Acknowlegments

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Introduction

Rises in construction and asphalt binder costs, as well as the growing pressures on landfills, have contributed to the increased use of Tear-Off Scrap Shingles (TOSS) and Manufacturer Waste scrap Shingles (MWSS) into Hot Mixed Asphalt (HMA) Pavement Mixtures. Currently the 2009 Minnesota Department of Transportation (Mn/DOT) specifications allow a 5% MWSS replacement for the allowable Recycled Asphalt Pavement (RAP) in HMA pavement mixtures. Although there have been pilot projects that have used TOSS with and without RAP, there is no provision for the use of TOSS in the current specifications.

This study investigated the effect of asphalt binder grade and content, RAP source and content and different shingle sources and proportions on HMA mixture properties. Research included testing a matrix of laboratory-produced mixtures that incorporated TOSS, MWSS, and RAP. Recovered asphalt binder from HMA and RAS was tested for high and low temperature properties. Tests for stripping and thermal cracking characteristics were performed on laboratory and field HMA specimens incorporating RAS. A survey of the field performance of RAS/RAP mixtures used in Minnesota was conducted to help verify laboratory evaluation. An outcome of the project was to recommend changes to the asphalt shingle specifications including the use of TOSS.

Mixtures

The mixtures appeared to be more homogenous with the finer ground TOSS. TOSS tended to demand slightly more asphalt binder than MWSS. All mixtures met AASHTO’s HMA mix design requirements as well as Mn/DOT’s volumetric mix specifications. All met Mn/DOT’s Asphalt Film Thickness requirements except the 25% RAP and 5% RAS.

MWSS (Left) and TOSS (Right).

Laboratory Mixtures.

Trends

Binder testing showed a strong correlation between the virgin binder content and the high and low PG temperatures. Mixture testing showed a correlation between virgin binder content and dynamic modulus values at a high test temperature. These results provide justification for the current 70% minimum virgin binder criterion. Mixture and binder testing indicated that increasing RAP in RAS mixtures increased the total stiffness of the mixture. The
use of different RAP sources in the mix design didn’t have a significant effect on the stiffness of the mixture.

The asphalt binder contained in TOSS is typically stiffer than that contained in MWSS; however, the age of the processed RAS needs to be considered. The differences in binder stiffness resulted in high mixture modulus for the TOSS mixes. Decreasing the shingle content to 3% minimized the observable differences between the MWSS and TOSS shingle sources.

**Project Outcome**

It was shown that using a softer virgin binder in the mixture could reduce the mix stiffness dramatically without a corresponding increase in cost. An unmodified Performance Grade (PG) 51-34 binder would not be significantly more expensive than a conventional PG 58-28 binder.

Plant-produced mixtures were found to have lower modulus values than comparable laboratory-produced mixtures. This difference, most likely, is due to the heating of the recycled materials and the longer mixing dwell times of laboratory produced mixtures, which allowed for significantly more mixing of the RAP, RAS and virgin binders to occur. It was unclear if the coarseness of the MWSS gradation or the difference in binder stiffness resulted in the MWSS mixes having lower dynamic modulus (|E*|) measurements. It is well documented that a finer RAS grind and longer mixing dwell time will result in more blending of the RAS binder.

The research team recommends:

- Both MWSS and TOSS can be used at the 3% level
- The present processed shingle gradation and deleterious material requirements should be incorporated for all shingles
- Binder grades used with TOSS and MWSS should be limited to PG 64-28, PG 58-28 and PG 51-34 until additional work can be done on the effect of shingles with modified binders.

**Performance tracking of local test sections.**

Recommended future research should focus on the development of an easier and quicker mixture performance test. This may involve applying the Hirsh model to calculate |E*| from binder tests. A new mix design procedure that more closely simulates plant production of RAP/RAS mixtures needs to be developed, including investigation of using softer binder or softening agents to allow more recycled materials to be used in RAP/RAS mixes. Wet Hamburg tests could be used to evaluate moisture sensitivity, and Flow Number tests could be used to characterize mixture stability.

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