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The King's gesture

Wash. pilot project signals the go-ahead to experiment more with recycled shingles

Road construction is a more than $80 billion annual industry in the U.S. Over the last decade, the industry has been driving toward greener and more sustainable design, construction, use and maintenance.

New technologies, new materials and new practices all play an important role in reducing the environmental impacts and maximizing economic and social benefits of our nation's roadways.

The use of recycled materials in hot-mix asphalt (HMA) in road construction has long been an important green strategy of the asphalt-paving industry. Reclaimed asphalt pavement (RAP) is one of the most widely recycled materials in the U.S., with much of this material going into the construction of new roadways.

Recently, the use of recycled asphalt shingles (RAS) in paving has gained significant momentum. RAS can be derived from tear-off shingles from re-roofing projects or from manufacturers' scrap. Currently 21 states and two Canadian provinces have specifications or procedures in place for using RAS in HMA (all allow manufacturers' scrap and 11 states allow tear-off roofing shingles).

Using RAS in HMA has the potential to reduce the costs of paving due to the high quantity of oil in the shingles. By capturing the oil from the shingles, less virgin oil is needed in the HMA. However, for widespread use of RAS in HMA, engineers demand data to confirm that the use of RAS in HMA has no negative impact on roadway performance. A rigorous paving demonstration in King County, Wash., is showing the potential for widespread use of this recycled material.

Certainty is high

In fall 2009, a 2-mile-long stretch of roadway in south King County was overlaid with a 2-in.-thick layer of HMA, incorporating both RAP and RAS derived from tear-off roofing shingles in designated test sections.

Road engineers have been closely monitoring the roadway's performance and are seeing good results. The project is a collaboration of King County Solid Waste Division's LinkUp program, the King County Road Services Division (KCRSD), the Washington State Department of Transportation (WSDOT) and Seattle Public Utilities. An advisory group of representatives from across the industry was brought together to provide input and help guide the project.

The goal of King County's paving demonstration is to show—with a high degree of certainty—that the addition of RAS to HMA has no significant negative impact on pavement performance. The paving demonstration was the first in the state to use RAS in HMA to pave a public roadway in a controlled experiment.

"We are pleased to report that, one year later, the pavement is performing as good as a traditional roadway," said Paulette Norman, KCRSD acting director. "This is an innovative approach that can help cut paving costs for taxpayers while keeping a valuable resource out of landfills. We are thrilled to see it performing well."

The positive results from a road-paving demonstration bodes well for the future recycling of some 40,000 tons of tear-off roofing shingles generated in King County annually.

"This is exciting because it creates a new use for a material that has traditionally gone to landfills," said Kevin Kiernan, division director of the King County Solid Waste Division. "Recycling asphalt shingles not only benefits the environment, but can have a positive economic impact as well."

The most recent development is that WSDOT—which was closely involved in King County's paving demonstration—is now working with the paving industry to outline requirements and next steps for a permissive specification to allow increased RAP and RAS in the design, production and acceptance of HMA in Washington state, with a goal to allow RAS in the 2011 paving season.

"This project is important to the paving industry in our state," said Tom Gaetz with the Washington Asphalt Paving Association. "Our members are excited and ready to provide HMA with shingles to private- and public-sector customers."

A touch of shingles

To implement the paving demonstration, LinkUp and its project partners worked with a team of stakeholders to address the interests of key market players, ground the study in reality and provide technical and other resource contributions. An advisory group was assembled to provide technical input and to ensure that the demonstration captured objective engineering data needed to gain wide acceptance of results. KCRSD played a leadership role by dedicating a roadway in King County for the demonstration, conducting pre- and post-construction testing and managing the paving contract. WSDOT provided valuable expertise and laboratory services related to the development of specifications and led the HMA mix design and testing. Advisory group members included regulatory agencies, HMA producers, recyclers, roofing contractors and local transportation agencies.

Selecting the right roadway helped lay a foundation for a successful demonstration. KCRSD selected a 2-mile stretch of roadway to be paved with 4,000 tons of 2-in.-thick overlay, offering the right mix of HMA tonnage requirements and traffic volumes, as well as manageable surface and subsurface conditions. Based on extensive evaluation of pre-construction roadway conditions, KCRSD designed the study with four HMA test sections: two experimental sections containing 3% RAS and 15% RAP, and two control sections containing only 15% RAP, as illustrated in Table 1.

Designing the technical standards involved developing specifications for the RAS product and the RAS-modified HMA mix.

The RAS specification included requirements for allowable materials, gradation, extraneous materials, moisture and asbestos-containing materials (ACM), as well as health, safety and other environmental requirements associated with handling asphalt shingles. The shingles recycler was required to inspect incoming loads of shingles, sort and remove all nonshingle materials and sample and test the shingles stockpile to verify that the material was free from ACM. While the risk of finding asbestos in asphalt shingles is low to none, other roofing products such as built-up roofing and mastics are known to contain asbestos, so they were not allowed.

After paving installation, a series of tests were conducted to evaluate pavement performance. Extensive initial materials-engineering tests indicate that using RAS as a part of the HMA mix has had no negative effect on pavement performance.

