Improving the Rolling Resistance of Pavements

What Was the Need?
Since 2006, as part of Transportation Pooled Fund study TPF-5(134), researchers have been investigating methods for creating quieter pavements at the MnROAD pavement research facility. Reducing the noise that tires make as they roll over pavement requires optimizing pavement surface textures, which are applied during construction to add friction and skid resistance. These textures are achieved by dragging materials across uncured concrete.

Quieter textures such as those applied by grinding grooves into pavements with diamond-coated saw blades may also have the advantage of reducing rolling resistance—the force resisting the tire rolling across the pavement surface. Reducing rolling resistance can increase vehicle fuel economy, producing significant savings for drivers and reducing the environmental impacts of automobiles. However, optimizing rolling resistance requires a better knowledge of the relationship between rolling resistance and detailed pavement surface characteristics, including noise, texture and friction. Research was needed to develop three-dimensional representations of MnROAD test pavement surface textures to facilitate noise-reduction research and to ascertain what surface characteristics influence rolling resistance.

What Was Our Goal?
This project’s goals were to collect detailed measurements of pavement texture at MnROAD and to perform multivariate analysis on this and other historical MnROAD data to investigate the relationship between rolling resistance and other pavement surface characteristics.

What Did We Do?
Researchers began by conducting pavement surface texture measurements on all MnROAD test cells. MnROAD includes a 3.5-mile mainline consisting of a working interstate freeway carrying more than 26,000 vehicles a day and a low-volume, 2.6-mile closed loop with vehicle weight and traffic volumes simulating rural road conditions. These segments include more than fifty 500-foot test cells using a variety of pavement material and design technologies to support various research projects.

RoboTex, a line-laser-based texture profiler, was used to measure texture both longitudinally (in the direction of traffic flow) and transversely (across wheel path). This is especially important for portland cement concrete pavements in which surface textures can differ with direction. Using RoboTex allowed researchers to determine various pavement surface texture properties from which they calculated standard texture metrics.

Researchers then investigated the relationship between these and other surface characteristics and the coefficient of rolling resistance using data that the Federal Highway Administration, MnDOT, Minnesota State University, Mankato and University of Gdansk, Poland had collected in a 2011 study. They combined RoboTex data with historical MnROAD data on CRR, roughness, friction and tire-pavement noise into a single database. Researchers then conducted a variety of multivariable regression analyses (a standard approach for statistical analysis) to determine combinations of surface characteristic variables that would yield good models for CRR.

Improved characterization of pavement textures and their relationship to rolling resistance will help in the design of pavements that lower vehicle fuel consumption, leading to significant cost and energy savings.
What Did We Learn?

Results showed that there are many possible combinations of surface characteristic variables that can predict CRR in pavements. Particularly important for the rolling resistance of concrete pavements was the characteristic of skewness, or the degree to which the distribution of a texture’s peaks and valleys are symmetrical around the profile axis. For asphalt, an important factor was texture level in the macrotexture range, a way of describing the variation in height of texture features (peaks and valleys) with spacing ranging from 0.5 to 50 mm.

Researchers also found that using the entire set of MnROAD test cells in regression analyses yielded a model of CRR that performed poorly. Consequently, they analyzed data separately for various pavement types:

- Asphalt, including regular hot-mix asphalt, NovaCHIP and pervious asphalt surface textures.
- PCC with various textures, including the longitudinal and transverse tine, longitudinal and transverse turf/broom drag as well as pervious concrete textures.
- PCC with conventional and innovative diamond grind textures.

From this analysis, researchers determined that the variables that best predict CRR are different in asphalt and PCC pavements. Researchers also obtained better regression results when they analyzed the data from MnROAD’s mainline and low-volume roads separately.

The multivariate analysis proved to be a useful approach as certain correlated combinations of surface characteristics were accentuated. Though all surface data were not collected on the same date, environmental data are available for future temperature corrections if deemed significant.

What’s Next?

In 2014, researchers from the Technical University of Gdańsk, Poland will return to MnROAD to conduct a second round of rolling resistance measurements in partnership with MnDOT and Minnesota State University, Mankato. The research team will use existing models to estimate the expected fuel consumption for various textures. MnDOT also plans to conduct further research into estimating rolling resistance using mechanistic analyses of vehicle operating costs.