TEXAS TRANSPORTATION INSTITUTE
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Project Summary Report 0-4278-S

Project 0-4278: Safety Measures for Rural Intersections

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PROJECT SUMMARY REPORT

Left-Turn and Rumble Strip Treatments for Rural Intersections: Project Summary Report

Traffic conflicts due to turns at intersections and driveways are among the leading causes of crash problems associated with roadway design or traffic operations. Department of Public Safety data for the year 2000 show that 37 percent of rural crashes are intersection, intersection-related, or driveway-related crashes.

Rural crashes at or near intersections or driveways can be further categorized by movement. The largest percentage is left-turn related at 31 percent. With the highest percentage of crashes at or near intersections being left-turn related, a better understanding of left-turn driver behavior is appropriate.

Straight, single-vehicle crashes in rural areas (12 percent) as compared to urban areas (5 percent) indicate a greater need for treatments warning drivers of a downstream intersection in rural areas than in urban areas. Additional investigation of single-vehicle rural crashes revealed that the greatest percentage of these crashes (43 percent) are occurring at T-intersections, followed by four entering roads at 19 percent.

What We Did…

The researchers had two major objectives for this project:

(1) identify and evaluate those measures that address safety at rural intersections and

(2) develop informational materials on rural intersection safety.

For the second objective, the researchers developed materials regarding safety treatments at rural intersections. This information was incorporated as Chapter 6 in Texas Department of Transportation (TxDOT) Report 4048-2, *Treatments for Crashes on Rural Two-Lane Highways in Texas*, dated April 2002. Report 4048-2 was developed to provide transportation practitioners with information on crash characteristics for rural roads in Texas and to help engineers identify problems at intersections and recommend potential countermeasures for installation. It presents discussion of low-cost safety treatments used on highways and at intersections, along with their known effectiveness. The report also includes experiences with selected treatments in Texas, including whether the treatment should be considered elsewhere.

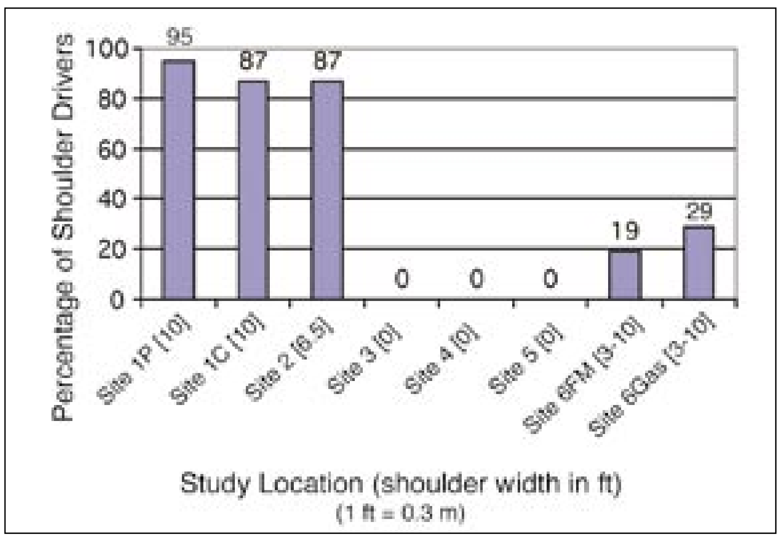

Figure 1. Percentages of Drivers on Shoulder at Each of the Six Study Sites.

The report was produced for insertion in a three-ring binder to allow easy additions or changes as new or updated information is available on the effectiveness of crash treatments.

To obtain a better understanding of left-turn driver behavior in Texas, data were collected at several intersections. Data were collected at six rural T-intersections where a minor arterial intersected with a major arterial with the minor arterial being controlled by a Stop sign. Data were also collected at a T-intersection where the minor arterial intersected initially a four-lane highway and in the after condition a two-lane highway with a two-way left-turn lane. At the sites, data were collected by two methods: laser and video. Laser guns were used to collect speed profiles on vehicles traveling through the study site. Video data were collected through the use of a trailer with a video camera mounted on an elevated telescoping arm and connected to a videocassette recorder.

The addition of a left-turn lane can improve operations and safety at an intersection. Guidelines as to when to include a left-turn lane in intersection design are plentiful. Because of the quantity of methods, questions remain regarding which method to use. For example, do the evaluations differ for number of lanes and for type of intersection? This project reviewed eight selected techniques and a number of criteria present in state manuals. Some of the assumptions used in the techniques were reviewed, and suggestions for changes to selected guidelines were made.

