Recycled Asphalt Pavement: MnROAD Study of RAP and Fractionated RAP

Project Summary – January 2013

Acknowledgments

This research was funded by the Minnesota Local Road Research Board and the Federal Highway Administration. The complete final report is available at the following link: http://www.dot.state.mn.us/research/TS/2012/201239.pdf

Introduction

This project evaluated the field and laboratory performance of Recycled Asphalt Pavement (RAP) and Fractionated Recycled Asphalt Pavement (FRAP) test cells at the Minnesota Road Research Project (MnROAD) between 2008 and 2012. Project scope included: developing specifications, construction of FRAP and RAP test cells at MnROAD, field performance evaluations, and laboratory testing of binders and mixtures on 11 test cells.

Mixture Designs and Study Cells

MnROAD is operated by MnDOT, and consists of an interstate mainline road segment along Interstate 94, and a closed-loop low volume test road. During 2008 three FRAP and eight RAP test cells were constructed. Ten of the 500-ft test cells were constructed on the interstate portion of MnROAD. Test cells and experimental variables are presented in the following table.

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<th>Bituminous Mixtures and Experimental Variables</th>
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The source of all RAP material was the original MnROAD asphalt surface that was constructed in 1993. FRAP was produced by splitting RAP on the ¼-in. screen, and was treated as two separate recycled products during design and plant mixing. An example of the fractionated material is shown in the following figure.

Fine and coarse RAP fractions.

The designs performed by the paving contractor were based on MnDOT’s 2008 Specifications for 3 to < 10 million ESAL traffic. All mixtures had a maximum aggregate size of ¾-in. (19.0 mm), and a nominal maximum aggregate size of ½-in. (12.5 mm). HMA and WMA designations denote Hot Mix Asphalt and Evotherm 3G Warm Mix Asphalt. Wear course mixtures had target air voids of 4.0% and non-wear mixtures had a target air voids content of 3.0%.

Testing and Evaluation Program

MnDOT and several academic institutions performed a variety of material tests. Binder and mixture laboratory evaluations of MnROAD’s RAP and FRAP included:

- Dynamic Shear Rheometer (DSR)
- Bending Beam Rheometer (BBR)
- Direct Tension Test (DT)
- Double-Edge Notched Tension Test (DENT)
- Indirect Tension Test (IDT)
- Semi-Circular Bend Test (SCB)
- Dynamic Modulus (\(|E^*|\))
The following figure shows SCB Fracture Energy trend was influenced by recycle percentage; predicting that cracking initiates at higher temperatures for these higher RAP mixtures.

Fracture Energy of MnROAD mixtures at 0, 20, and 30% RAP.

MnROAD staff performed field inspections and evaluations of performance at regular intervals. Field evaluations of pavement performance included:

- Distress Surveys (LTTP Method)
- Ride (IRI)
- Rutting (ALPS)
- Pavement Deflection (FWD)
- Noise (OBSI)
- Friction (FN40)

Cracking distresses for non-overlay test cells were similar, indicating RAP percentage and fractionation did not greatly influence low temperature performance after four years of service.

- 46% of the total underlying transverse cracks reflected through the Cell 15 warm mix overlay.
- Cell 20 and 21 (HMA+30% RAP) developed 2 transverse cracks during service year four.
- Cell 21 (HMA+30% FRAP) and Cell 23 (WMA+20% RAP) developed low severity longitudinal cracks during service year four.
- None of the other cells exhibited signs of cracking distress.

Ride performance was influenced more by seasonal variation and base material type than by mix type and recycle percentage. Cells with similar construction had similar IRI deterioration rates. Ride decay in the recycled unbound base and FRAP/low temperature cracking groups was very similar.

Rutting was measured, and no significant values in excess of ½-in. were measured except for Cell 18, where median and maximum statistics were equal to 0.28 and 0.64 in.

Deflection measurements showed the study cells appeared to have similar structural characteristics, and maintained their relative deflection relationships through four years.

Tire-pavement noise: Four years of data showed that measured values of tire-pavement noise output increased for all cells. All cells had somewhat lower friction characteristics than after construction. Seasonal effects were the greatest influence on sound intensity measurements, but all study cells were affected by the seasonal variations in the same way.

Conclusions

Overall, the field performance of the study cells exhibited few distresses during the initial four years of service life. The visual distresses, ride and rutting were not observed to be influenced by the experimental variables. Laboratory testing of the mixtures showed that higher RAP percentages are prone to fracture at relatively higher temperatures. Mixtures with PG 58-28 binder were stiffer than those with PG 58-34, as expected.

Additional cracking is anticipated as the pavements remain in service, and continue to be exposed to low temperature conditions.

Selected task reports for this project are posted at the following link: [www.dot.state.mn.us/mnroad/lrrb_864_rap.html](http://www.dot.state.mn.us/mnroad/lrrb_864_rap.html)

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