Wednesday, 02 May 2012 11:18

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Editor's Note:

Dr. Elseifi presented a full version of this concept at the recent18th C&D World, the Annual Meeting of the CMRA, in Nashville, Tenn.

The EPA estimates that 170 million tons of construction and demolition (C&D) debris are generated every year with asphalt shingles making up to 15% of this waste.[1] While C&D debris have increased by 25% from 1996 to 2003, the recovery rate has increased from 25% to 48% during that period. However, the recycling of asphalt shingles has trailed other construction components such as wood, concrete, and asphalt mainly due to the need to enhance its recycling applications. The EPA estimates that about 11 million tons of asphalt shingles are placed in landfills annually in the U.S. Of this waste, 10 million tons of asphalt shingles are the results of C&D debris while 1 million tons originate from asphalt shingles manufacturers.[2]

Recycling of asphalt shingles in hot-mix asphalt (HMA) has received considerable attention in recent years for technical, economical, and environmental reasons. Numerous benefits may result from the recycling of asphalt shingles in HMA:

- Reduced consumption of virgin materials;
- Reduced emissions and energy consumption during processing and manufacturing of virgin materials;
- Reduced byproduct materials disposed in landfills;
- Diminished consternation of public over emissions; and
- Improved economic competitiveness of asphalt pavement construction.

Recent estimates indicate that recycled asphalt shingles (RAS) contain 15% to 35% of asphalt binder, which may provide an annual savings of $1.1 billion and reduce nonrenewable energy consumptions in the U.S.[3,4] It is also noted that in the past eight years, the price of a ton of asphalt binder has increased by 280% (See Figure 1). The use of RAS also allows decreasing the amount of produced waste and helps resolve disposal problems especially in the neighborhood of large cities.

While the recycling of RAS is beneficial by reducing the consumption of virgin materials and it is needed to ensure economic competitiveness of asphalt paving construction, the performance of the highway should not be compromised. Research studies were recently initiated to conduct demonstration projects and to determine the behavior and performance of RAS when dry blended with the aggregates before the asphalt binder is added to the batch.[5] Based on the results of these projects, many states including Minnesota, Georgia and Florida, allow up to 5% RAS in the production of HMA. Two strategies are typically adopted in the recycling and processing of tear-off asphalt shingles.[6] In the first strategy, tear-off shingles are separated by the roofing contractor before transferring to the shingle recycling plant. In the second strategy, mixed roofing materials are loaded to the recycling facility, at which non-shingle debris is removed from the recycled material. RAS is usually ground to a uniform particle size ranging from 12.5 to 19 mm.

In spite of the various promises of recycling RAS in asphalt pavements, field practices of dry blending tear-off asphalt shingles with the aggregates before the asphalt binder is added to the batch are often criticized due to the large variability observed in the asphalt content of asphalt shingles. In addition, while the use of RAS results in a decrease in the required virgin binder content and improves the mixture resistance to permanent deformation, mixture resistance to low temperature cracking and fracture resistance appears to decrease when RAS is used.[7] Therefore, it is important that the influence of the recycling process is thoroughly evaluated and quantified.

Researchers at Louisiana State University are currently developing a new approach to recycle asphalt shingles in asphalt paving construction in which RAS is ground to ultra-fine particle size (more than 80% passing sieve No. 200 – 0.075 mm) and blended with asphalt binder through a wet process. In the proposed wet process, the ground recycled material is blended with the binder at high temperature prior to mixing with the aggregates (See Figure 2). The proposed wet process offers the potential for a better control of the chemical and physical reactions taking place in the blend. The idea behind the proposed method was motivated by the successful recycling of scrap tires in HMA using a wet process to create what is commonly known as asphalt rubber or crumb rubber modifier. In this laboratory study, two unmodified binders that are classified as PG 64-22 and PG 52-28 were blended with two contrasting sources of RAS at a modification level ranging from 10% to 40% by weight of the binder. Two contrasting sources of RAS consisting of tear off shingles from Missouri and manufactured shingles from Maine were obtained from C&D processing plants. RAS materials were ground to an ultra-fine particle size distribution at room temperature using a Pulva-Sizer hammer mill.

The laboratory experimental program was designed to determine the effects of RAS modification on the binder rheological properties, molecular and fractional compositions, and compatibility of the blends when the wet process is used.[8] Prepared blends were characterized using fundamental rheological tests (i.e., dynamic shear rheometry, rotational viscosity, and bending beam rheometer) and by comparing the Superpave Performance Grade (PG) of the

RAS-modified blend to the unmodified binders as per AASHTO M 320-09 (Standard Specification for Performance-Graded Asphalt Binder). Microscopic analysis of the microstructure of the prepared asphalt blends was conducted using Confocal Laser-Scanning Microscopy (CLSM) in a fluorescence mode. In addition, the compatibility and stability of the prepared blends were evaluated using the cigar tube test (ASTM D 7173-05).

Results of this study showed that the use of RAS modification through the proposed wet process was successful in the laboratory at a modification content of 20% or less. The use of RAS as a modifier to the binder increased its viscosity, stiffened the binder at high temperature, and reduced its elongation properties at low temperature. However, the use of RAS modification through the proposed wet process would generally improve or not influence the high temperature grade of the binder. An optimum shingle content may be identified that will improve the high temperature grade without influencing the low temperature grade of the binder. In the second phase of this project, researchers will design and measure the performance of asphalt mixtures prepared with the proposed wet method against major distresses including rutting, low temperature cracking, and fracture.

About the Author

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