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Recommended Citation
Williams, R. Christopher, "Performance of Recycled Asphalt Shingles in Hot Mix Asphalt: TPF-5(213), Illinois DOT's Project Involvement" (2013). *Tech Transfer Summaries*. 22.
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Performance of Recycled Asphalt Shingles in Hot Mix Asphalt: TPF-5(213), Illinois DOT's Project Involvement

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 postconsumer (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 postconsumer 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.

Keywords
Civil Construction and Environmental Engineering

Disciplines
Civil and Environmental Engineering

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

Illinois 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 Illinois Demonstration Project

The field demonstration project sponsored by the Illinois Department of Transportation (IDOT) investigated replacing fibers and virgin asphalt with RAS in stone mastic asphalt (SMA). Several different plant and laboratory SMA mixes were produced using post-consumer RAS, recycled asphalt pavement (RAP), and ground tire rubber (GTR) with different types of base binders. The objective of this demonstration project was to evaluate the performance of SMA mixtures using post-consumer RAS, GTR, and RAP with different base binders and to investigate the performance differences between laboratory produced SMA-RAS mixes to plant produced SMA-RAS mixes.

IDOT Experimental Plan

Mix ID	Binder PG	% RAP	% RAS	Mix Type	Contractor
Dcon 70-28P	70-28	0	5	Plant	D Construction
Dcon 70-28L	70-28	0	5	Lab	D Construction
Dcon 58-28L	58-28 w/ 12% GTR	0	5	Lab	D Construction
Curran 70-28P	70-28	11	5	Plant	Curran
Curran 70-28L	70-28	11	5	Lab	Curran
Curran 58-28L	58-28 w/ 12% GTR	11	5	Lab	Curran

"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."

"The Illinois SMA mixes exhibited the longest fatigue lives out of all the RAS mixes tested in the pooled fund study."

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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Two different projects that used an SMA-RAS surface course were evaluated as part of the pooled fund study, a 14 mile segment of I-80 east of Joliet and a 10 mile segment of the Jane Addams Memorial Tollway (I-90) in Hoffman Estates, IL. Both projects were completed in the summer of 2011. D Construction, Inc. completed the I-80 project and Curran Contracting Company, Inc. completed the I-90 project. Post-consumer RAS with 36.7% asphalt and 100% passing the 3/8 in. sieve was supplied by Southwind RAS for both projects.

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 SMA pavements with RAS were successfully produced and constructed while meeting IDOT's quality assurance requirements. The SMA's did not have any binder drain-down when 5 percent RAS was utilized as a stabilizer. 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 addition of 5 percent RAS in the D Construction SMA mixes increased total binder blend from a PG 70-28 to a PG 70-22. The addition of 5 percent RAS and 11 percent RAP in the Curran SMA mixes increased the total binder blend from a PG 70-28 to a PG 82-16.

PG Grading Results

Material Identification	% Binder Replacement	High PG Temp, °C	Low PG Temp, °C	PG
PG 70-28	-	73.2	-29.9	70-28
PG 58-28 with 12% GTR	-	78.3	-26.1	76-22
Southwind Post-Consumer RAS	-	129.7	-	-
Type 1 Fine RAP	-	78.5	-19.2	76-16
SMA mix for Dcon 70-28P	21.0	72.8	-24.3	70-22
SMA mix for Dcon 70-28L	21.0	72.7	-23.7	70-22
SMA mix for Dcon 58-28L	21.0	77.2	-21.3	76-16
SMA mix for Curran 70-28P	35.0	82.8	-18.1	82-16
SMA mix for Curran 70-28L	35.0	84.4	-14.5	82-10
SMA mix for Curran 58-28L	35.0	81.8	-17.7	76-16

Results from the laboratory performance tests on the mixes suggest the SMA-RAS mixes will perform well in the field. The lab mixes performed similarly to the field mixes indicating that data obtained from SMA-RAS lab mixes can be used to estimate the performance of field mixes. Dynamic modulus and flow number tests results showed the mixes have excellent rutting resistance. Fatigue cracking tests using the four-point bending beam apparatus indicated all the mixes had good resistance to fatigue damage. The Illinois SMA mixes exhibited the longest fatigue lives out of all the RAS mixes tested in the pooled fund study. For the SCB low temperature cracking test, statistical analysis of the fracture energy results showed no differences in cracking performance between the mixes.

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 on the I-80 and I-90 test sections.

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