

I. Research Project Title: Minimum Virgin Binder Limits in Recycled Superpave (SR) Mixes in Kansas

II. Problem Statement: The Kansas Department of Transportation (KDOT) is increasingly allowing recycled materials in Superpave hot-mix asphalt (HMA) mixtures. As materials and construction costs continue to rise, there is a strong interest by both KDOT and paving industry to develop ways to include more recycled materials in asphalt pavements. The two recycled materials that have received the most attention are recycled asphalt pavement (RAP) and recycled asphalt shingles (RAS). The latter seemed to contribute a lot of binder although that binder is highly aged. There have some concern that as the percentages of these recycled materials are increasing, there is a tendency in the industry to use lesser and lesser amounts of virgin binder. Again, instead of developing separate specifications for RAP and RAS, it will be beneficial if a universal specification can be developed for all recycled materials that contribute binder to a SR-type mixture. Such specification must consider the effects of recycled materials on the binder as well as on the mixture. For example, KSU has been doing rut testing on the samples from high RAP content projects using the Hamburg Wheel Tracking Device (HWTM). In general, the HWTM results for a non-RAP mixture are very consistent. However, results with higher RAP percentages are quite variable. Table 1 shows an example from two projects. With only 24% RAP, the consecutive lots show completely different results. Another mix with 35% RAP performed much better than the mix with only 24% RAP. This trend is also evident for other high-RAP mixtures evaluated at KSU. The variability in the RAP is being thought to be responsible for the variability of performance of the high-RAP mixtures including early cracking. The results with the fractionated RAP are also not very encouraging. It is also to be noted that RAP that now would be produced now would be different from previous generations because of recycling Superpave pavements that have better aggregates and binder. These RAP sources are expected to less variable and highly valuable. Thus careful planning and implementation of various recycled materials would help KDOT achieve its economic and sustainability goals.

Table 1 Summary of the Hamburg Wheel Test Results of RAP Mixes of SR-12.5A

Mix No./Lot	RAP (%)	Average Number of Passes	Average Rut Depth (mm)
1/LOT-6A	24	16,070	11.20
1/LOT-6C	24	20,000*	19.38
2/LOT-1D	35	20,000*	3.36

* reached maximum number of passes

Another major factor that is not fully clear is the level of interaction between aged and virgin asphalt binders. If RAP or RAS acts like a black rock, the aged and virgin binders may not interact. In that case, RAP would not significantly change the virgin binder properties and a blending chart is not necessary. However, current KDOT specifications assume that RAP or RAS does not act as a black rock and that the aged asphalt blends with the virgin binder during mixing. Thus the amount of virgin asphalt binder can be reduced by the full amount of asphalt binder in the RAP for the percentage specified. The effect of this assumption on mixture performance in Superpave pavements has not been fully established.

III. Research Proposed: The specific objectives of this research project will be to investigate various sources and amounts of recycled binder from Recycled Asphalt Pavement (RAP) and Recycled Asphalt Shingles (RAS) to establish limits for these recycled materials based on mixture performance. In other words, the project will assess the effect of varying virgin binder contents on SR mixes irrespective of recycled binder source. It will be assumed that the blending chart developed by KDOT is still valid. If needed and requested by KDOT, the blending chart will be revisited. The following tasks need to be accomplished to fulfill objectives of this study (Kansas State University will be responsible for accomplishing all tasks).

Task 1: Evaluate current KDOT specifications for designing SR mixtures with RAP and RAS. Also, review specifications from other states regarding use of RAP and RAS in Superpave mixtures.

Task 2: Select/Design SR mixtures to be studied in this project in consultation with the KDOT monitor.

Task 3: Conduct dynamic modulus, flow number, and fatigue tests using AMPT on selected specimens prepared with the mixture designs in Task 2

Task 4: Conduct Hamburg Wheel and KT-56 tests for evaluating moisture susceptibility of mixtures designed in Task 2

Task 5: Correlate the effect asphalt content and/or VMA with other mixture properties. Identify the absolute minimum value of the virgin binder content.

Task 6: Develop a draft specification that use the limits for recycled materials based on absolute minimum virgin binder percentages in the mix.

Task 7: Write the final report.

IV. Estimate of Funding and Research Period:

Estimated project duration: 18 months (start: May 2011)

Estimated budget: \$72,000

V. Urgency and Payoff Potential: The research should have a high priority. With higher binder prices and in a lean economic environment, extending lives of HMA overlays and pavement should save KDOT millions of dollars. The research results will also help KDOT to do less maintenance and rehabilitation thereby achieving its sustainability goals.

VI. Implementation Strategy: Implementation of this study is expected to be carried out by the Bureau of Materials & Research.

VII. Project Personnel: This project will be carried out under the direction of **Mustaque Hossain**, Principal Investigator in close cooperation with the Bureau of Materials & Research. **Mr. Lon Ingram** will work as a consultant to this project. One graduate students and one undergraduate student in civil engineering will also work on this project.

Mustaque Hossain is a professor of Civil Engineering at Kansas State University. His areas of expertise are pavement materials, pavement design, performance, management and non-destructive evaluation using Falling Weight Deflectometer (FWD). **Lon Ingram** retired as the Acting Director of the Division of Operation of KDOT. He has many years of experience with Superpave HMA and specifications in Kansas.

VIII. Submission Information:

November 23, 2011

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