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LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

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LRRB PROJECT COST:
$45,400

Researchers found that adding rumble strips was the most cost-effective strategy for reducing crashes.

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

In-Vehicle Technologies and Infrastructure Modifications to Prevent Crashes Along Curves and Shoulders

Researchers investigated the most cost-effective roadway designs, treatments and in-vehicle technologies for improving the safety of rural two-lane highways. They found that while static warning signs have a high benefit-to-cost ratio, 80 percent of curves studied had such signs and still had high crash rates.

What Was the Need?

Forty percent of fatal crashes in Minnesota are road departure crashes, and these occur primarily on rural curves and adjacent roadway segments, also referred to as tangential sections. Systems are needed to prevent these crashes but because agencies have limited financial resources, it is important to find strategies that provide the greatest benefit for a given fixed cost.

What Was Our Goal?

The goal of this study was to establish the most cost-effective roadway designs, treatments and in-vehicle technologies for improving the safety of rural two-lane highways.

What Did We Do?

Researchers completed this study in two phases. In the first phase, they began by collecting data for 204 curves and 137 tangential sections from Mn/DOT districts and county highway departments. They analyzed this data to correlate crash and fatality rates to curve radius (a measure of the severity of curves) and to shoulder width and paving material (which affect the ability of drivers to recover from lane departures). Researchers then identified curves and tangential sections that had received safety treatments, including:

- Rumble strips and stripes, grooved patterns on roadsides and/or centerlines that alert drivers by causing their vehicles to vibrate and make noise; stripes also have highly reflective paint for nighttime visibility.
- Curve flattening, a process in which curves are realigned or completely reconstructed to alter their radius and so decrease their severity.
- Traffic control devices, such as chevrons alerting drivers to the shapes of curves, static warning signs alerting drivers to sharp curves, and static speed warning signs informing drivers of a lower speed limit during the curve.
- Paving and widening of tangential section shoulders.

Researchers compared crash and fatality rates for road sections before and after the implementation of these treatments and used this comparison to establish cost-benefit ratios for each.

In the second phase of this study, researchers compared the costs and benefits of these traditional road safety treatments to newer, technology-based treatments, including dynamic curve warning signs, which detect the speed of oncoming vehicles and use flashing beacons to warn drivers if they are coming into a curve too quickly, and lane departure warning systems, which alert drivers of unintentional lane changes using either a Global Positioning System or cameras that track lane markings.

continued

"Results suggested that agencies with limited budgets should improve road safety by adding rumble strips or stripes before they consider more expensive measures such as widening shoulders."

–Craig Shankwitz,
Program Director,
University of Minnesota
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Vehicles Program

"This project optimizes the ability of Mn/DOT to improve highway safety on a fixed annual budget, moving Minnesota closer to its goal of eliminating fatal crashes."

–Glen Ellis,
Mn/DOT Metro District
Design Engineer

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A vision-based lane departure warning system uses a camera and software to track and display a vehicle's position relative to lane markings, alerting the driver when a vehicle crosses markings at speeds greater than 25 mph or without a turn signal.

What Did We Learn?

Results show that while static warning signs have a high benefit-to-cost ratio, 80 percent of curves studied had such signs and still had high crash and fatality rates. Researchers recommend complementing signs with additional cost-effective countermeasures for curves with radii between 500 and 1,500 feet, which account for 90 percent of fatal crashes and 75 percent of injuries in curve-related accidents. When possible, curves should be designed with radii of more than 2,000 feet.

Of such countermeasures, while curve flattening was the most effective infrastructure-based treatment, it is also the least cost-effective. For a given fixed safety budget, adding rumble strips or stripes to tangential sections is the most cost-effective treatment and produced the highest reduction in fatalities. Researchers recommend paving shoulders and adding rumble strips or stripes on all projects since the latter are much more cost-effective than paving alone.

Treatments in order of cost-effectiveness from highest to lowest (with absolute crash-rate reduction percentages in parentheses) were: addition of rumble strips on curves of any width or on tangential sections up to four feet in width (15 percent crash-rate reduction), paving and addition of rumble strips to tangential section aggregate shoulders (37 percent), static curve warning signs (18 percent), chevrons (20 percent), static curve speed warning signs (22 percent), dynamic curve speed warning signs (30 percent) and curve flattening (66 percent). Because paving tangential section aggregate shoulders without adding rumble strips or widening tangential section paved shoulders showed inconclusive safety benefits, cost-benefit analyses were not undertaken for these conditions.

For in-vehicle technologies, camera-based lane departure warning systems were about as cost-effective on a 10-year analysis as adding rumble strips or stripes to tangential section shoulders, and are about as effective as paving shoulders (a 7 percent crash-rate reduction). Although differential GPS-based lane departure warning systems have proven to be very effective, today's low deployment numbers and a conservative 20-year price/volume model make these systems currently about as cost-effective as paving shoulders.

What's Next?

With limited financial resources, achieving Minnesota's Toward Zero Deaths initiative of eliminating fatal traffic crashes requires finding the most cost-effective road safety strategies. To that end, the results of this study will be incorporated into Mn/DOT's highway safety manual to help local agencies make critical decisions about how they spend their highway safety funding.

This Technical Summary pertains to the LRRB-produced Report 2009-39, "Benefit:Cost Analysis of In-Vehicle Technologies and Infrastructure Modifications as a Means to Prevent Crashes along Curves and Shoulders," published December 2009. The full report can be accessed at http://www.lrrb.org/PDF/200939.pdf.