In order to gauge the effectiveness of in-lane rumble strips on driver speeds, rumble strips were installed on 14 approaches to rural intersections. Sites for rumble strip installation near Abilene and Gatesville were selected by the TxDOT districts, and the Dallas installations were initiated based on the results of recommendations from a previous rural crash study. "Before" data were collected when the researchers were notified of the planned installations, and "after" data were collected approximately 30 days after the rumble strip installation. Two patterns were used for the rumble strip installation: parallel and staggered. The data collection effort included obtaining both the characteristics of the site and the speed data of vehicles approaching the intersection.

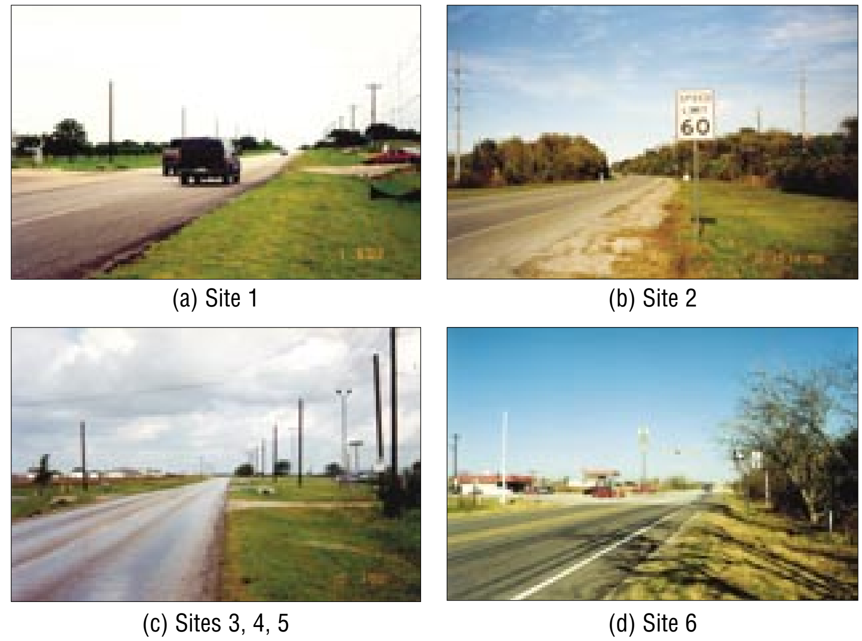

Figure 2. Photographs of Sites.

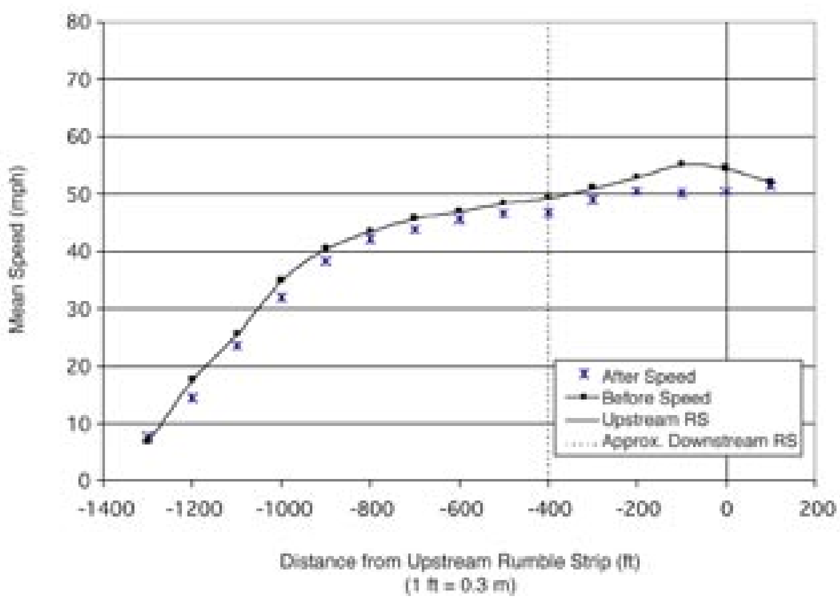

Figure 3. Comparison of Mean Speeds Relative to Upstream Rumble Strip on Five Approaches.

