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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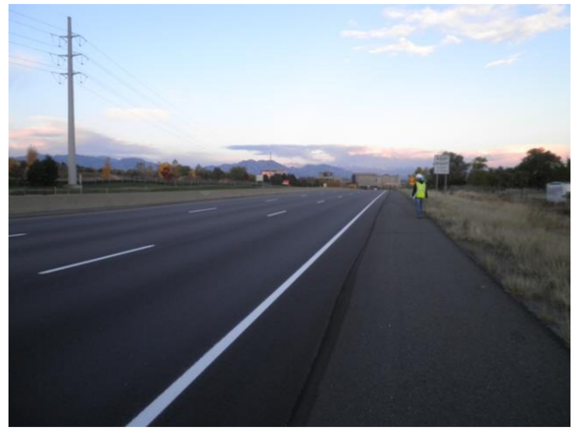
Performance of Recycled Asphalt Shingles in Hot Mix Asphalt: TPF-5(213)

Colorado 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 Colorado Demonstration Project

The field demonstration project sponsored by the Colorado Department of Transportation (CDOT) investigated the economic and performance benefits of replacing recycled asphalt pavement (RAP) with RAS in HMA. For the experimental plan, a typical CDOT mix design containing 20 percent RAP was compared to a mix designed containing 15 percent RAS and 3 percent RAS (presented in the table below) to see how replacing 5 percent RAP with 3 percent RAS will affect the performance of the HMA.

CDOT Experimental Plan

Mix ID	% RAS	% RAP	% Binder Replacement
HMA-RAP	0	20	23.5
HMA-RAS	3	15	26.9

“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.”

“Fracture energy results showed no differences in cracking performance between the two mixes.”

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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The demonstration project, totaling 4 miles, was completed by Asphalt Specialties in August 2011 on US Route 36 south of Boulder. The existing pavement structure consisted of 6 inches of HMA over concrete pavement. Two inches of HMA was milled and replaced. The 20% RAP mix was placed in the WB lanes and the 3% RAS mix was placed in the EB lanes. Post-manufactured RAS with 18.1% asphalt was used for the mix design and contained 100% passing the 1/2 in. sieve.

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 year after paving to assess the condition of the pavements.

Key Findings

The contractor successfully produced and constructed both HMA mixes; however, there were several production days where not all volumetric requirements were met. During night paving of the RAS mix, individual tabs of RAS were visible on the pavement surface indicating the 1/2 inch minus grind size of the RAS was too large to adequately blend with the virgin materials. A finer RAS grind of 3/8 inch minus or less should help reduce the presence of tabs during paving.

The greatest effect of incorporating RAS into the mixes was the change in binder performance grade (PG), since the RAS contains much stiffer asphalt than paving grade asphalt. The following table shows how using RAS and RAP changed the PG of the base binder. Adding 20% RAP raised the low temperature PG 7°C and the high temperature PG 1°C. When 5% RAP was replaced with 3% RAS, the low temperature PG of the base binder increased 14°C and the high temperature PG of the base binder increased 6°C.

PG Grading Results

Material Identification	High PG Temp, °C	Intermediate PG Temp, °C	Low PG Temp, °C	Performance Grade
PG 64-28	66.4	12.4	-34.8	64-34
RAS	111.2	-	-	-
RAP	77.7	26.5	-18.8	76-16
RAP HMA	67.6	18.7	-27.5	64-22
RAS/RAP HMA	71.9	19.7	-21.1	64-16

Results from the laboratory performance tests on the mixes suggest the RAP and RAS mixes will perform well in the field and that replacing 5% RAP with 3% RAS will not reduce the performance of the HMA. Dynamic modulus and flow number tests results showed the mixes have good rutting resistance. Fatigue cracking tests using the four-point bending beam apparatus showed the RAS/RAP mix had greater resistance to fatigue distress than the RAP mix and a higher estimated fatigue endurance limit (244 compared to 195 μstrain). For the SCB low temperature cracking test, statistical analysis of the fracture energy results showed no differences in cracking performance between the mixes.

Field condition surveys conducted one winter season after the demonstration project revealed minor transverse cracking in the RAS and RAP mixture (25 linear feet of cracking per 500 feet), and very little transverse cracking in the RAP only mixture (1.5 linear feet of cracking per 500 feet).

These results show great promise for future use of RAS applications in HMA and will be shared with other departments of transportation participating in the pooled fund study to help CDOT 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.