

## 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)

## Missouri 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. The Missouri Department of Transportation's (MoDOT) involvement with the study was unique in that they were the lead state and provided the management and organization of the study.

### The Missouri Demonstration Project

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 field demonstration project sponsored by the Missouri Department of Transportation (MoDOT) investigated two RAS factors: RAS grind size and asphalt mixes that use RAS and modified asphalt binder. The objective of this demonstration project was to identify potential economic and performance benefits when incorporating a finer grind size of RAS in HMA using asphalt modified with ground tire rubber (GTR) and transpolyoctenamer rubber (TOR).

Evaluating the grind size of RAS was important to the project since grind size can change the consistency of the mix. A finer grind produces a more consistent mixture and can increase the tensile strength more than a coarser grind. State agencies have become more aware of the importance of obtaining a consistent RAS gradation with fine particles in order for the RAS to blend well with the other HMA components.

“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 pavement containing coarsely ground RAS exhibited more transverse cracking than the pavement containing finely ground RAS.”

“both the fine and coarse RAS improved the estimated fatigue endurance limit of the mix”

Transportation Pooled Fund Website for TPF-5(213):  
<http://www.pooledfund.org/De tails/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 MoDOT demonstration project took place in May 2010 on US Route 65 south of Springfield, MO. Test sections were placed on the two northbound lanes for a total project length of 8.8 miles. In the test sections, a 3.75 inch HMA overlay was placed over a jointed concrete pavement. The 1.75 inch surface coarse contained three different mix sections: a control section with 15% recycled asphalt pavement (RAP) and 0% RAS, a test section with 5% post-consumer fine RAS (100% passing the 3/8 in. screen) and 10% RAP, and a test section with 5% post-consumer coarse RAS (100% passing the 1/2 in. screen) and 10% RAP. All three designs used a base PG 64-22 binder with 10% GTR by weight of the asphalt binder and 4.5% TOR by weight of the GTR to achieve an equivalent PG 70-22 binder.



Fine RAS (< 3/8 in.)



Coarse RAS (<1/2in.)

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 mix designs using the RAP, RAS, GTR, and TOR were successfully designed and produced to meet MoDOT specifications. Both the fine RAS and coarse RAS mixes contained the targeted volumetric properties, however, the presence of larger shingle particles was noticeable in the mix with the coarse grind RAS. The mix with the finer grind RAS appeared to be more homogeneous and less likely to result in RAS tabs protruding from the pavement.

The greatest effect of incorporating the RAS into the mixes was the change in total binder performance grade (PG), since the addition of RAS raised the performance grade of the binder in the mixes. The continuous PG for the control mix was 75.0-16.8, while the PG's for the fine RAS and control RAS mix was 90.1-8.7 and 88.3-4.9, respectively.

Results from the laboratory performance tests on the mixes suggest that the RAP and RAS mixes will perform well in the field. Dynamic modulus and flow number tests results showed the mix with 15% RAP had excellent rutting resistance and was further enhanced with the addition of the RAS. Fatigue cracking tests using the four-point bending beam apparatus showed the control mix had greater fatigue resistance at higher strain levels while both the fine and coarse RAS improved the estimated fatigue endurance limit of the mix (from 139 to 159  $\mu$ strain). Statistical analysis of the low temperature cracking tests using the SCB test showed no differences in cracking performance among the mixtures.

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 pavement containing coarsely ground RAS exhibited more transverse cracking than the pavement containing finely ground RAS, but the non-RAS pavement exhibited less cracking than both coarse and fine RAS pavements.

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 MoDOT and other state agencies develop specifications for optimizing the performance of HMA containing RAS. The final report can be downloaded at the pooled fund website.