What We Found…

Behavior on the major road at a T-intersection is influenced by the width and type of the shoulder. For each of the six sites, driver behavior at and approaching the site was observed. Figure 1 shows the percent of drivers on the shoulder at each site. Figure 2 presents pictures of the sites. When a wide level shoulder was provided, a large percentage of the drivers, up to 95 percent, drove on the shoulder. At the site where the shoulder was retrofitted using available materials and widened from 3 ft (0.9 m) to 10 ft (3.1 m) just prior to the intersection, only 19 to 29 percent of the drivers used the shoulder. At the site with minimum paved shoulder, none of the recorded drivers used the shoulder (although the number of drivers who may want to drive on the shoulder was low, on the order of 1 to 3 vehicles per hour).

Shoulder width and type also appear to influence driver speeds for various movements. Sites 1 and 2 had higher recorded speeds than other sites. The average 85th percentile speed for shoulder drivers at Site 1 was 64 mph with a range of speeds between 22 and 67 mph. At Site 2, only one car was measured on the shoulder, and its speed was 52 mph. At Site 6, the only shoulder driver recorded had a lower speed (37 mph).

Several methods are available for determining when to include a left-turn lane in intersection design. Methods based on delay typically do not recommend a left-turn lane at lower left or through volumes when compared to methods based on conflict avoidance or safety. Because of the high benefits for crash reductions provided by left-turn lanes, a method that results in a recommendation at lower volumes would be preferred.

The Harmelink model is a widely accepted approach that is based on conflict avoidance. The procedure first proposed by Harmelink in 1967 includes assumptions that may need to be revised. Findings from current research on the time to clear an intersection and on critical gaps suggest that Harmelink guidelines should be modified. The updated values include a critical gap of 5.5 sec, a time to make a left turn of 4.3 sec, and a time to clear the approaching lane of 3.2 sec. Table 1 lists suggested guidelines developed based on the findings from this research for installing left-turn lanes for operating speeds of 30, 50, and 70 mph (50, 80, and 110 km/h).

An analysis of the speed data collected at the rumble strip sites revealed a small decrease, generally 1 to 2 mph (1.6 to 3.2 km/h) in mean and 85th percentile speeds on approaches with rumble strips at distances of 1000 ft (305 m) or less from the stop line. A comparison of deceleration behavior shows a less gradual deceleration for drivers in the “after” period. Statistical tests on mean speeds from a subset of five similar sites revealed that all differences in mean speeds greater than 1.0 mph (1.6 km/h) were statistically significant throughout the entire speed profile. Thus, while the magnitude of difference in speed does not appear substantial in practice, it is statistically significant and occurs along the entire approach to the intersection (see Figure 3).

The Researchers Recommend...

As a result of this project, the researchers recommend:

- adopting new left-turn lane installation guidelines,
- encouraging the use of rumble strips at locations where drivers need additional warning of the downstream intersection, and
- conducting a safety study on in-lane rumble strip installations.

Table 1. Recommended Guidelines for Installing Left-Turn Lanes on Two-Lane Highways.

Opposing Volume (vph)	Advancing Volume (vph) — Percent Left Turns: 10	20	30
30 mph (50 km/h)			
800	197	148	121
700	217	162	133
600	238	178	146
500	261	196	160
400	286	215	175
300	314	236	193
200	345	259	211
100	380	285	232
0	418	313	256
50 mph (80 km/h)			
800	153	115	94
700	168	126	103
600	184	138	113
500	202	152	124
400	222	166	136
300	244	183	149
200	268	201	164
100	294	221	180
0	323	243	198
70 mph (110 km/h)			
800	88	66	54
700	97	73	59
600	106	80	65
500	117	88	71
400	128	96	78
300	141	105	86
200	154	116	95
100	170	127	104
0	187	140	114

Example: For a 70 mph (110 km/h) two-lane highway with 10 percent left turns, a left-turn lane should be considered when the opposing volume is 200 vph and the advancing volume is more than or equal to 154 vph.

For More Details . . .

The research findings, results, conclusions, and recommendations are documented in:

Report 4048-2, *Treatments for Crashes on Rural Two-Lane Highways in Texas*

Report 0-4278-2, *Left-Turn and In-Lane Rumble Strip Treatment for Rural Intersections*

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TxDOT Implementation Status January 2004

The objective of this research project was to identify and evaluate safety measures at rural intersections and to develop materials regarding rural intersection safety. One product was required for this project: a rural intersection safety handbook. The information contained in this product was submitted as Chapter 6 in Research Report 4048-2, *Treatments for Crashes on Rural Two-Lane Highways in Texas*, which has been distributed to all TxDOT districts. As a result, the recommendations that were developed in this research project can be implemented immediately.

For more information, contact Mr. Wade Odell, P.E., RTI Research Engineer, at (512) 465-7403, or e-mail wodell@dot.state.tx.us.

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