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PROJECT SUMMARY

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Estimation of Low Temperature Properties of RAP Binder without Extraction

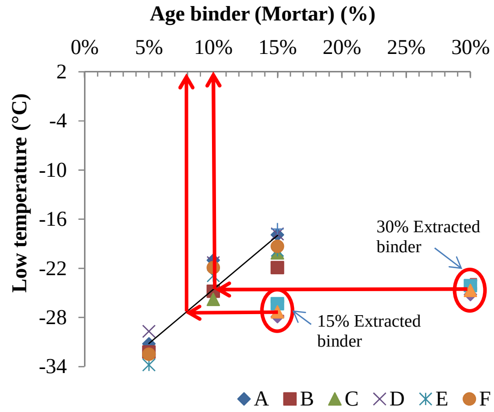
Overview

In recent years, the use of reclaimed asphalt pavement (RAP) as a component of asphalt mixtures has become a common practice. For many years, researchers and DOT officials have questioned the adverse effects, if any, of using solvents to extract and recover the binder. Therefore, researchers have been investigating new methods, without extraction techniques, of estimating the RAP binder properties, especially with respect to the low-temperature characteristics of binders and the mixtures. The major goal of this research project was to determine if the low-temperature properties of the aged asphalt binder in RAP could be obtained by using the fines (-#50 to +#100) generated from sieved RAP materials rather than from the binder extracted from the RAP. In addition, the low-temperature characteristics of several mixtures containing RAP were studied and evaluated for any correlation with the binder properties. Several samples were made with different RAP sources, different percentages of RAP content, various low temperatures (i.e., 0, -6, -12, and -18 °C), and at virgin, RTFO, and PAV states. In addition, some of the RAP sources were obtained again after one year, and bending beam rheometer (BBR) testing was conducted. Other testing procedures and specifications such as indirect tensile strength (ITS) and semi-circle bending (SCB) were used and evaluated.

Literature Review

A survey conducted in 2011 indicated that the asphalt industry remains the country's number one recycler. About 96% of the contractors/ branches reported using RAP. The amount of RAP used in HMA/WMA was 56.0 million tons in 2009 and 62.1 million tons in 2010. Assuming 5 percent asphalt binder in RAP, this represents over 3 million tons (19 million barrels) of asphalt binder conserved. Less than 1% of RAP was sent to landfills. In recent years, a few researchers have indicated that the BBR with only minor modifications can be used to test RAP mortars produced by mixing selected sizes of RAP with fresh binder. In addition, based on extensive testing, it was found that certain sizes of RAP can be separated and used in producing mortars that can be easily mixed, cast in standard BBR molds, and aged in the PAV. The recommended selected size of RAP is passing the #50 sieve and retained on the #100 sieve. Simple binder–mortar relationships, as well as widely-used linear blending charts, were found sufficient to obtain very good estimates of the binder properties in the RAP.

Results



The RAP mortar contents of the modified binder were determined by the properties of extracted binder in terms of their low temperature performance characteristics. Several correlation analyses were performed and many graphs, as shown as an example to the right, were developed indicating as how to determine these percentages. For instance, the modified asphalt blended with PG 58-28 binder and RAP mortar containing three percentages of aged binders have a linear relationship between aged binder and low temperature. In addition, the low temperatures of the modified binders with 15% and 30% extracted binders (from RAP) are shown above. The average low temperatures of these six modified binders (from six RAP sources) can be used to determine the aged binder concentrations from RAP mortars by back-calculation process. In other words, the low temperature of the modified binder containing 15% extracted aged binder is the same as the modified binder blended with RAP mortar containing 8% aged binder. Additionally, the modified binder containing 30% extracted binder has the same low temperatures as the modified binder blended with RAP mortar with 10% aged binder.

Summary & Conclusions

For this research project, in order to determine the low-temperature characteristics of mortar made from fine material, six RAP sources (2 with high stiffness, 2 with medium stiffness, and 2 with low stiffness) mixed with virgin asphalt binders were used. One size fraction of fine RAP materials (-#50 to +#100) and 3 binder grades (PG 58-28, PG 64-22, and PG 76-22) were utilized. In addition, three aged binder contents from RAP mortar (5%, 10% and 15%) were used. RAP mortar mixtures were used to test for low-temperature properties using the modified BBR procedures. In addition, other tests were utilized (e.g., DSR) in determining some other properties (e.g., aging characteristics) of these mortars. The test results were also compared to those of virgin binders mixed with 15% and 30% extracted aged binder from the six RAP sources to correlate low temperature results for these two aged binder contents (15% and 30% respectively) to aged binder from RAP mortar contents.

The ignition oven was also used in obtaining fine aggregates from the six RAP sources to make blended mortar samples not containing the aged binder from the RAP. The fine aggregates from the burned RAP materials were mixed with virgin asphalt binders (PG 58-28, PG 64-22, and PG 76-22), RTFO-aged binders, and PAV-aged binders. These blended mortars were tested for low-temperature properties using the modified BBR procedures. In addition, DSR testing procedures were used in determining the aging characteristics of these mortars. The findings indicated that the fine RAP mortars (with different stiffness values) could be mixed with virgin binders to produce modified binders that could be tested with a traditional bending beam rheometer (BBR) test apparatus without any modifications. The blended procedure of fine RAP with virgin binders is easy to control at a relative high mixing speed and a proper temperature based on the viscosity of the modified binders. In general, the stiffness values of the modified binders were high when incorporated with fine RAPs, and the samples might be destroyed at a test temperature of -18 °C with PG 64-22 and PG 76-22 binders. The minimum low temperatures could be determined based on the simple regression analysis. It was found that the RAP source affected the minimum low temperatures of the various modified binders.

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