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Performance of Recycled Asphalt Shingles in Hot Mix Asphalt: TPF-5(213), Iowa DOT's Project Involvement

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Abstract
US transportation agencies have been increasingly using recycled asphalt shingles (RAS) in hot mix asphalt (HMA) applications over the last 25 years. Initial use of RAS started with recycled post-manufacturers shingles, but now agencies are showing a growing interest in using post-consumer (tear-off) RAS in asphalt applications. Postconsumer asphalt shingles typically have 20 to 30 percent asphalt by weight of the shingles as well as fine aggregates, mineral filler, polymers, and cellulosic fibers from the shingle backing. Each year, an estimated 10 million tons of post-consumer shingles are placed in landfills in the US. Utilization of this waste product presents an opportunity to replace virgin asphalt binder with the RAS binder while taking advantage of the additional fibers which can improve performance. Thus, a material that has historically been deemed a solid waste and has been placed in landfills can decrease pavement costs and reduce the burden on everdecreasing landfill space.

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TECH BRIEF

Performance of Recycled Asphalt Shingles in Hot Mix Asphalt

Transportation Pooled Fund Program

RESEARCH PROJECT TITLE:

Performance of Recycled Asphalt Shingles in Hot Mix Asphalt

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Iowa DOT's Project Involvement

Pooled Fund Study Description

US transportation agencies have been increasingly using recycled asphalt shingles (RAS) in hot mix asphalt (HMA) applications over the last 25 years. Initial use of RAS started with recycled post-manufacturers shingles, but now agencies are showing a growing interest in using post-consumer (tear-off) RAS in asphalt applications. Post-consumer asphalt shingles typically have 20 to 30 percent asphalt by weight of the shingles as well as fine aggregates, mineral filler, polymers, and cellulosic fibers from the shingle backing. Each year, an estimated 10 million tons of post-consumer shingles are placed in landfills in the US. Utilization of this waste product presents an opportunity to replace virgin asphalt binder with the RAS binder while taking advantage of the additional fibers which can improve performance. Thus, a material that has historically been deemed a solid waste and has been placed in landfills can decrease pavement costs and reduce the burden on ever-decreasing landfill space.

Many agencies share common questions about the effect of post-consumer RAS on the performance of HMA. Previous research has allowed for only limited laboratory testing and field surveys. The complexity of RAS materials and lack of past experiences led to the creation of Transportation Pooled Fund (TPF) Program TPF-5(213). TPF-5(213) is a partnership of several state agencies with the goal of researching the effects of RAS on the performance of HMA applications. Multiple state demonstration projects were conducted to provide adequate laboratory and field test results to comprehensively answer design, performance, and environmental questions about asphalt pavements containing post-consumer RAS. Each state transportation agency in the pooled fund study proposed a unique field demonstration project that investigated different aspects of asphalt mixes containing RAS specific to their state needs. The demonstration projects focused on evaluating different aspects (factors) of RAS that were deemed important for their state to move forward with RAS specifications.

The Iowa Demonstration Project

The field demonstration project sponsored by the Iowa Department of Transportation (DOT) investigated the effect of different percentages of post-consumer RAS in HMA. Since RAS contains a much stiffer binder than paving grade asphalt, blending RAS binder with virgin binder can significantly increase the binder performance grade (PG). While this may be desirable for improved rutting resistance in asphalt pavements, it can cause the HMA to be more susceptible to low temperature thermal cracking. To counter these negative impacts, engineers can specify a softer virgin binder grade so the final binder blend is appropriate for the climate and traffic conditions. The results of this study will help Iowa DOT engineers determine the appropriate percentage of RAS and virgin binder grade for future specifications.

The demonstration project, totaling 17 miles, was completed by Tri-State Paving in July 2010 on Highway 10 west of Paullina in Sioux County. A two-inch HMA surface course was placed over existing jointed concrete pavement. Sections within the project contained HMA with 0, 4, 5, and 6 percent. RAS was supplied by Dem-Con Companies, LLC in Shakopee, MN and contained 100% passing the 1/2 in. sieve.

"Utilization of this waste product [RAS] presents an opportunity to replace virgin asphalt binder with the RAS binder while taking advantage of the additional fibers which can improve performance."

