Iowa DOT Synthesis of Transverse Rumble Strips at Rural Stop-Controlled Intersections

tech transfer summary

This study found that identifying rural intersections for transverse rumble strip installation through a combination of both a systemic, risk-based, and a traditional, hot spot, approach will likely lead to the largest safety benefits by identifying the sites that are at highest risk for future crashes to occur as well as those that have a crash history.

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RESEARCH PROJECT TITLE
Iowa DOT Synthesis of Transverse Rumble Strips at Rural Stop Controlled Intersections

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The mission of the Center for Transportation Research and Education (CTRE) at Iowa State University is to conduct basic and applied transportation research to help our partners improve safety, facilitate traffic operations, and enhance the management of infrastructure assets.

Problem Statement

In response to the proposed House File (HF) 2004 – Rumble Strips, Highway Intersections (commonly known as Baylee's Bill) in the Iowa Legislature, the Iowa DOT was charged through House Study Bill (HSB) 711, which was succeeded by HF 2644, with studying "the effectiveness of rumble strips in preventing vehicle crashes at certain stop-controlled intersections as determined by the department."

Project Objectives

- Summarize the effectiveness of transverse rumble strips (TRS) at stop-controlled rural intersections based on the relevant current literature
- Document the practices of other state departments of transportation (DOTs) related to the application of TRS at stop-controlled intersections
- Provide cost estimates and benefit-cost ratios for various scenarios of TRS implementation in Iowa

Background

Drivers failing to recognize and stop at rural stop-controlled intersections are a significant safety issue that resulted in an estimated 2–3% of all fatal crashes within Iowa for the five years from 2016 through 2020. One treatment that agencies utilize to help reduce these crashes are TRS.

TRS are a low-cost countermeasure that can be grooved into the pavement or raised strips of materials such as plastic, rubber, or thermoplastic that are placed either across the whole travel lane or the wheel paths to provide an audible and tactile warning to drivers when the strips are driven over.

Nicole Oneyear, InTrans

Transverse rumble strips grooved into the pavement preceding a two-way stop at a four-legged rural intersection near Eddyville, Iowa

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Study Description

- A summary of the relevant literature was compiled and analyzed related to the use of TRS at stop-controlled rural intersections.
- A synthesis of state DOT policies was compiled through a search of published policy and responses to a survey that was sent to state DOT safety engineers through the American Association of State Highway and Transportation Officials (AASHTO) Safety Committee listserv.
- An economic analysis was conducted to determine the estimated benefit-cost ratios of implementing TRS in Iowa using two different site selection installation criteria.

To put the economic analysis in context, Baylee's Bill proposed a systematic installation of TRS at virtually all high-speed, rural paved, stop-controlled approaches that intersect with primary roads throughout Iowa. The research team used the last five years of Iowa crash data (for 2016 through 2020) along with a crash modification factor (CMF) and the Iowa DOT Intersection Database to determine the number of intersections that would be treated under the suggested systematic approach versus using a targeted approach for installing TRS based on the top 5% of high-crash intersections (from the 1,845 intersections of interest in the Iowa DOT Crash Database).

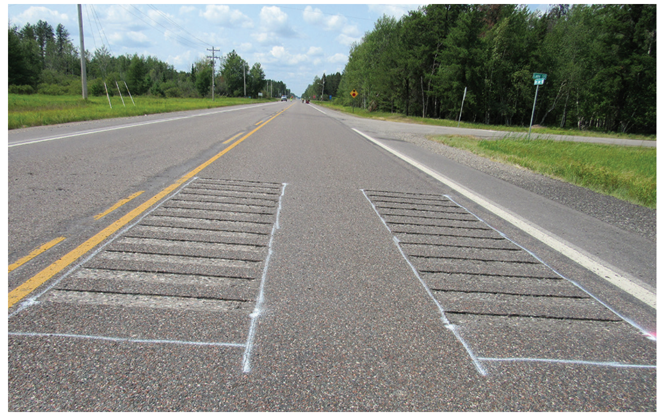
Key Findings

Summary of Literature

Research has found reductions in crashes ranging from about 20% to 40% at stop-controlled intersections after the installation of TRS (Srinivasan et al. 2012 and Torbic et al. 2015). TRS have also been found to reduce driver speeds in the approach to the intersection in the range of 1 mph to 5 mph (Harder et al. 2006, Ray et al. 2008, Thompson et al. 2006, Yang et al. 2016).

