



## TECHNICAL SUMMARY

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### LRRB PROJECT COST:

\$225,000



Ontario Ministry of Transportation

One of the several ways in which researchers evaluated friction was measuring the force on a locked wheel as its tire skid across the pavement.



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# Optimizing Asphalt Pavement Surfaces to be Safer, Quieter, Longer Lasting

## What Was the Need?

In designing pavements, engineers try to optimize surface characteristics such as skid resistance and tire-pavement noise while maintaining durability. Fully accomplishing this would require a more detailed knowledge of the ways in which automobile tires interact with pavement surfaces. The need is especially great in Minnesota, as MnDOT begins to use innovative hot-mix asphalt (HMA) designs.

## What Was Our Goal?

The goal of this research was to determine the relationship between asphalt mixture properties and various pavement surface characteristics so that pavements can be designed for optimum durability, safety and quietness.

## What Did We Do?

Researchers constructed test cells using various asphalt mixtures at the MnROAD pavement research facility and monitored them from 2008 to 2012 for friction, ride quality, texture, sound absorption, tire-pavement noise and distress. Then they analyzed the results to determine the relationship between these surface characteristics and asphalt mixture properties.

Mixtures varied according to their gradation, type of binder and the use of recycled asphalt pavement (RAP). Gradation is a measure of the range of particle sizes within mixtures. Gap graded mixtures have few particles of intermediate sizes; dense graded mixtures are relatively impermeable and classified as coarse or fine, depending on particle sizes; and open graded mixtures have few smaller particles, making them more permeable to water. Most of the mixtures used the Superpave method of design, in which they are tailored to expected traffic by being compacted to different levels.

Pavement surface types included:

- Two cells with an ultra-thin bonded wearing course (UTBWC), a thin, gap graded layer of a heavy polymer-modified asphalt applied with a spray paver over 2 inches of Superpave and a 6-inch base constructed using full depth reclamation in which an existing pavement is pulverized and recompact.
- Four Superpave cells with varying thicknesses and binders. One cell used no RAP; another used 20 percent RAP and warm mix asphalt, a technology in which asphalt binder is mixed with aggregate at lower temperatures; and a third cell used 30 percent RAP. These three cells were densely graded, while a fourth cell used a 4.75 mm Superpave mix layer composed of taconite aggregate, a by-product of iron mining, constructed over a new concrete pavement.
- One cell with HMA and 20 percent RAP as a control to the warm mix cell; two cells with 5-inch layers of porous HMA; and one cell with a chip seal, a surface treatment in which a thin layer of asphalt and aggregate are sprayed onto the pavement.

## What Did We Learn?

Cells with porous asphalt mixtures showed a substantial amount of raveling, most likely because of construction defects, snowplow damage and wear from heavy truck traffic.

*This project will help researchers optimize pavements for durability, safety and quietness. Quieter pavements are a more economical solution than noise walls, which can cost millions of dollars per mile to construct.*

*“Quieter pavements would be a great alternative to expensive, cumbersome noise walls.”*

—**Greg Johnson,**  
Assistant Bituminous  
Engineer, MnDOT  
Bituminous Engineering  
Unit

*“Pavements have always had the requirement of being safe and durable. This study is a step toward meeting the public’s expectation that pavements also be quiet and environmentally friendly.”*

—**Bernard Izevbekhai,**  
Concrete Research  
Operations Engineer,  
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Materials and Road  
Research

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Porous pavements had the lowest tire-pavement noise, greatest sound absorption and similar friction values to other surfaces. However, they were also the roughest and had the greatest rut depths.

They also had the greatest rut depths, while the taconite mixture showed the lowest rut depths, closely followed by some of the dense graded mixtures.

UTBWC surfaces were the smoothest over time, while porous surfaces were roughest. Open graded surfaces—porous asphalt, chip seal and UTBWC—had the highest mean profile depth, a measure of the variability of the height of texture peaks on a pavement surface, while the taconite mixture had the lowest.

Friction was generally very good for test cells. Ribbed tires had significantly higher friction than smooth tires on dense graded asphalt surfaces, but had similar values on more open surfaces, with the smooth tire often having better friction. In general, the outside lane had a higher friction number than the inside lane, illustrating the effect of traffic on friction. UTBWC and taconite surfaces had the highest friction, while the dense graded Superpave surfaces had approximately the same friction.

For noise, the porous asphalt surfaces were the quietest, while the chip seal and some of the dense graded asphalt mixtures were the loudest. Porous asphalt surfaces absorbed sound more than other surfaces, with UTBWC sound absorption a distant second, followed by extremely low absorption for dense graded mixtures and the lowest for taconite.

The results of data analysis showed that ambient temperature affects noise measurements with even greater severity for asphalt pavements than for concrete pavements, and researchers suggested an algorithm to correct for this effect. Results also showed that skewness, a measure of the extent to which a surface texture is spiky rather than indented, was a far better predictor of noise and friction than mean profile depth.

## What’s Next?

Researchers recommend more attention to texture orientation in future studies of asphalt surfaces since it can affect tire-pavement noise. They also recommend an analysis of seasonal trends so that these can be integrated into a method for predicting surface characteristics from mixture properties.

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*This Technical Summary pertains to the LRRB-produced Report 2014-28, “Hot Mix Asphalt Surface Characteristics,” published August 2014. The full report can be accessed at <http://www.lrrb.org/PDF/201428.pdf>.*