



## RESEARCH SERVICES & LIBRARY

OFFICE OF TRANSPORTATION  
SYSTEM MANAGEMENT

## TECHNICAL SUMMARY

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### Principal Investigator:

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### PROJECT COST:

\$45,000



Reflective rumble stripes are painted over the ground-in recesses of rumble strips, providing drivers with extra warning against lane drift.

# Reflectivity of Glass Beads in Rumble Stripes Depends on Installation Practices

## What Was the Need?

Pavement marking retroreflectivity—how much light reflects back at a driver—is critical to providing nighttime guidance to motorists. A [2010 Iowa State University study](#) found that for white edge lines, yellow edge lines and yellow centerlines, retroreflectivity was a statistically significant factor in the likelihood of crashes.

Retroreflectivity is typically achieved on pavement stripes, including stripes on rumble strips, by spraying tiny glass beads onto the fresh paint. How well rumble stripes supplement the safety function of rumble strips depends on the retroreflectivity of the pavement marking.

Researchers measure retroreflectivity in terms of millicandelas per meter squared per lux (mcd); when more beads are available to return light toward the viewer, stripes yield a higher mcd number and higher retroreflectivity. Higher retroreflectivity counts point to greater nighttime visibility.

Since pavement markings can fail on many highway surfaces within a year of application due to traffic and snowplowing activity, the performance over time of rumble stripes is a concern. In addition, reflective beads are sprayed at an angle over pavement stripes, which engineers believe causes reflective beads to collect disproportionately against the forward wall of the rumble strip recess in the direction of traffic, causing retroreflectivity to be greater in one direction of traffic than the other.

## What Was Our Goal?

Researchers aimed to evaluate the retroreflectivity performance of rumble stripes in Minnesota in terms of current performance as well as expected performance over the long term. The evaluation considered both centerline and edge line rumble stripes, and measured retroreflectivity both with and against the direction of travel.

## What Did We Do?

Working closely with MnDOT's Technical Advisory Panel, researchers conducted field evaluations of retroreflectivity at a number of Minnesota sites.

In-service evaluation included centerline rumble stripes at eight segments on four roadways, and profile stripes (edge lines painted 8 inches wide rather than 4 inches) at 18 segments on 10 roadways. All were installed in the 2013 mill-and-overlay season. Analysis was conducted after one winter with no data available on initial, prewinter installation.

Long-term evaluation measured initial performance of centerline rumble stripes as well as performance 18 months later—that is, after two winters—on seven segments on three roadways constructed during the 2012 mill-and-overlay season.

*MnDOT research shows that retroreflectivity in pavement rumble stripes varies significantly from installation to installation. Variation in measured retroreflectivity stems from methods for embedding reflective beads in stripes during installation, suggesting that installation practices are key to meeting minimum specifications for retroreflectivity.*

*“We are requiring that contractors measure retroreflectivity in both directions. We’ll make sure they are aware of these results so they can work with their suppliers to meet specifications.”*

—Ken Johnson,  
Work Zone, Pavement  
Marking and Traffic  
Devices Engineer,  
MnDOT Office of Traffic,  
Safety and Technology

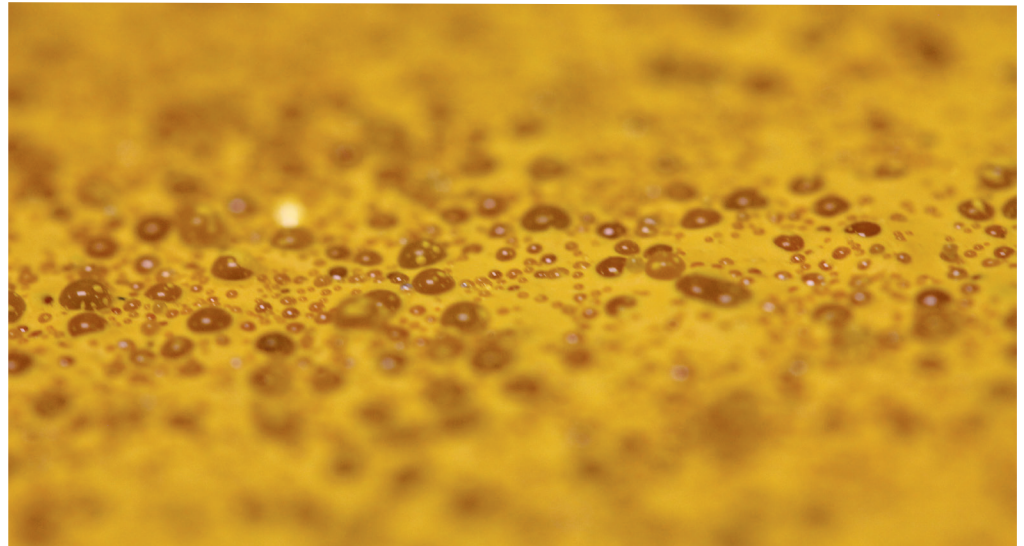
*“This retroreflectivity research serves as a point of data that lets MnDOT consider how it contracts for these services. MnDOT isn’t just about impressions; MnDOT is data-driven.”*

—Neal Hawkins,  
Director, Center for  
Transportation Research  
and Education, Iowa State  
University

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Retroreflectivity is the measure of the brightness at which the glass beads embedded in pavement markings reflect light back to the viewer. It’s a key measure of the effectiveness of reflective striping at night.

## What Did We Learn?

Field data confirmed recent steps taken by MnDOT pavement marking engineers to require contractors to measure retroreflectivity after installation. The data validate that these new requirements should ensure that rumble striping meets minimum retroreflectivity standards from all directions of travel.

In-service evaluation of two-lane roadway rumble stripes showed considerable variation in performance.

- Centerline retroreflectivity values, a key to road user safety, varied up to 32 percent within the same striping segment. Profile striping showed variance of up to 86 percent retroreflectivity within single lines.
- Performance by roadway also varied significantly after a year of service. Yellow centerlines on two roadways measured in the mid 150-mcd range, and the other two in the mid 70-mcd range. White profile markings ranged from 72 mcd to 366 mcd.
- On nine of 14 roadways, over 90 percent of retroreflectivity readings were measured at a level greater than 100 mcd.

Long-term evaluation found significant variation in retroreflectivity by direction of travel.

- Retroreflectivity varied within striping segments from 2 to 40 percent depending on the direction of travel, suggesting that bead distribution varies considerably with direction of installed application.
- Retroreflectivity measured at consistent levels within each roadway after two winters but varied between roadways. Results ranged from a high of 121 mcd on Trunk Highway 68 to a low of 55 mcd on Trunk Highway 55.

## What’s Next?

MnDOT will use these results to consider striping installation compliance with standards and opportunities to ensure consistency. MnDOT pavement marking engineers would like to see a large-scale national study—perhaps from the National Cooperative Highway Research Program or as a pooled fund study—that determines optimal retroreflectivity performance goals for wet pavements.

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*This Technical Summary pertains to Report 2016-13, “Rumble Stripe: Evaluation of Retroreflectivity and Installation Practices,” published April 2016. The full report can be accessed at [mndot.gov/research/TS/2016/201613.pdf](http://mndot.gov/research/TS/2016/201613.pdf).*