2015-48TS
Published May 2016

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OFFICE OF TRANSPORTATION SYSTEM MANAGEMENT

TECHNICAL SUMMARY

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PROJECT COST:
$130,000

To measure noise from tire-pavement interaction, researchers used onboard sound intensity testing in which microphones are mounted near the interface of tire and pavement.

Improving Pavement Performance by Optimizing Concrete Surface Features

What Was the Need?

After the placement of concrete pavements, MnDOT and other agencies texture the surfaces to ensure that they have sufficient friction and skid resistance. Most textures are created by dragging various materials across the fresh concrete to create asperities before it completely hardens.

Optimizing concrete pavement surface characteristics can help to reduce noise levels while ensuring ride quality, skid resistance and durability.

Texture characteristics, such as the width, wavelength, orientation and direction, affect not only friction but also the pavement's ride quality, durability and level of noise generated from tire-pavement interactions. Optimizing texture properties is an important priority for transportation agencies for both safety and economic reasons. Greater skid resistance means safer roads, fewer crashes and reduced loss of life and property. Significant reductions in tire-pavement noise could save up to $3 million per mile if sound barriers were not needed. Appropriate pavement textures can also reduce the long-term costs for repair, rehabilitation and reconstruction.

What Was Our Goal?

The objective of this study was to evaluate how new concrete surfaces performed over time with respect to friction, noise, texture, faulting and smoothness.

What Did We Do?

From 2008 to 2014, MnDOT conducted a series of experiments at the MnROAD pavement research facility to evaluate the effects of various concrete pavement surface characteristics on pavement performance. MnROAD contains more than 50 500-foot test cells on two roadway segments. Most of the test sections for this study were constructed at MnROAD in 2008, 2010 and 2011 after the original 1993 construction with transverse tined texturing. Researchers evaluated various concrete surface textures, including:

- The transverse tine, produced by dragging a metal rake laterally across a concrete surface before it has fully cured.
- The longitudinal tine, which is like the transverse tine but textured in the direction of traffic.
- The turf drag and broom drag. Because the transverse tine can cause a significant amount of tire-pavement contact noise, in 1998 MnDOT began to use the turf drag, a method that involves dragging an inverted strip of carpet over the pavement surface, resulting in a finer texture that produces significantly less noise. Dragging a specified broom also achieves a similar effect.
- Pervious concrete pavements, which are highly porous mix designs that don't need additional texturing. They reduce runoff by allowing water to flow vertically through the pavement.
- An exposed aggregate concrete surface, in which a surface retardant is aggressively applied to the pavement surface followed by removal of loose paste.
- Diamond grinding, a rehabilitation method that involves cutting longitudinal grooves into the pavement surface using closely spaced, diamond-tipped saws and spacers.

In addition to the evaluation of these textures, researchers conducted a cost-benefit analysis of quiet pavements; developed models showing how skid resistance changes over time for both smooth and ribbed tires as concrete textures degrade; analyzed the

continued

"We found that the mechanism of noise reduction through air compression relief and tire tread block impact reduction exceeds that of noise reduction through pavement sound absorption. That explains why certain nonpervious pavements are as quiet as and even quieter than pervious pavements."

—Dr. Bernard Izevbekhai,
Concrete Research Operations Engineer, MnDOT Office of Materials and Road Research

"This project showed that MnDOT can successfully build new concrete roads that are safe and quiet, and as pavements age, have rehabilitation options to maintain that high standard."

—Ben Worel,
Acting Road Research Manager, MnDOT Office of Materials and Road Research

Produced by CTC & Associates for:
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Turf drag is the texture most commonly used by MnDOT for concrete pavement surfaces because it provides good skid resistance while causing less noise than other textures.

performance of pavement surface characteristics over time, including the effects of texture direction and orientation on performance; and examined the accuracy of various laser types for measuring pavement smoothness.

What Did We Learn?

This project provided useful information on concrete pavement surface characteristics that will help improve MnDOT's infrastructure planning. Results show that:

- It is possible to produce cost-effective, quiet concrete pavements, and most texture types can be optimized to perform with good friction and low noise by adjusting their configurations.
- Pavement performance after initial loss of texture depends on both mix design and texture configuration. Increased joint deterioration, faulting, and warp or curl result in an increase in pavement roughness and a corresponding increase in tire-pavement noise.
- Noise reduction is achieved in both porous and nonporous concrete pavements more by reducing tire tread block impact and air compression than by pavement sound absorption. Consequently, certain nonporous concretes are likely to be quieter than porous concretes.
- Texture direction and texture orientation were found to influence surface characteristics. While they did not significantly affect roughness, they had a significant effect on noise levels.

What's Next?

MnDOT is evaluating the implementation of these results in both new construction and rehabilitation to provide a safe and quiet pavement surface. Researchers recommend that in addition to current use of the longitudinal turf drag, MnDOT may also see occasional benefit in using drag as a pretexture followed by texturing with the longitudinal tine. The pretextured longitudinal tine appears to provide more friction and texture durability than drag textures in current MnDOT specifications. For preventive maintenance, it may be beneficial to use diamond grinding in the 10th year of a 60-year design, which would shift the first rehabilitation from the 17th year to the 22nd year. This will improve overall concrete pavement performance and reliability. Researchers also recommend investigating the use of acoustic signals to monitor joint conditions in concrete pavements.

This Technical Summary pertains to Report 2015-48, "Pavement Surface Characteristics Concrete New Construction (MnROAD Study)," published February 2016. The full report can be accessed at mndot.gov/research/TS/2015/201548.pdf.