" flow number tests results showed an increase in rutting resistance with the addition of RAS "

" the SCB test showed the 4% RAS mixture has greater ability to resist cracking than the 0% RAS mixture "

Transportation Pooled Fund Website for TPF-5(213): http://www.pooledfund.org/Details/Study/441

Iowa State University Institute for Transportation Website for TPF-5(213): http://www.intrans.iastate.edu/tpf-5-213/

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Loose samples of each mix type during production were obtained to conduct laboratory performance tests (dynamic modulus, flow number, four-point beam fatigue, and semi-circular bending (SCB)) and binder extraction and recovery for subsequent binder characterization. After construction of the demonstration project, field surveys were conducted on each pavement test section one and two years after paving to assess the condition of the pavements.

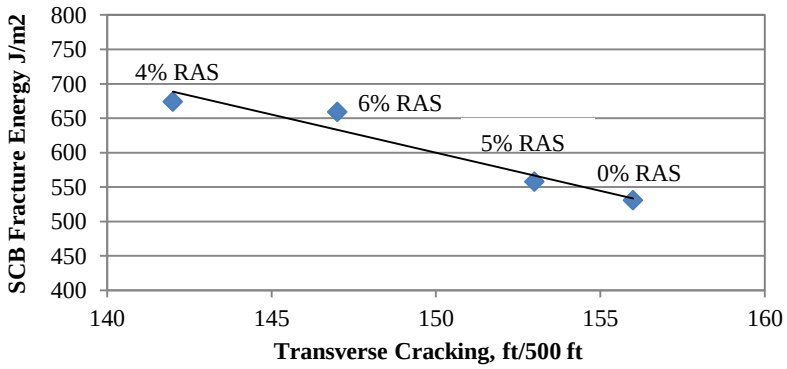
Key Findings

Asphalt mixes using different percentages of post-consumer RAS were successfully designed and produced to meet Iowa DOT specifications. Tri-State Paving won a Quality in Construction award by the National Asphalt Pavement Association (NAPA) for the project. The greatest effect of incorporating the RAS into the mixes was on the binder PG. A PG 58-28 was used as the virgin binder. The following table shows how the addition of RAS to the mix design changed the PG. Heating the HMA during production and reheating the samples during laboratory extraction had an aging effect on the binder since the asphalt extracted from the 0% RAS mixture had a continuous PG of 73.0-19.7. As RAS was added to the mix design, the low and high PG temperatures increased. In the mix with 5% RAS, the high temperature PG increased one grade bump while the low temperature PG remained the same.

Material Identification	% Binder in RAS	% Binder Repl. in HMA	High PG Temp, °C	Low PG Temp, °C	Performance Grade
Virgin PG 58-28	-	-	61.1	-28.2	58-28
RAS	-	-	124.1	-	-
0% RAS Mix	-	0	73.0	-19.7	72-16
4% RAS Mix	20.5	16.3	75.8	-19.1	72-16
5% RAS Mix	20.5	19.4	81.3	-16.8	76-16
6% RAS Mix	20.5	22.8	86.1	-14.7	86-10

Results from the laboratory performance tests on the mixes suggest that the RAS mixes will perform well in the field. Dynamic modulus and flow number tests results showed an increase in rutting resistance with the addition of RAS. Fatigue cracking tests using the four-point bending beam apparatus showed that the addition of RAS increased the fatigue life of the asphalt mixtures in a controlled strain mode of loading (the condition of thin pavements). This could be from fibers in the RAS providing additional ductility to the mixtures. Statistical analysis of the low temperature cracking tests using the SCB test showed the 4% RAS mixture has greater ability to resist cracking than the 0% RAS mixture due to a higher fracture energy.

The pavement condition of the mixes in the field after two years corroborated the laboratory test results. No signs of rutting, wheel path fatigue cracking, or thermal cracking were exhibited in the pavements. However, transverse reflective cracking from the underlying jointed concrete pavement was measured in each mix section. The amount of transverse cracking after two years correlated with the average laboratory fracture energy of the HMA as shown in the following graph.



These results show great promise for future RAS applications in HMA and will be shared with other departments of transportation participating in the pooled fund study to help the Iowa DOT and other state agencies develop specifications for optimizing the performance of HMA containing RAS. The final report can be downloaded at the pooled fund study website.