



Project Summary Report 0-4472-S

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Project 0-4472: Evaluation of Edgeline and Centerline Rumble Strips

Authors: Paul J. Carlson and Jeffrey D. Miles

## Research Recommendations for Uniform Rumble Strip Applications in Texas

### PROJECT SUMMARY REPORT

Research findings have clearly shown that continuous rumble strips along the shoulder of expressways and freeways provide significant benefits in terms of reducing run-off-the-road (ROR) crashes. More recently, studies are beginning to show that continuous rumble strips installed along the shoulders and centerlines of conventional highways have the potential to impact safety in a positive manner. Less understood, but potentially just as beneficial, are in-lane or transverse rumble strips, which are normally installed on approaches to rural high-speed intersections, unexpected horizontal curves, or other locations where crashes occur more frequently than expected.

This project included an investigation of these three different types of rumble strips on Texas highways. The primary focus of the project was on the operational aspects of transverse rumble strips (TRSs) and centerline rumble strips (CRSs). Also included in the research scope, but with less emphasis, was an evaluation of edgeline rumble strips (ERSs) on conventional highways.

### What We Did...

Researchers first conducted a synthesis of rumble strip usage across the United States and internationally. This synthesis was designed to determine which rumble strip designs are being used on conventional highways, where they are being used, and why. The researchers were interested in learning if prior research had been used to select the rumble strip designs and applications. Also of interest was the determination if any safety analyses had been conducted on the rumble strip installations.

Using the safety effectiveness findings from the synthesis effort described above, the researchers used Texas crash data to forecast the potential safety benefits of using centerline rumble strips and shoulder rumble strips on conventional highways in Texas.

The researchers also used the findings from the synthesis effort to develop candidate rumble strip designs for TRSs, CRSs, and ERSs on conventional highways. The candidate designs were installed at various evaluation sites across Texas. Specific issues related to each of the

three types of rumble strip applications were studied.

For TRSs, the research evaluated the speeds and deceleration rates at approaches to rural stop-controlled intersections and horizontal curves. Figure 1 shows an example installation site. The researchers also monitored selected sites for erratic maneuvers within the first 24 hours after TRSs were installed.

For CRSs, the primary focus was to determine if there was any change in passing maneuvers before and after the installation of CRSs. The researchers evaluated other issues associated with CRSs such as vehicle lateral placement as a function of CRSs and centerline pavement marking retroreflection after milling CRSs. Figure 2 shows a typical installation of CRSs.

For ERSs, the primary focus was to investigate how the presence of ERSs on a two-lane highway with wide shoulders would impact shoulder usage. ERSs were also installed on a two-lane highway with narrow shoulders and a Texas po-boy (a four-lane undivided highway with no shoulders). Figure 3 shows a typical installation of ERSs.





Figure 1. Typical Installation of TRSs.

The limited time associated with the research project prevented formal safety analyses of field installations. Instead, traffic operational studies were used to evaluate the effectiveness of the rumble strips. Informal monitoring of the study sites revealed no immediate concerns, but more time is needed to fully understand the safety impacts of these rumble strip applications.

## What We Found...

### Benefit-to-Cost Analysis

The safety benefits were estimated using a benefit-cost analysis and the most recent findings in terms of crash reductions and installation costs. For the analysis of CRSs on Texas highways, the researchers used a crash reduction rate of 20 percent and a conservative cost estimate of \$1.50 per linear foot (which includes the restriping of the centerline after the installation of the rumble strips). Table 1 shows the resulting safety calculations in relation to average daily traffic (ADT).

The results of the estimated safety impacts of installing ERSs

were considerably greater than those for CRSs. The safety impacts increase for CRSs and ERSs as the ADT of the roadway increases, but shoulder width also plays a role. An example of the findings for two-lane highways with ADT greater than 4500 vehicles is shown in Table 2.

### Field Evaluation

The researchers found that the installation of TRSs produced small



Figure 2. Typical Installation of CRSs.

but consistent reductions in speed. In addition, there was no sudden braking, hard braking, or swerving for the first 24 hours immediately following the installation of TRSs. Furthermore, TRSs are low-cost treatments that are easy to install and appear to be durable.

