2023-19TS
Published June 2023

LRRB
LOCAL ROAD RESEARCH BOARD

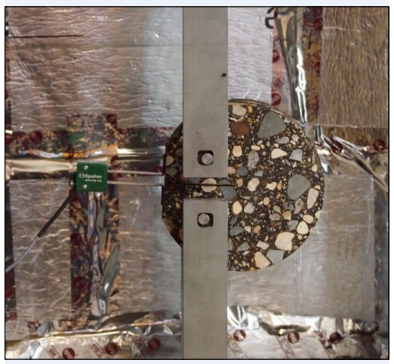
TECHNICAL SUMMARY

Questions?
Contact research.dot@state.mn.us.

Technical Liaison:
Jed Nordin, Hubbard County
Jed.Nordin@co.hubbard.mn.us

Investigator:
Mihai Marasteanu,
University of Minnesota

LRRB PROJECT COST:
$171,777



The disk-shaped compact tension test is a standard way to understand the crack resistance of asphalt.

DEPARTMENT OF TRANSPORTATION
OFFICE OF RESEARCH & INNOVATION

Comparing the Cost-Effectiveness of Asphalt Binders for Local Roads

What Was the Need?

Polymer-modified binders (PMBs) compared to unmodified asphalt binders improve the performance of asphalt pavements. Used in the U.S. for many decades, PMBs decrease rutting, fatigue cracking and low-temperature cracking, which is particularly useful in Minnesota's cold winter temperatures.

Although the initial costs of using PMBs on high-traffic roads are greater than for unmodified binders, the performance benefits are clear—longer intervals before maintenance is needed—and justify their higher costs. As a result, many local agencies already use grade C binders, which contain PMBs, in new road construction.

Whether the modified binders are cost-effective for lower volume local roads, however, is not clear. Unmodified grade B binders are generally a cheaper option, at least initially, for counties that are paving low-volume roads. On the other hand, a pavement's shorter life span and increased maintenance needs may cost more over the long term. The Local Road Research Board wanted to understand whether PMBs are worth the initial higher costs for lower volume roads.

Asphalt containing polymer-modified binders may cost more initially but perform better in the long run. Comparing performance and life cycle costs of modified and unmodified binders, researchers found modified binders are more cost-effective, even for local low-volume roads.

What Was Our Goal?

The goal of this project was to compare the cost-effectiveness of asphalt binders modified with polymer to unmodified asphalt binders used on lower volume roads.

What Did We Do?

A review of existing literature on PMBs, including laboratory testing and field observations, illustrated the material's superior performance in pavement. Researchers also reviewed previous life cycle analyses and cost-effectiveness studies to understand the methods for comparing costs and benefits of PMBs in pavement under various circumstances. Lastly, they reviewed the limited existing case studies of PMB use on low-volume roads.

MnDOT's Office of Materials and Road Research provided historical data on pavement performance using grades B (unmodified) and C (modified) binders in new construction. Analyses of ride quality index and surface rating identified the effects of polymer modifications on pavement performance.

Laboratory testing of seven samples each of grade B and C binders previously used in Minnesota demonstrated differences in strength, including stress-strain curves, and the ability to resist low-temperature cracking. Investigators then examined a variety of asphalt mixtures prepared with grade B or C binders for fracture energy to aid in predicting likely repair schedules. MnDOT provided results for 88 mixes and researchers tested eight other mixes in the laboratory.