The HMA mix design specified the amounts of RAS and RAP, as well as the estimated amount of virgin binder replacement from the RAS. The inclusion of RAP was not initially part of the study but because King County roads are traditionally paved with an average of 15% RAP, stakeholders strongly recommended that the experimental mix design include RAP to best reflect typical asphalt mixes in production today.

Through a competitive bidding process, KCRSD awarded the paving demonstration contract to Woodworth & Co. in July 2009. Woodworth is an HMA producer and paving contractor.

More stock in the pile

Woodworth proposed using an existing RAS stockpile (ground product) for the demonstration. While the RAS specification called for specific quality assurance and quality control procedures for incoming whole shingles, King County agreed to consider the proposed stockpile provided that the material met asbestos and material engineering standards. Initial testing of 20 samples of the ground stockpile using the standard polarized light microscopy test for ACM came back nondetect for all 20 samples.

King County also tested five additional samples using transmission electron microscopy, a more sensitive test for asbestos, which detected ACM in low levels. King County worked closely with its asbestos-accredited laboratory and a consultant with extensive experience as a roofer and accredited asbestos inspector to understand the test findings. Given the low level of ACM by weight in the samples, the expert consensus was that the ACM most likely came from nonshingle material.

The team decided that more aggressive inspection and sorting of incoming material was needed to identify and remove any potential ACM. Using a revised protocol and on-site training, the crew at Woodworth's facility hand-sorted and rejected any potential ACM roofing materials from new incoming roofing material. Of the few nonshingle items sorted out of the whole shingle stockpile, two types of ACM roofing materials were identified through testing: builtup roofing with an aluminum coating and a patching material found on a few of the shingles. Within several days, a new RAS stockpile was produced, tested and accepted for processing.

Looking at fines

Materials engineering testing of the RAS product after processing indicated that the RAS product met the extraneous materials limit of the RAS specification, but did not meet the gradation and moisture content requirements by relatively small margins. Table 2 summarizes key engineering properties of the finished RAS product. Even though the materials exceeded the gradation and moisture limits, the KCRSD determined that the RAS product substantially met the engineering intent for the paving demonstration. This decision was in part based on the facts that Woodworth's process included further reducing the material in size when blended with RAP and that excessive moisture content was manageable given consistent readings.

Additional testing was conducted on the HMA mix during production and pavement construction. Testing verified that all but one of the four test sections substantially met project specifications and materials standards. The test section in question was the first RAS-modified HMA mix, where higher oil and fines content led to significantly low air voids in the job mix. In-place density tests further verified air void loss. These results were below the WSDOT acceptance tolerance for air voids for field-produced HMA. However, the pavement looked perfect at lay down and initially performed as expected.

Additionally, WSDOT's HMA mix design was slightly over-engineered in that it was for a roadway with more traffic than what is typical for the demonstration roadway. Thus, the engineering team decided to leave the questionable test section pavement in place but to modify the HMA to reduce the virgin asphalt content and fines for the second RAS-modified test section, which proved successful.

The high oil content in the first RAS-modified HMA mix indicated that the RAS product introduced into the HMA mix contributed a greater amount of asphalt binder to the final HMA product than originally expected.

Table 1. Test Section Layout

	Test Section #1	Test Section #2	Test Section #3	Test Section #4
1000 tons/day	½ mile	½ mile	½ mile	½ mile
Lane 1 (eastbound)	HMA Mix with 15% RAP	HMA Mix with 3% RAS and 15% RAP	HMA Mix with 3% RAS and 15% RAP	HMA Mix with 15% RAP
Lane 2 (westbound)	HMA Mix with 15% RAP	HMA Mix with 3% RAS and 15% RAP	HMA Mix with 3% RAS and 15% RAP	HMA Mix with 15% RAP

Table 2. Final RAS Stockpile Test Results

Test procedure	Requirement	Lab Sample KC-09-1122	Lab Sample KC-09-1123	Lab Sample KC-09-1124
Gradation, ½-inch sieve	100% Passing	99%	98%	98%
Gradation, ⅜-inch sieve	95% Minimum. Passing	94%	92%	93%
Lighter Extraneous Material	1.5% Maximum	0.06%	0.01%	0.03%
Total Extraneous Material	3.0% Maximum	0.06%	0.01%	0.03%
Moisture Content	5.0% Maximum	10.0%	9.3%	10.8%

Both Woodworth and WSDOT staff hypothesize that double grinding RAS to meet gradation requirements resulted in smaller particle sizes and may have enabled more of the RAS binder to be released and effectively utilized in the HMA than originally predicted. Future research and analysis is recommended to confirm this hypothesis.

Meeting King's demands

After paving installation, a series of tests were conducted to evaluate pavement performance. Extensive initial materials-engineering tests on the demonstration pavement indicate that using RAS as a part of the HMA mix has had no negative effect on pavement performance. Initial post-construction testing for deterioration, skid resistance, roughness, structural condition and rutting all indicated that all test sections of the roadway were meeting performance standards. To assess the condition of the roadway, the King County Materials Laboratory performed pavement-condition surveys by walking the site and documenting distressed areas.

