



## RESEARCH SERVICES SECTION

# TECHNICAL SUMMARY

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### PROJECT COST:

\$60,080



Researchers compared the stiffness of unbound and stabilized material samples by testing resilient modulus confining pressures in triaxial cells.



# Design Procedure for Bituminous-Stabilized Road Surfaces for Low-Volume Roads

## What Was the Need?

Gravel roads are common in rural Minnesota. While these roads are sufficient for ordinary low-volume traffic, gravel surfaces offer poor traction and bumpy driving; traffic generates dust and gradually displaces gravel. These roads may also be damaged by heavy farming equipment and other rural industry transportation.

Rural gravel roads can be improved by bituminous stabilization, a process that involves placing up to 10 inches of additional aggregate and mixing its upper 4 to 7 inches with an emulsified asphalt binder. This surface is then treated with a seal coat one to two weeks after compaction.

As Minnesota counties seek to upgrade roads to accommodate heavy equipment and produce better driving surfaces, bituminous stabilization is increasingly becoming more attractive than other alternatives. Maintaining a gravel surface or adding an asphalt overlay may be more expensive in the long term, although a surface with bituminous stabilization needs to be properly maintained: If the seal coats that protect the surface and hold the stabilized layer together are damaged, a more expensive rehabilitation may be required.

Despite the increasing use of bituminous stabilization in Minnesota, its efficacy has not been established by quantitative research, and its design is based on empirical estimates by county engineers. Counties needed a stabilization design procedure confirmed by research.

## What Was Our Goal?

The objective of this study was to establish mechanistic design methods for constructing bituminous-stabilized roads. Investigators focused on determining the optimum thickness of the stabilized layer, material properties relevant to design, and the costs associated with construction.

## What Did We Do?

Investigators first conducted a literature search of bituminous stabilization practices. They then evaluated stabilized sites in the field, observing construction at two sites and evaluating material samples in the laboratory with tests for soil classification, gradation, moisture content and stiffness. This data was used to identify the costs and benefits of bituminous stabilization of gravel roads.

Investigators then developed software and design procedures for determining the depth to which binder should be mixed with gravel to meet desired load requirements.

Finally, investigators evaluated the respective costs of:

- Maintaining gravel road surfaces
- Maintaining bituminous-stabilized roads
- Overlaying gravel with hot mix asphalt
- Upgrading gravel to HMA over the following stages: an initial bituminous overlay; a 1- to 1-1/2 inch overlay after 5 years; and a second overlay after 12 years

*“Under the right conditions, bituminous stabilization improves gravel roads. It eliminates dust; provides a harder, smoother surface; and doesn’t lose gravel like unstabilized roads do.”*

—James Wilde,  
Associate Professor,  
Minnesota State University,  
Mankato Center for  
Transportation Research  
and Implementation

*“Regrading and replacing aggregate on gravel roads are expensive measures. This study confirmed the decisions we have been making about bituminous stabilization.”*

—Alan Forsberg,  
Public Works Director,  
Blue Earth County

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Bituminous stabilization involves laying new gravel and mixing asphalt binder to a depth that supports anticipated loads on a roadway.

### What Did We Learn?

In the cost comparison, bituminous stabilization was much less expensive, at \$363 per mile per year for maintenance, than alternatives for maintaining and upgrading gravel roads. A staged upgrade to HMA was the most expensive alternative at \$5,196 per mile per year, followed by maintaining gravel surfaces at \$4,160 and HMA overlay at \$2,460.

Other benefits included smoother driving surfaces and better traction for increased safety; the near elimination of dust problems; a reduction in aggregate loss; a reduction in maintenance costs; and relatively inexpensive upgrades.

There were also several disadvantages to bituminous stabilization, including pavement distress and higher driving speeds on road systems not geometrically designed for safety at these speeds. Despite these disadvantages, researchers concluded that bituminous stabilization is the best choice for maintaining low-volume roads, both economically and in terms of driving quality.

To aid engineers in implementing bituminous stabilization, investigators developed the following design steps for determining the depth to which asphalt binder should be mixed with gravel during construction:

- Use a dynamic cone penetrometer to collect stiffness data at regular intervals along the roadway.
- Determine soil type and gravel thickness.
- Determine expected traffic and the road’s required load-bearing capacity.
- Use the data acquired above with the software developed in the course of this study to perform a load-rating analysis of the depth to which asphalt binder should be mixed with gravel to achieve the desired load-bearing capacity.

### What’s Next?

Because the design procedures established in this study are newly developed, roadways designed and constructed according to them should be monitored over time. Further, more research is required to enhance these procedures by determining design sensitivity to more than one binder source as well as types other than those used in this study; evaluating and improving dynamic cone penetrometer methods; developing and incorporating updated design models; expanding test sites to collect additional data; and identifying fatigue and defining failure for stabilized roadway layers.

*This Technical Summary pertains to LRRB-produced Report 2008-28, “Design Procedure for Bituminous Stabilized Road Surfaces for Low Volume Roads,” published August 2008. The full report can be accessed at <http://www.lrrb.org/PDF/200828.pdf>.*