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Project Summary Report 0-4618-S
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Project 0-4618: Conversion of Two-Lane Rural Roadways to Four-Lane Roadways

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PROJECT SUMMARY REPORT

Summary of Comparison of Crashes on Rural Two-Lane and Four-Lane Highways in Texas

The selection of a cross section is a major decision and turning point for a roadway design. Decisions regarding number of lanes, presence and width of a median, lane width, and shoulder width greatly affect safety, cost, and capacity of a roadway. Although capacity and cost considerations are generally readily evaluated, the impact of the cross section on safety is not always apparent. Recent efforts both on a national level with the development of the *Highway Safety Manual* and within the state of Texas as part of Texas Department of Transportation (TxDOT) Research Project 0-4703, however, are developing guidance materials that can evaluate potential safety effects of different design alternatives.

TxDOT sponsored Project 0-4618 with the following objectives:

- identify the relationship between cross sectional elements (e.g., lane width, shoulder width) with crashes on rural two-lane highways;
- identify the relationship between cross sectional elements (e.g., lane width, shoulder width, median width or type) with crashes on rural four-lane highways;
- compare the number of crashes between rural two-lane highways with wide shoulders and rural four-lane highways with narrow shoulders; and
- determine intersection characteristics, especially left-turn lanes, on intersection crashes.

What We Did...

In order to fulfill these objectives, Project 0-4618 developed two datasets—roadway segments and intersections. To compare the safety relationships for cross sectional elements on rural, two- and four-lane roadways, a range of lane widths and shoulder widths is needed (photographs of example sites are shown in Figure 1). The dataset of rural highway roadway segments included the following:

- two- and four-lane segments,
- range of shoulder widths (between 0 and more than 12 ft),
- range of lane widths (between 9 and more than 12 ft), and
- a sample of median types and widths.

The dataset for intersections included the above information and a number of other variables, such as skew of the intersection, type of control, and presence of turn lanes.

The overall data collection procedure was to identify roadway segments of interest, to videotape those roadways while driving at or near highway speed, and then to pull geometric information from the videotapes in the office. The videotapes would also be used to identify intersections of interest for the intersection analyses. Supplementing the data from the video were:

- information from straight-line diagrams provided by the districts and
- data, such as average daily traffic (ADT) values, from the Texas Reference Marker databases.

What We Found...

Rural Two-Lane Highways

The objective of this portion of the project was to find the relationship between crashes on rural two-lane highways with lane and shoulder widths. A subset of Texas on-system crashes called surface width influence crashes (SWIC) for the years 1999 to 2001 was used in the analysis. While SWIC were the crash type primarily used in the evaluations, other crash types (e.g., total crashes and fatal/injury crashes) were also considered. Prediction models

Example of Two-Lane Highway

Example of Four-Lane Highway

Example of a Two-Lane with Wide Shoulder

Example of Four-Lane with Minimal Shoulder

Figure 1. Examples of Roadway Segments Included in Dataset.

were developed, and the equations are shown in Table 1. These prediction equations can be used to identify the mean crash value over roadway segments of similar conditions.

The impact of changes in lane width and shoulder width on crashes can be seen in the ratios of number of crashes for a given width to the number of crashes on a roadway with a selected width. For example, the ratio of crashes on a roadway with no shoulders as compared to a roadway with 8 ft shoulders is 1.62. In other words, the no-shoulder segment is predicted to have 62 percent more crashes. This example assumes that all other conditions for the two roadways are similar, such as lane width and roadside conditions. The ratios for shoulders and lane widths were determined and are listed in Table 2.

Rural Four-Lane Highways

The relationship between crashes on rural four-lane highways with lane, shoulder, and median widths was also examined as part of this project. Again SWIC, along with other crash types, for the years 1999 to 2001 were used in the analysis. The regression evaluations found median class to not meet the significance at the 5 percent alpha level requirement in the evaluation of total crashes. Other research has found median width or type of median to be significant; however, the data available within this project (which included a large portion of segments with no median due to other objectives of the project) did not show a relationship between crashes and median class or width.