Additional pavement condition surveys were conducted by WSDOT using a distress data collection van. The surveys revealed the roadway surface in all test sections continued to appear in excellent condition. The minor amounts of wear and tear shown are consistent with the expected performance of a road paved with traditional HMA. These tests were repeated one year after construction, yielding positive results, and are currently planned to continue annually through 2012.

Just as significant as these empirical engineering test results, the paving demonstration illustrated the critical importance of a multiparty partnership approach to such research and development efforts. Successful implementation of the paving demonstration was a direct result of the productive input and engagement of KCRSD, WSDOT, Woodworth and stakeholders.

LinkUp is continuing to coordinate with other regional and national efforts to further the use of RAS in HMA and is planning to incorporate pavement with RAS in its own projects, including the rebuilding of several solid-waste transfer stations. LinkUp also will support WSDOT and the paving industry through the development of a permissive specification in Washington state for using RAS in HMA. Part of this effort will involve closer coordination with regulators, roofing contractors and shingle recyclers on best practices for sourcing and testing of tear-off roofing asphalt shingles for processing.

For additional details on King County's Shingle in Paving Demonstration, visit the asphalt shingles pages at www.kingcounty.gov/linkup. **R&B**

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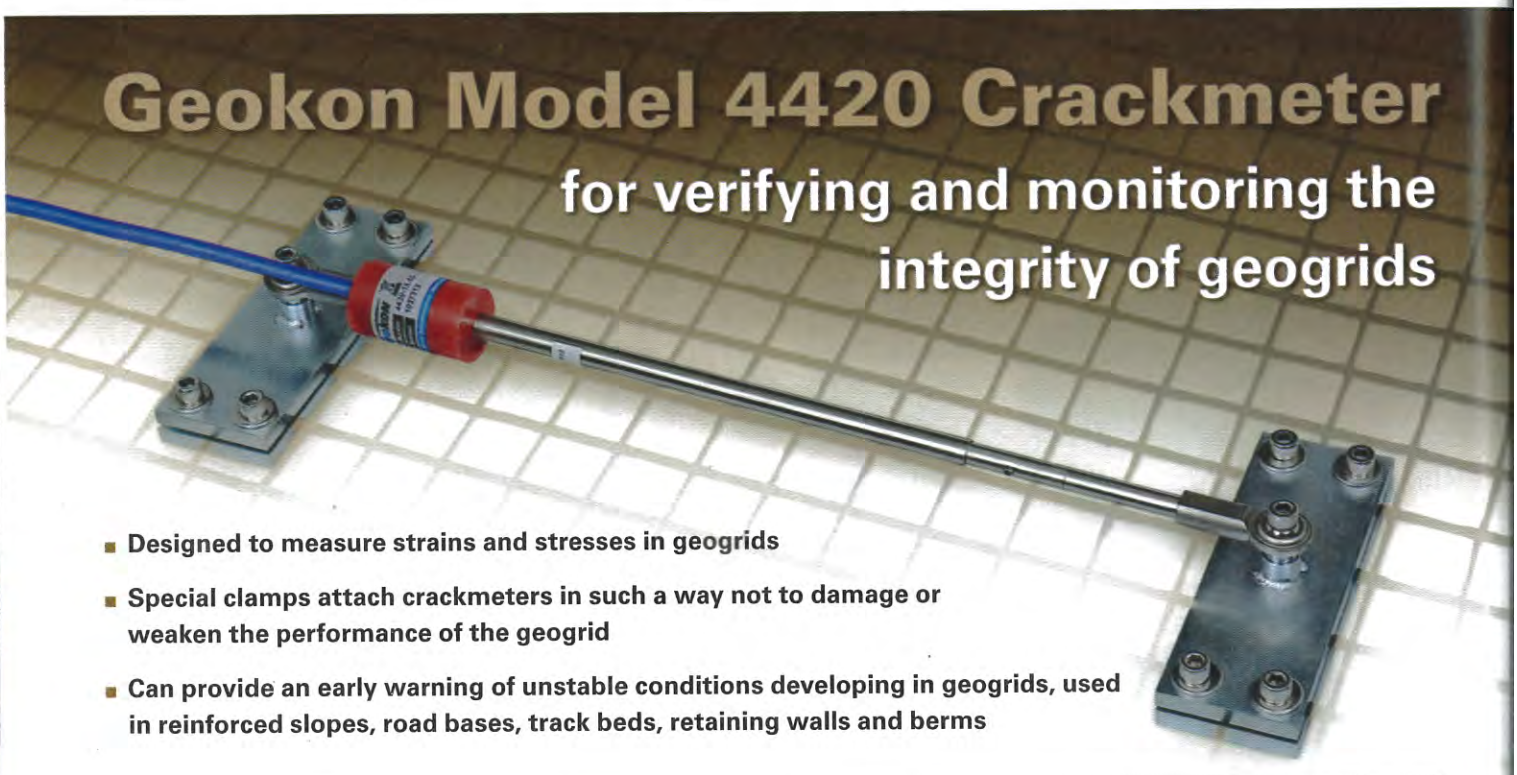
For more information about this topic, check out the Asphalt Zone at www.roadsbridges.com.



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