These performance differences and estimated rehabilitation schedules were used in a life cycle cost analysis comparison of the construction costs of identically structured asphalt pavements with one using grade B binder in the top layer and the other using grade C binder. Then using MnDOT's Pavement Design Manual, which details crack treatment, milling and overlay, chip sealing and other treatments needed over a pavement's lifetime, investigators calculated the age differences when the treatments would be needed for each of the two asphalt pavements.

continued

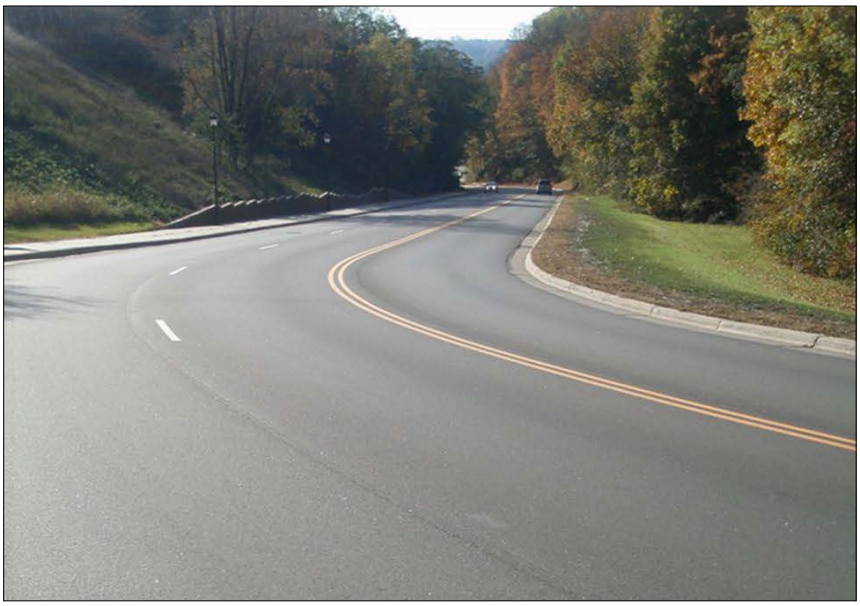
"This research confirmed the benefits of polymer-modified binders we've been hearing about. The extra costs are likely justified, even on lower traffic roads, due to the longer life cycle of a road paved with these binders."

—Jed Nordin,
Engineer/Public Works Coordinator, Hubbard County Highway Department

"In addition to confirming the superior performance of PMBs in avoiding low-temperature cracking and how that benefits Minnesota's pavement, we developed a step-by-step process for performing a life cycle cost analysis that can be applied in other contexts."

—Mihai Marasteanu,
Professor, University of Minnesota Department of Civil, Environmental and Geo-Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Office of Research & Innovation
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
651-366-3780
www.mndot.gov/research



Using PMBs in asphalt is more cost-effective than unmodified binders due to the longer life span and decreased maintenance requirements. Adding costs saved by the traveling public due to fewer road closures increases the cost-effectiveness.

What Did We Learn?

While previous research illustrated the superior performance of PMB asphalt mixtures, the few studies evaluating the cost-effectiveness for using the material on low-volume roads had mixed results.

A review of historical performance data in Minnesota was consistent with previous research and showed, in general, an improved performance of grade C binders over grade B binders in new construction. In the laboratory, researchers found grade C binders had a higher low-temperature cracking resistance than grade B binders by observing lower thermal stress, superior strength in general and a higher failure strain threshold. On average, investigators found the asphalt mixes containing grade C binders provided approximately 50% more fracture energy compared to grade B binders, which indicated a better cracking resistance at low temperatures.

The life cycle cost analysis showed that using grade C PMBs in new construction would extend pavement life by six years over pavement using grade B unmodified binders. Given the initial construction costs of each mixture, researchers estimated using grade C binders could result in a 14.4% cost savings over the pavement's life, noting that this estimate did not include road user cost savings from decreased maintenance time.

What's Next?

These study results can give local road engineers more confidence that using PMBs is likely cost-effective, even on low-volume roads. While the construction costs calculated in this project for asphalt using a PMB provide a general estimate for comparison, there are many variables and uncertainties with petroleum-based material costs. Also, an accurate benefit–cost analysis of pavement depends on accurate predictions of field performance. As more field performance data becomes available, cost comparisons will become more precise.

This Technical Summary pertains to Report 2023-19, "Cost Estimate of B vs. C Grade Asphalt Binders," published May 2023. More information is available at mdl.mndot.gov.