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

R. Christopher Williams
Iowa State University, rwilliam@iastate.edu

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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. 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.

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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

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

WisDOT AGENCY CONTACT:

Judie Ryan
Judith.Ryan@dot.wi.gov

IOWA STATE UNIVERSITY
Institute for Transportation

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

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Wisconsin 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 Wisconsin Demonstration Project

The field demonstration project sponsored by the Wiscons Department of Transportation (WisDOT) investigated the effect of using Evotherm 3G® warm mix asphalt technology as a compaction aid in hot mix asphalt (HMA) containing post-consumer RAS. Evotherm 3G® is a liquid additive that includes chemical agents designed to improve bitumen coating of aggregates, workability, and aggregate-binder adhesion. Its ability to increase the workability of HMA could lengthen the compaction window for mixes during colder weather or improve the compatibility mixes that are stiffer due to higher amounts of recycled materials.

The objective of this demonstration project was to evaluate the performance of a typical WisDOT mix design containing RAS, with and without Evotherm 3G®, at hot mix production and compaction temperatures during late season construction (November). The experimental plan was implanted by producing two asphalt mixtures as presented in the following table.

"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."

"Evotherm 3G® did not affect he mix's rutting resistance."

"Fracture energy results showed no differences in cracking performance when Evotherm 3G® was used as an additive."

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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Institute for Transportation

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WisDOT Experimental Plan

Mix ID	% RAS	% FRAP	WMA Technology
Evo	3	13	Evotherm 3G®
No Evo	3	13	None

The demonstration project, totaling 8 miles, was completed by Payne & Dolan in November 2011 on State Trunk Highway 144 north of West Bend in Washington County. The existing pavement structure consisted of 4.5 to 6 inches of HMA over concrete pavement. 1.5 inches of HMA was milled replaced with 2.75 to 3.25 inches of HMA. The mix design contained a combination of RAS and fractionated recycled asphalt pavement (FRAP), both of which Payne and Dolan crushed and processed. The RAP was fractionated to pass the 3/4 in. sieve and contained 4.1% asphalt; the RAS was processed to pass the 3/8 in. sieve and contained 35.4% asphalt.

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 the HMA with a combination of post-consumer RAS and FRAP (30.4% binder replacement) during late season paving by using Evotherm 3G® as a compaction aid. The contractor met WisDOT's quality verification requirements on mix properties and pavement density. 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 PG of the total binder in the asphalt mixtures increased from a PG 58-28 to a PG 64-22 with the addition of RAS and FRAP. The addition of Evotherm 3G® did not significantly impact the HMA performance grade.

PG Grading Results

Material Identification	% Binder Replacement	High PG Temp, °C	Low PG Temp, °C	PG
Virgin Binder	-	60.7	-29.1	58-28
RAS	-	124.1	-	-
Mix Sample (No Evo)	30.4	68.5	-24.0	64-22
Mix Sample (Evo)	30.4	69.5	-22.5	64-22

Results from the laboratory performance tests on the mixes suggest the mixes will perform well in the field and using Evotherm 3G® additive as a compaction aid is effective in helping the contractor achieve density with mixes containing RAS during late season paving. Dynamic modulus and flow number tests results showed the mixes have excellent rutting resistance and adding Evotherm 3G® did not affect he mix's rutting resistance. Fatigue cracking tests using the four-point bending beam apparatus indicated the mixes had good resistance to fatigue damage. For the SCB low temperature cracking test, statistical analysis of the fracture energy results showed no differences in cracking performance when Evotherm 3G® was used as an additive.

The pavement condition of the mixes in the field after one winter season corroborated the laboratory test results. Field condition surveys revealed no pavement distresses in the test sections.

These results show great promise for using RAS in combination with Evotherm 3G® as a compaction aid and will be shared with other departments of transportation participating in the pooled fund study to help WisDOT 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.