

Design Considerations When Using Reclaimed Asphalt Shingles (RAS) in New Hot Mix Asphalt (HMA)

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1. SCOPE

- 1.1. This recommended practice provides guidance for designing new hot mix asphalt (HMA) that incorporates reclaimed asphalt shingles (RAS). Specific guidance includes design considerations, how to determine the shingle aggregate gradation, how to determine the performance grade (PG) and percentage of the virgin asphalt binder, and how to estimate the contribution of the shingle asphalt binder to the final blended binder.

Note 1—Refer to MP 15 for information specifying the use of RAS in HMA. Additionally, refer to the *White Paper for Recycled Asphalt Shingle as an Additive in Hot Mix Asphalt* for more details concerning the origins and development of this recommended practice.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards:*

- M 320, Performance-Graded Asphalt Binder
- M 323, Superpave Volumetric Mix Design
- MP 15, Use of Reclaimed Asphalt Shingles as an Additive in Hot Mix Asphalt (HMA)
- R 30, Mixture Conditioning of Hot Mix Asphalt (HMA)
- R 35, Superpave Volumetric Design for Hot Mix Asphalt (HMA)
- R 59, Recovery of Asphalt Binder from Solution by Abson Method
- T 30, Mechanical Analysis of Extracted Aggregate
- T 164, Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)
- T 308, Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
- T 319, Quantitative Extraction and Recovery of Asphalt Binder from Asphalt Mixtures

2.2. *ASTM Standard:*

- D 228/D 228M, Standard Test Methods for Sampling, Testing, and Analysis of Asphalt Roll Roofing, Cap Sheets, and Shingles Used in Roofing and Waterproofing

2.3. *Other Reference:*

- *White Paper for Recycled Asphalt Shingle as an Additive in Hot Mix Asphalt*. University of New Hampshire, Recycled Materials Resource Center, Project 13: Development and Preparation of Specifications for Recycled Materials in Transportation Applications, 123 Nesmith Hall, Durham, NH, 2003.

3. INTRODUCTION

- 3.1. Although RAS has been used as an additive in HMA in the United States for more than 15 years, it remains a relatively new application. As a result, there are design considerations that are not generally known to the specification user. Four separate areas are addressed by this recommended practice, with each elaborating on and providing recommendations relative to the following:
- Design Considerations When Using RAS in HMA;
 - Determining the Shingle Aggregate Gradation and Specific Gravity;
 - Estimating the Contribution of the Shingle Asphalt Binder to the Final Blended Binder in New HMA (Values of F); and
 - Determining the Performance Grade (PG) and Percentage of the Virgin Asphalt Binder in New HMA.

4. DESIGN CONSIDERATIONS WHEN USING RAS IN NEW HMA

- 4.1. The introduction of shingle aggregate from RAS will affect the gradation properties of the new HMA. The designer must determine the particle size and percentage of shingle aggregate present and adjust the virgin aggregate composition, if necessary, to ensure that the new HMA meets the appropriate gradation requirements.
- 4.2. The introduction of RAS will affect virgin asphalt binder content requirements. The designer must determine the virgin asphalt binder content of the new HMA as part of the volumetric design procedure.
- 4.3. During the production of the new HMA, shingle asphalt binder present in the RAS will mix with the virgin asphalt binder to produce a final blended binder. The properties of the shingle asphalt binder can be considerably different from those of virgin asphalt binder. If the quantity of virgin asphalt binder is less than 70 percent by mass of the total binder, the properties (PG) of the final blended binder may be measurably different from the design PG of the binder as specified by the local jurisdiction. In addition, the size of the RAS can be expected to affect the percentage of shingle asphalt binder that contributes to the final blended binder. For example, material that is ground to a size passing a 12.5-mm (0.5-in.) sieve can be expected to release lower levels of available shingle asphalt binder (20 to 40 percent) than RAS ground to a size passing a 4.75-mm (No. 4) sieve (as much as 95 percent available). The designer must be prepared to adjust the PG of the virgin asphalt binder to compensate for this effect.
- 4.4. The release of shingle asphalt binder into the virgin asphalt binder can result in reduced virgin asphalt binder requirements. It is unlikely, however, that all of the shingle asphalt binder will dissolve and blend with the virgin asphalt binder. Particles of undissolved shingle asphalt binder may act like aggregate particles that require more virgin asphalt binder to accomplish coating. Additionally, particles of shingle asphalt binder may absorb bituminous oils from the virgin asphalt binder. The location in an HMA plant where RAS is introduced into new HMA can also affect the binder blending process. This point of introduction must minimize damage to the RAS from excess heat and maximize the softening of shingle asphalt binder to facilitate the blending of the shingle asphalt binder with virgin asphalt binder.

5. DETERMINING THE SHINGLE AGGREGATE GRADATION AND SPECIFIC GRAVITY

- 5.1. Collect a representative sample of RAS and proceed in accordance with R 59, T 164, or T 319 to extract the shingle asphalt binder. The size of the sample should be such that the amount of aggregate material recovered will meet the size requirements of the gradation procedure. Alternate

extraction methods, when it is not necessary to retain the shingle asphalt binder, are provided in T 308 and ASTM D 228.

- 5.2. To determine the shingle aggregate gradation, it is suggested that the shingle fiber present in the RAS be removed prior to testing the recovered aggregate in accordance with T 30. Because the major portion of the shingle fiber will be retained on a 4.75-mm (No. 4) sieve, the fiber fabric can be removed by tweezers or other appropriate method prior to grading the shingle aggregate during the T 30 test procedure.

Note 2—Sieving the aggregate may liberate fiberglass or other fibers present in the RAS. The amount of aggregate contributed by the RAS produces an almost negligible effect in the overall mixture gradation. The following gradation, which approximates the composition of most types of shingles, may be used as a standard gradation in lieu of determining the shingle aggregate gradation:

Shingle Aggregate Gradation	
Sieve Size	Percent Passing by Mass
9.5 mm ($\frac{3}{8}$ in.)	100
4.75 mm (No. 4)	95
2.36 mm (No. 8)	85
1.18 mm (No. 16)	70
600 μ m (No. 30)	50
300 μ m (No. 50)	45
150 μ m (No. 100)	35
75 μ m (No. 200)	25

- 5.3. Determine the shingle aggregate specific gravity by determining the theoretical maximum specific gravity (G_{mm}) of the RAS according to T 209 and calculating the effective specific gravity (G_{se}) of the aggregate according to Equation 1. A fine spray of alcohol may help reduce surface tension to allow fine particles to sink.

$$G_{se} = \frac{100 - P_{br}}{\left(\frac{100}{G_{mm}}\right) - \left(\frac{P_{br}}{1.03}\right)} \quad (1)$$

where:

G_{se} = the effective specific gravity of the shingle aggregate;

G_{mm} = the theoretical maximum specific gravity of the RAS; and

P_{br} = the percentage of shingle asphalt binder in the RAS by mass, percent.

Note 3—The absorption of most shingle aggregate is so low that little difference exists between the bulk and apparent specific gravities. Therefore, the effective specific gravity of the shingle aggregate may be substituted for the bulk specific gravity in subsequent calculations.

6. ESTIMATING THE CONTRIBUTION OF THE SHINGLE ASPHALT BINDER TO THE FINAL BLENDED BINDER IN NEW HMA (VALUES OF F)

- 6.1. When RAS is added to new HMA, there is uncertainty as to the exact amount of asphalt binder that is released from the shingle asphalt binder to blend with the virgin asphalt binder. There are many factors that control the blending of these two binders. Perhaps the most significant factor is the size to which the RAS is ground. The finer the grind, the greater the amount of the