Common concerns related to TRS include noise and adverse impacts on motorcyclists and bicyclists. Unlike other longitudinal rumbles, which are only struck when a driver is leaving their lane, the placement of TRS results in them being struck theoretically by every driver, which makes the noise produced a greater concern. This is often combated by not placing TRS near residential areas or only placing them a set distance from residences.

Research has shown using a shallower depth rumble has resulted in lower external noise while still producing adequate internal noise to be effective. However, an optimal depth/noise ratio has not been well established.



Hossein Naraghi, InTrans

States with wheel path designs (like this one in Minnesota) include Minnesota, New Mexico, and Texas

To better accommodate cyclists, wheel path designs or paved shoulders are sometimes used. A few states utilize a standard design that uses a wheel path only TRS design that allows for the accommodation of bicyclists and motorcyclists who can avoid traversing the rumbles by traveling in the space between them.

Additional concerns that are often voiced have been so far to be unfounded. For instance, research has found no increase in erratic maneuvers nor issues related to maintenance.

Synthesis of State DOT TRS Usage

Eight states, including Iowa, were found to have published policies that could easily be accessed. Of the 25 DOTs that responded to the survey, only two states that responded did not allow for TRS in advance of rural stop-controlled intersections.

Iowa's current policy allows for the use of TRS on roads with speed limits of 55 mph+ and where noise is not a concern. It also allows for the use on roads with speed limits under 55 mph if warranted by an engineering study.

States that allowed for TRS appeared to mainly take a targeted approach to selecting sites for installation with all but two noting that less than 25% of their rural county paved intersections in their state currently had TRS installed. Two states (North Dakota and South Dakota) responded that they take a more systematic approach, while the rest mostly took a traditional hot-spot approach.

Four states noted that they specifically require a history of crashes before installing TRS, while an additional nine noted they often use crash history. A systemic-like approach based on risk level was taken by states such as Maryland, Missouri, Ohio, and Wisconsin, which included selecting sites with risk factors that increased the likelihood of a ran-stop-sign crash occurring. Some of these risk factors included sites with inadequate stopping sight distance or intersections that followed a long approach.

Six states required other less intrusive countermeasures be tried before TRS were installed. Common countermeasures that were considered included removing sight obstructions, doubled-up stop signs and advance warning signs, oversized signs, flags or flashing beacons on advance warning or stop signs, on pavement signing, light-emitting diode (LED) stop signs, intersection lighting, and overhead flashing beacons.

Cost Analysis Summary

The research team used their economic analysis results to develop benefit-cost ratios for a systematic approach versus a targeted approach to determine if significant differences exist in the economic benefits between the two approaches.

Estimated benefit-cost ratios for TRS implementation

Intersection Road Type	Method	Benefit-Cost Ratio
Primary Road	Treat All Intersections	13.177
	Treat Top 5% of Intersections	66.722
Secondary Road	Treat All Intersections	3.695
	Treat Top 5% of Intersections	22.948

Primary=Iowa DOT maintained; Secondary=county maintained; Top 5%=top 5% of high-crash intersections based on all crashes used in the analysis for Iowa from 2016 through 2020

Implementation Readiness and Benefits

The cost analysis found that, while both the systematic approach and the targeted approach were economically sound investments with benefit-cost ratios over 3 for all scenarios, the ratios were five to six times greater for the targeted approach.

It should be noted that the CMF utilized for this analysis was most appropriate for locations with a demonstrated failure-to-yield crash history. Therefore, the benefits of the estimated benefit-cost ratios may be overestimated or underestimated for any particular intersection in Iowa.

National guidance suggests TRS should be used sparingly in order to remain effective due to their effectiveness being dependent on them being out of the ordinary (Newman et al. 2003). Therefore, a targeted approach choosing sites both systemically and through hot spot analysis will likely lead to the largest safety benefits by identifying the sites that have a crash history as well as those that are at highest risk for future crashes to occur.

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