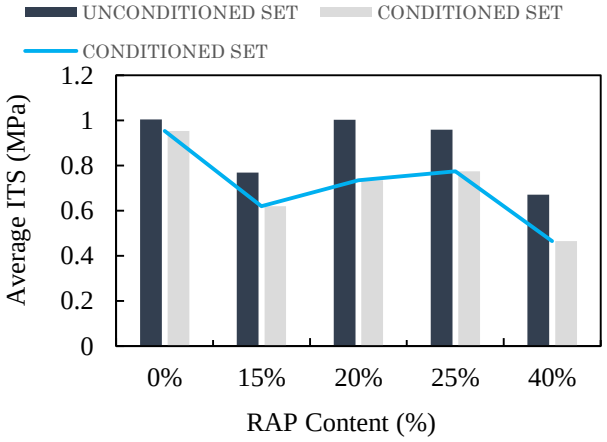

Figure 2 *Average ITS Obtained from the AASHTO T-283 Test*

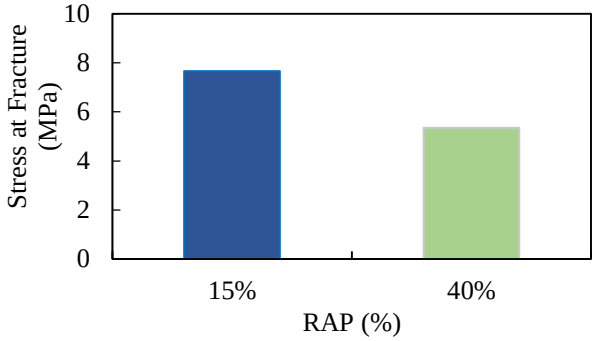

Figure 3 *Average Stress at Fracture of RAP Mixtures*

Reference

- Reclaimed Asphalt Pavement in Asphalt Mixtures: State of the Practice, April 2011 (U.S Department of Transportation).
- The Comparison of Modified IDOT & AASHTO T-283 Test Procedures on Tensile Strength Ratio and Fracture Energy
- X. Yu and Y. Li (2010). Optimal percentage of reclaimed asphalt pavement in central plant hot recycling mixture.