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

Indiana 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 Indiana Demonstration Project

The field demonstration project sponsored by the Indiana Department of Transportation (INDOT) investigated using RAS in combination with foaming Warm Mix Asphalt (WMA) technology. The objective of this demonstration project was twofold: first, to evaluate the performance of WMA containing RAS, and second, to compare a typical INDOT mix design that contains recycled asphalt pavement (RAP) to a mix design that contains RAS. The experimental plan for the project was implanted by producing three asphalt mixtures as presented in the following table.

INDOT Experimental Plan

Mix ID	% RAS	% RAP	RAS Source	WMA Technology
HMA-RAP	0	15	-	None
HMA-RAS	3	0	Post-Consumer	None
WMA-RAS	3	0	Post-Consumer	Foaming

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

PRINCIPAL INVESTIGATOR:

R. Christopher Williams, PhD
Professor of Civil, Construction, and Environmental Engineering
Iowa State University
515-294-4419
rwilliam@iastate.edu

PARTICIPATING STATES:

MO (Lead State), CA, CO, IA, IL, IN, MN, WI, FHWA

INDOT AGENCY CONTACT:

Mike Prather
Asphalt Engineer
mprather@indot.IN.gov

IOWA STATE UNIVERSITY
Institute for Transportation

Institute for Transportation
2711 South Loop Dr, Suite 4700
Ames, IA 50010-8664

“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 three 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 7 miles, was completed by Phend & Brown in August 2009 on US Route 6 east of Nappanee in Elkhart County. The existing pavement structure consisted of HMA placed over a concrete pavement. For the demonstration project, 1.5 inches of HMA was milled and replaced with one of the three mix designs in the experimental plan. The post-consumer RAS used in the designs contained 26.8% asphalt with 100% passing the 1/2 in. sieve and 97% passing the 3/8 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, two, and three years after paving to assess the condition of the pavements.

Key Findings

The asphalt mixes using RAS with and without WMA technology were successfully designed and produced to meet INDOT specifications. 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. Adding 15% RAP binder raised the low temperature PG one grade higher to -16°C while keeping the high temperature PG the same at 70°C. When 3% RAS was used in the mix design, the low temperature PG increased another grade to -10°C and the high temperature PG increased to 76°C. Using foaming WMA technology did not change the PG.

PG Grading Results

Material Identification	% Binder Repl. in HMA	High PG Temp, °C	Low PG Temp, °C	Performance Grade
PG 70-22	-	72.2	-24.2	70-22
RAS	-	134.2	-	-
HMA-RAP	19.3	75.6	-20.1	70-16
HMA-RAS	12.9	77.6	-14.2	76-10
WMA-RAS	12.9	78.8	-15.1	76-10

Results from the laboratory performance tests on the mixes suggest the RAP and RAS mixes will perform well in the field and that using foaming WMA with RAS will not reduce the performance of the HMA. Dynamic modulus and flow number tests results showed the mixes have good rutting resistance. Higher flow numbers in the RAS mixtures indicated that mixtures with 3% RAS will be more rut resistant than mixtures with 15% RAP. Fatigue cracking tests using the four-point bending beam apparatus showed the HMA and WMA with RAS has similar fatigue properties as the HMA with RAP. For the SCB low temperature cracking test, statistical analysis of the fracture energy results showed no differences in cracking performance between the three mixes.

Field condition surveys conducted one, two, and three years after the demonstration project revealed that all three pavement sections exhibited transverse cracking, longitudinal cracking, and fatigue cracking. The transverse cracking is most likely caused by differential movement of the concrete and HMA pavement below the asphalt overlay. High amounts of truck traffic observed on the highway may be accelerating wheel path distresses. The RAP pavement section contained the least amount of distress, and the RAS with WMA pavement section contained the greatest amount of distress. However, the level of distress may be dependent upon the condition of the pavement underneath the overlay.

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