As with the two-lane highway analysis, the impact of changes in lane width and shoulder width on

Table 1. Regression Prediction Models.

The following model was selected for predicting **SWIC** on rural two-lane highways: E(SWIC) = [exp(–5.0189 – 0.1126 RTLane – 0.0509 RTShou + 0.9091 LogLen + 0.9085 LogADT)]/3 The following model was selected for predicting **total crashes** on rural two-lane highways: E(Total Crashes) = [exp(–5.0981 – 0.1372 RTLane – 0.0601 RTShou + 0.8514 LogLen + 1.0045 LogADT)]/3
The following model was selected for predicting **SWIC** on rural four-lane highways: E(SWIC) = [exp(–6.8122 – 0.0427 RTShou + 0.9354 LogLen + 0.9441 LogADT)]/3 The following model was selected for predicting **total crashes** on rural four-lane highways: E(Total Crashes) = [exp(–5.1437 – 0.1392 RTLane – 0.0618 RTShou + 0.7956 LogLen + 0.9990 LogADT)]/3

Table 2. Ratios for Lane Width and Shoulder Widths Based on Total Crashes.

Rural Two-Lane Highways		Rural Four-Lane Highways	
Lane Width (ft)	Ratio to 12 ft Lane	Lane Width (ft)	Ratio to 12 ft Lane
12	1.00	12	1.00
11	1.15	11	1.15
10	1.32	10	1.32
9	1.51	9	1.52
Shoulder Width (ft)	**Ratio to 8 ft Shoulder**	**Shoulder Width (ft)**	**Ratio to 8 ft Shoulder**
10	0.89	10	0.88
9	0.94	9	0.94
8	1.00	8	1.00
7	1.06	7	1.06
6	1.13	6	1.13
5	1.20	5	1.20
4	1.27	4	1.28
3	1.35	3	1.36
2	1.43	2	1.45
1	1.52	1	1.54
0	1.62	0	1.64

crashes can be seen in the ratios of number of crashes. The ratios for shoulders and lane widths were determined based on the predictions of total crashes and are listed in Table 2.

Conversion from a Two-Lane to a Four-Lane Highway

A low-cost method to increase capacity on rural highways is to stripe a formerly two-lane highway with wide shoulders into a four-lane with minimal shoulders. These decisions have generally been made based on capacity criteria. Information on the safety trade-offs was sought. An analysis used crash data from 1999 to 2001 to examine the safety performance on highways with a surface width of 44 to 54 ft with either two lanes and wide shoulders or four lanes with minimal shoulders. The findings indicate that the conversion should be considered only at very high ADTs (e.g., 10,000 and greater) and wide surface widths (53 ft and more) based on safety.

Intersections

In the intersection analysis, major-road ADT and cross-road ADT were statistically significant. Other variables were significant in different situations and should be considered as appropriate when making safety decisions regarding an intersection. For example, the right shoulder width and the presence of left-turn lane(s) were significant in certain conditions. Previous research projects have also demonstrated the value of left- and right-turn lanes and wider outside shoulders along with the value of lighting at intersections.

The Researchers Recommend...

Lane width and shoulder width have a significant impact on safety of rural two-lane and four-lane highways. Prediction models were used to generate the percent change in crashes between different shoulder or lane width decisions. These values can be used when evaluating alternatives. A conversion from a two-lane with wide shoulder cross section to a four-lane with narrow shoulder cross section should be considered only at very high ADTs and wide surface widths based on safety. Several variables were found through the literature and through this project that affect crash prediction at rural intersections. Those elements that can be influenced by designers with the greatest benefits in affecting crashes include left-turn lanes, lighting, and wider right shoulders/right-turn lanes. Variables with the greatest influence on crashes are the subject-road ADT and the cross-road ADT.

For More Details...

The research is documented in Report 0-4618-1, *Comparisons of Crashes on Rural Two-Lane and Four-Lane Highways in Texas.*

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