RESEARCH SUMMARY

OCTOBER 2023

Adapting Asphalt Mixtures for Tougher Rural Roads

Seasonal and daily temperature variations, freeze-thaw cycles and other environmental factors lead to pavement distress on low-volume rural roads. Modifying asphalt mixtures could improve pavement resistance to these environmentally driven distresses. A comparison of the mechanical properties and performances of selected asphalt mixtures identified a mixture and method that hold considerable promise for improving performance and longevity on low-volume roads.

What Was the Need?

Minnesota's temperature extremes impact the performance and longevity of rural roads. Freeze-thaw cycles occurring over days or weeks test the durability of these low-volume roads, which on average carry fewer than 400 vehicles per day. When water penetrates and expands in distressed asphalt pavement, cracks and potholes can form that shorten the road's life and affect the driving experience.

With the advent of new and improved techniques, asphalt pavement design and construction can be adjusted for these environmental conditions. Past research has focused on structural design procedures for improving low-volume road performance but not the asphalt mixtures used to build these roads. Selection of the right asphalt mixture can improve the service life of low-volume roads and mean safety and financial benefits for all residents.

The Local Road Research Board was interested in exploring the properties of asphalt mixtures that minimize environmentally driven distresses and in developing guidelines for designing asphalt mixtures that would optimize their performance for the state's rural conditions.

"These results offer promising indications that improvements in asphalt mixtures can have a positive effect on pavement performance for Minnesota's rural roads."

—JOEL ULRING, PAVEMENT PRESERVATION ENGINEER, MnDOT OFFICE OF MATERIALS AND ROAD RESEARCH

What Did We Do?

In the initial phase of the study, researchers reviewed existing literature to understand which factors affect the asphalt's performance over time in low-volume roads. They also explored the state's current mixture design practices and those of other cold climate states. Through an online survey, representatives from Minnesota transportation agencies identified the most common forms of damage on state rural roads.

Then asphalt cores were collected from 34 road sections in 10 Minnesota counties. Among other characteristics, data recorded from these samples measured road densification, which is the compression of asphalt over time due to repeated vehicle loads. The types of stresses observed in these samples led to the development of cracks, wheel ruts and potholes.

Seven asphalt mixes were tested in the laboratory to identify those with superior performance. Stress tests for fracture toughness and resilience measured the mechanical properties of each across different temperatures, assessing the likelihood of the damage previously observed. The asphalt mix candidate with the strongest results in the performance tests was studied further using samples from other field projects in the state to evaluate its characteristics.

What Did We Learn?

The research results emphasize the importance of comparing both laboratory and fieldwork testing to evaluate asphalt performance in different settings. The longevity of high-volume roads is affected by stressors from vehicle use of the roads, measured as wheel load repetitions or vehicles per day. In designing asphalt mixtures for these busier roads, engineers account for the densification that occurs with repeated use, and over time the asphalt performs as designed in the laboratory. Although busy roads face their own challenges due to the densification from high vehicle volume, they experience less of the damage that is more common in rural roads.

By contrast, the asphalt cores taken from the rural roads confirmed that the lower vehicle frequency resulted in less compression of the pavement, preventing it from reaching the intended densification designed in the laboratory tests. This densification is needed to prevent water incursion and expansion since it shrinks or eliminates air pockets (air voids), which reduces the cracking and other damage in the asphalt caused by freeze-thaw cycles.

With the specific challenges of low-volume roads in mind, researchers recorded the mechanical properties of the seven different asphalt mixtures studied in the laboratory, which demonstrated the superior performance of Superpave 5. In addition, they examined the other asphalt design factors that may improve pavement performance, such as varying different components of the asphalt mixture and implementing different techniques for compacting the asphalt to achieve the desired amount of air voids. The final assessment of the Superpave 5 field mix samples compared them to those produced in the laboratory, confirming the superior performance of the mix in mechanical testing.

What's Next?

The results of the study indicated that using the Superpave 5 mixture in low-volume roads could potentially improve asphalt performance and may also offer benefits for other road types in Minnesota. Further collaboration with state and county engineers will create opportunities for employing the guidelines for improved asphalt mixes in upcoming projects.

About This Project

REPORT 2023-34
"Optimizing Asphalt Mixtures for Low-Volume Roads in Minnesota." Find it at mdl.mndot.gov.

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