Texas A&M Transportation Institute

PROJECT SUMMARY

Texas Department of Transportation

0-7062: Synthesis for Quantification of Binder Availability in Recycled Materials

Background

During the last several decades, the inclusion of reclaimed asphalt pavement (RAP) and reclaimed asphalt shingles (RAS) in asphalt mixtures has increased due to environmental and economic benefits. However, due to the aged state of these recycled materials, their use increases the stiffness and brittleness of the recycled asphalt mixtures and can make them more prone to cracking.

One of the main factors that controls the performance of recycled asphalt mixtures is the recycled binder availability, defined as the amount of recycled binder that activates at conventional production temperatures, blends with the virgin binder, and becomes an effective component in the asphalt mixture. Recycled binder availability can be illustrated by three possible scenarios: no availability, partial availability, or full availability. Previous research showed that partial availability is the most realistic scenario; however, the majority of state departments of transportation assume 100 percent availability in their mix designs. Overestimating recycled binder availability can result in dry mixtures that are susceptible to cracking and moisture damage. Therefore, it is important to quantify recycled binder availability. This study compared recycled binder availability quantification methods. Based on the analysis results, researchers proposed revisions for incorporating recycled binder availability in the Texas Department of Transportation (TxDOT) balanced mix design spreadsheet.

What the Researchers Did

In this project, researchers addressed the issue of recycled binder availability by:

- Reviewing relevant literature on recycled binder availability of RAP and RAS, including quantification methods and the effects of different factors.
- Conducting surveys to collect information on the state of the practice regarding recycled binder availability.
- Performing a detailed comparison of three existing recycled binder availability quantification methods by reviewing the results from:
  - Recently completed National Cooperative Highway Research Program (NCHRP) project 09-58.
  - An ongoing International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM) effort.
  - A Federal Highway Administration (FHWA) initiative.
- Investigating the impact of recycled binder availability on aggregate coating and mixture performance in terms of cracking resistance (indirect tensile [IDT] strength and cracking test index [CT_{Index}]).
- Revising the TxDOT balanced mix design spreadsheet to incorporate recycled binder availability.
- Estimating the environmental, economic, and engineering-related benefits associated with quantifying recycled binder availability.

What They Found

The researchers found the following:

- Recycled binder availability reported in the literature varied from 16 to 96 percent for RAP and 36 to 61 percent for RAS.
- The majority of states assume 100 percent availability for both RAP and RAS.

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- Analysis of the three existing quantification methods indicated that the NCHRP 09-58 method can provide the most realistic quantification; however, it requires extensive laboratory work. The RILEM method provides the most practical and comprehensive approach; however, additional research is needed to understand how recycled binder availability obtained from this method can be used for design of mixtures that contain both virgin and RAP materials. The FHWA method provides the simplest approach but does not correlate with other methods. Table 1 lists the advantages and limitations of these three methods.
- The selection of an appropriate recycled binder availability value is necessary to ensure sufficient aggregate coating and to minimize workability and durability issues.
- Mixture cracking resistance parameters (IDT and CT_{Index}) may not always capture recycled binder availability.
- Significant environmental, economic, and engineering cost savings can be realized by accounting for recycled binder availability. The value of research on an annual basis for this project was estimated at $1:$1954 in terms of cost-benefit ratio.

What This Means

Based on the findings of this project, the researchers recommend the following for TxDOT:

- Use 75 percent recycled binder availability for RAP and/or RAS in recycled asphalt mixtures when any of the following conditions are met:
  - The fractionated RAP content exceeds 20 percent.
  - The recycled binder ratio exceeds 20 percent.
  - The RAS content exceeds 3 percent.
  - The RAP high-temperature performance grade exceeds 100°C.
- Explore alternate approaches to account for reduced recycled binder availability such as increasing total binder content, increasing voids in the mineral aggregate (VMA), and/or evaluating VMA considering only effective binder, decreasing air voids, or decreasing the number of gyrations.
- Characterize RAP sources throughout Texas to estimate representative RAP binder availability in mixtures with RAP and virgin materials.

Table 1. Comparison of Three Recycled Binder Availability Quantification Methods.

	NCHRP 09-58	RILEM	FHWA
Advantages	• Better simulates field • Does not require performance testing at multiple temperatures	• Only requires RAP • Uses relevant conditioning temperatures • Correlates relatively well with NCHRP 09-58 method • Captures gradation effects and effective binder content	• Only requires RAP • Does not require performance testing
Limitations	• Requires ignition oven to determine RAP binder content • Uses only specific virgin materials • Only considers RAP retained on the No. 4 sieve	• Requires performance testing at multiple temperatures • Must compare to many varied RAP sources	• Requires using Superpave gyratory compactor with modified control software • Does not correlate with recycled binder availability from NCHRP 09-58 method

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