



## RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS,  
RESEARCH & INNOVATION

## TECHNICAL SUMMARY

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### PROJECT COST:

\$192,000



Researchers evaluated several local aggregate samples for size and shape properties using the University of Illinois Aggregate Image Analyzer.

# Best Value Local Aggregates for Road Foundations

## What Was the Need?

To achieve long-lasting roads, materials are typically mined from gravel pits and rock quarries. Because these materials are becoming increasingly scarce and expensive in many parts of Minnesota, it is important to better predict how aggregates affect road performance. The quality of an aggregate is determined by how well particles interlock to provide structural support for upper pavement layers and protection to lower subgrade soils, and also how stable the aggregate is under freeze-thaw and wet-dry cycles. These functions in turn depend on properties including aggregate shape, surface texture and angularity.

By better understanding the quality of local aggregates, the mechanistic-empirical pavement design software application MnPAVE was used to determine where and how these aggregates can be used most effectively in roads. This requires establishing the relationship between aggregate properties and MnPAVE inputs such as shear strength and resilient modulus.

## What Was Our Goal?

The goal of this project was to determine how mechanistic-empirical design procedures can be used to make effective use of local Minnesota aggregates in the unbound layers supporting flexible pavements by determining:

- How an aggregate's properties affect its quality, as measured by resilient modulus and shear strength, and consequently how they affect the design thickness of unbound aggregate layers.
- Where locally available materials with defined quality should be placed.
- What traffic design levels are appropriate for locally available aggregates.
- How to combine high quality and marginal quality aggregates for optimal performance.

## What Did We Do?

Researchers began by analyzing the properties of aggregate materials from gravel pits and rock quarries throughout Minnesota. They supplemented this data by analyzing images of aggregate samples to determine their shape, angularity and surface texture. They correlated this data with laboratory and field tests of aggregate strength and resilient modulus from MnDOT-sponsored research studies using computer modeling to establish resilient modulus as a function of aggregate properties.

Researchers then classified aggregates used in Minnesota into three representative quality ranges based on resilient modulus and peak deviator stress at failure. Then they used MnPAVE to determine the expected service lives of flexible pavements using aggregate bases with varying properties. They also explored the relationship between the gradation and mechanical properties of aggregates.

Finally, researchers established target mechanistic design input values for aggregate base and subbase layer strength and modulus under various design scenarios using various locally available aggregate materials. They also made recommendations to facilitate aggregate source management, property determination and cost-effective source selection.

*Better quantifying the quality of local aggregates will help Minnesota make the most efficient use of its resources, achieving better value for its construction dollars and promoting sustainability.*

*“This project helps us get better value from our aggregates by using them more efficiently to construct more miles of road with the same quantity of materials.”*

—John Siekmeier,  
Research Engineer,  
MnDOT Office of Materials

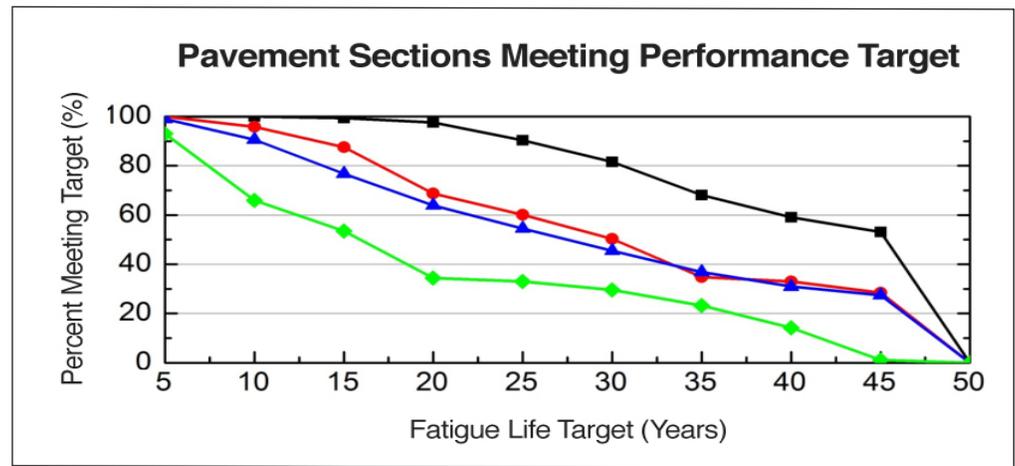
*“On low-volume roads, lower road layers that don’t receive the highest loads don’t always require the highest quality aggregates, making the sustainable use of local sources a good option.”*

—Erol Tutumluer,  
Professor, University of  
Illinois Department of  
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This graph illustrates the estimated effect of unbound granular quality on the fatigue life of pavement sections in Beltrami County given an estimated 1.5 million equivalent single-axle loads per 20 years: high quality base and subbase (black), high quality base and low quality subbase (red), low quality base and high quality subbase (blue), and low quality base and subbase (green).

### What Did We Learn?

Results showed that aggregate angularity and surface texture were important in determining the resilient modulus of aggregates and far better correlated to this property than gradation alone.

Analyses using MnPAVE showed that use of locally available materials can be cost-effective for low-volume roads provided that the 20-year design traffic level does not exceed 1.5 million equivalent single-axle loads. Most state and local roads have traffic levels less than this. Analyses confirm that the quality of base layer materials directly impacts the predicted service lives of roads. Increasing the thickness of a base layer with low quality materials did not improve the fatigue life expectancy of a road, although it did significantly improve subgrade rutting performance. The quality of aggregates used in the subbase had a much greater effect on rutting performance. Researchers concluded that a high quality, stiff subbase has a bridging effect and can offset some of the negative effects of low base stiffness.

### What’s Next?

MnDOT is currently incorporating the results of this study into MnPAVE, including design inputs for surface texture and angularity, and equations for predicting resilient modulus from them. Researchers recommend continuing to build a database of properties for an increasing number of local aggregate sources to improve the correlations developed in this study. They also recommend establishing guidelines for using visual inspection to characterize aggregate properties and developing rapid field imaging technologies for the same purpose. MnDOT is currently conducting a related project to improve concrete pavement foundations.

*This Technical Summary pertains to Report 2012-01, “Best Value Granular Material for Road Foundations,” published January 2012. The full report can be accessed at <http://www.lrrb.org/PDF/201201.pdf>.*