Passing operations before and after the installation of CRSs were studied along a 15-mile stretch of two-lane rural highway. The researchers demonstrated that there



Figure 3. Typical Installation of ERSs.



were no erratic maneuvers before or after the CRSs were installed. Besides erratic maneuvers, the researchers also studied a number of additional driver behavior and operational metrics associated with passing maneuvers, such as number of centerline encroachments prior to passing, gap distance at pass initiation, centerline crossing time into opposing lane, passing opportunity, and number of passes. The results indicated that there were no practical changes in driving behavior as a function of the CRSs, and no unsafe driving practices were observed.

The study of vehicle lateral position as a function of CRSs showed that the frequency of inadvertent contact with the centerline decreases with the installation of CRSs. The researchers also found that the majority of drivers shifted their vehicles' lateral position between 6 to 12 inches farther from the centerline pavement markings after the installation of raised CRSs (consisting of non-reflective buttons).

Shoulder usage as a function of ERSs appears to be positive in all regards. Shoulder usage data were collected using a video trailer and several traffic counters installed to record lateral position of vehicles encroaching on the highway shoulders. Shoulder usage was categorized into emergency, turning, passing, and other. 'Other' included inadvertent

Table 1. Safety of Centerline Rumble Strips in Texas.

ADT	≤ 1500	1500–2999	3000–4499	≥ 4500
Texas Lane Miles	41,923	9,067	4,575	8,897
B/C Ratio <sup>1</sup>	0.95	6.23	15.09	26.42
Lives Saved Annually	9.70	12.67	16.71	51.20

<sup>1</sup> Benefit-Cost Ratio (B/C) is the estimated benefit value divided by the estimated cost.

contact with the shoulder due to poor lane placement, intentional encroachment with the shoulder due to drivers' desire to place more distance between their vehicle and oncoming vehicles (e.g., drivers of vehicles with wide loads, such as manufactured homes), or intentional encroachment of the shoulder by a driver who wishes to drive below the speed limit.

Overall, shoulder encroachment decreased by 46.7 percent, and this reduction was almost entirely a result of fewer shoulder encroachments labeled as 'other.' In the average encroachments labeled as 'other,' drivers shifted 8 to 18.5 inches farther onto the shoulder, a change that was statistically significant. For shoulder usage labeled as passing, where drivers used the shoulder to allow faster vehicles to pass, there were no practical changes.

### The Researchers Recommend...

Despite the low cost of this treatment, the researchers

recommend a limited use of TRSs until follow-up work determines the safety impacts of TRSs. For this project, there were no erratic maneuvers, and the reductions in speed were consistent but small. The researchers do not feel that the findings warrant widespread implementation. However, a standard application layout was developed for future use as needed and documented in *Traffic Operational Impacts of Transverse, Centerline, and Edgeline Rumble Strips* (Report 0-4472-2).

With the estimated high safety impacts combined with the results of driver behavior studies, the researchers recommended the use of CRSs and ERSs on conventional highways in Texas. A more rigorous crash study should be conducted once enough time has elapsed to generate enough data for a statistically robust analysis. In addition, the researchers recommend further study of ERSs with a focus on roadway cross-section features such as number of lanes and widths of lanes and shoulders.

Table 2. Safety of Edgeline Rumble Strips on Two-Lane Highways in Texas (ADT > 4500).

Shoulder Width (ft)	0–1.5	2.0–4.0	4.5–6.0	6.5–8.0	8.5–9.0	9.5–10	>10
Texas Lane Miles	148	155	342	687	451	505	106
Benefit-to-Cost Ratio	96	199	102	161	144	200	60
Lives Saved Annually	<1	1.77	5.32	12.41	2.55	1.71	1.77



## For More Details...

The research is documented in the following reports:

0-4472-1, *Effectiveness of Rumble Strips on Texas Highways: First Year Report*

0-4472-2, *Traffic Operational Impacts of Transverse, Centerline, and Edgeline Rumble Strips*

**Research Supervisor:** Paul J. Carlson, P.E., TTI, (979) 845-1728, paul-carlson@tamu.edu

**Researcher:** Jeffrey D. Miles, (979) 845-1728, j-miles@tamu.edu

**TxDOT Project Director:** Brian Stanford, Traffic Operations Division, (512) 416-2719, bstanfo@dot.state.tx.us

**TxDOT Research Engineer:** Wade Odell, P.E., Research and Technology Implementation Office, (512) 465-7403, wodell@dot.state.tx.us

To obtain copies of reports, contact Nancy Pippin, Texas Transportation Institute, TTI Communications, at (979) 458-0481 or n-pippin@ttimail.tamu.edu. See our online catalog at <http://tti.tamu.edu>.

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