Appropriate Use of RAP Based on Field Performance:
Project Summary – August 2010

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http://www.mrr.dot.state.mn.us/research/pdf/200915.pdf

Introduction
This study was developed to investigate the perception that asphalt pavements containing Recycled Asphalt Pavement (RAP) may be prone to early failures. The work plan included a survey of local agencies, field performance observations of new bituminous and bituminous overlay construction, and laboratory testing. It was found that in Minnesota the most commonly used asphalt binders were performance grades PG 58-28 and PG 58-34. These were used with or without RAP in the mixture design. It was also found that mixtures most commonly included recycled pavement at levels of 20 to 30 percent.

Local engineers regarded cracking, rutting, and construction issues as most important with respect to using recycled asphalt pavement in asphalt mixtures. Roughly one-third of the Minnesota agencies using RAP exclude or restrict its use in wear course mixtures. In a survey, 29% of all respondents reported they had not observed early failures of HMA in general.

Some respondents were concerned that wearing course mixtures with RAP could potentially become dry or brittle, and therefore exclude or restrict the percentage of RAP allowed in the wear course.

Case Studies
Several construction projects were identified for early performance monitoring. The projects included construction of four new bituminous pavements. Early performance issues were apparent on one of the projects, where a design combining PG 64-34 asphalt binder and 30 percent RAP could not prevent extensive reflective cracking during the first winter of service. A second project included a design using PG 58-28 and PG 58-34 binders and no recycled material. Reflective cracking also occurred on that project, but at a gradual rate over a period of years. Monitoring results showed that PG 58-34 performed better than the PG 58-28 during the early period of service.

The four projects were placed over reclaimed base or reconstructed base courses. RAP percentages were maintained between wear and non-wear courses. One pair of

![Graph showing asphalt binder PG's used in Minnesota.]

![Diagram of project summary graph showing number responses for wear course, non-wear course, and both.]

Minnesota's use of RAP in pavement construction.
reconstructed projects from northern Minnesota used RAP from the same source while the mixture varied by RAP percentage and asphalt binder grade. That pair showed significantly different early performance as the 30 percent RAP plus PG 58-28 design developed extensive transverse cracking during the first winter of service, and the 20 percent RAP plus PG 58-34 did not develop early transverse cracks. Observations of the surface performance of this pair found popouts and spalling, especially the road with early cracking.

The second pair of reconstructions from southern Minnesota designs with PG 58-34 binder plus either zero or 20 percent RAP. In this case the contractor RAP stockpile was the source of recycled material. This pair showed good performance during the first year, and only several cracks in the RAP section during the second winter of service.

**Testing and Evaluation Program**

Roadway cores were obtained from the field monitoring sites, and the new constructions were selected for laboratory evaluations. Laboratory testing included aggregate gradation, asphalt content and grade, specific gravity, and dynamic modulus. A method was developed to fabricate dynamic modulus specimens from wear and non-wear components of field cores.

Aggregate gradations of all mixtures except one wear course were generally finer than a theoretical 12.5 mm (0.5 in.) maximum density, and testing showed that the asphalt binders generally met high and low-temperature PG standards.

Dynamic modulus $|E^*|$ data obtained at 14 ° F showed that the stiffest performance occurred in the southern Minnesota 20 percent RAP and the northern Minnesota 30 percent RAP mixtures. Analysis of mixture master curves showed that wear and non-wear course mixtures performed essentially the same and that curves from full-depth specimens were more useful for relating field performance to dynamic modulus.

A statistical analysis of field performance versus test results and mixture characteristics showed that stronger relationships existed for low-temperature PG and the percentage of new asphalt binder in the mixture than to the percentage of RAP in the mixture. Field performance related well to mixture master curves in the middle portion of the test frequency range. The strength of the relationship decreased as frequency increased.

**Conclusions**

The project survey showed that some practitioners had concerns regarding use of RAP in the wear course, and some agencies restrict use to the non-wear course. It is strongly recommended that agencies review their policy to include RAP in the wear course for the following reasons:

- Based on the laboratory test results and field observations, all of the mixtures performed acceptably in terms of rutting resistance.
- Asphalt high temperature PG’s indicate the contribution of rut resistance provided by the binder. This particular data set possessed similar high temperature PG’s, and no strong relationship resulted between high temperature PG and percent RAP. However, RAP material can often have elevated high temperature PG’s that could beneficially contribute stiffness during conditions when mixtures are prone to rutting.
- Results from this study found only a moderate relationship between the percent of RAP in the mix and the onset of early thermal cracking.
- The low-temperature grade of the binders and percentage of new binders used in this study were strongly related to early performance. This reinforces the concept that it is possible to address concerns about low-temperature performance during the mixture design phase, whether or not the design includes RAP.

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