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16. Abstract The safety and operations of Texas rural two-lane highways are being affected by increased traffic associated with the energy sector, including the unique characteristics of heavy trucks. Researchers reviewed existing conditions on select rural two-lane highways along with recent literature to develop the following two-page briefing sheets:					
<ul style="list-style-type: none"> • Length and Spacing of Super 2 Passing Lanes. • Operational Characteristics of Super 2 Corridors. • Safety Characteristics of Super 2 Corridors. • Signing and Marking on Super 2 Corridors. • Turn Lanes on Rural Highways. 					
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BRIEFING SHEETS ON SAFETY AND OPERATIONS OF RURAL TWO-LANE HIGHWAYS

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

This report is not intended for construction, bidding, or permit purposes. The engineer in charge of the project was Kay Fitzpatrick, P.E., #86762.

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LENGTH AND SPACING OF SUPER 2 PASSING LANES

*Two previous TxDOT-sponsored research projects have involved observation of Super 2 traffic and analysis of traffic on simulated Super 2 corridors to gain insights into operational performance. **Research results indicated that passing lane lengths of 1.5 to 2.0 miles provide the best operations; additional length provides diminishing additional benefit compared to adding another lane elsewhere in the corridor. Research also recommended passing lane spacing of 3.5 to 4.0 miles for ADTs above 3000, depending on other constraints.***

Background

Rural two-lane highway corridors with periodic passing lanes (called “Super 2” highways in Texas) provide operational and safety improvements at a much lower cost than a traditional expansion to four lanes. For the passing lanes to be effective, however, they need to be long enough and occur frequently enough to allow passing to take place where it is most needed, without being too long or resembling a four-lane highway

TxDOT Research

A previous TxDOT project (0-4064) conducted simulation on Super 2 passing lanes of various lengths and spacing for two-way volumes between 400 and 1000 vph. The research indicated that passing lane lengths should be between 1.5 and



Most passing occurs in the first 1.5 miles of a passing lane.

Improvements achieved by increasing the number of passing lanes usually are greater than the improvements achieved by increasing the length.

2.0 miles for ADT ≥ 3550 on level terrain and ≥ 3000 on rolling terrain. The distance between passing lanes for those volumes was 3.5 to 4.0 miles, with the guidance that passing lanes should be located to best fit existing terrain and field conditions and avoid major intersections.

A more recent TxDOT-sponsored project (0-6135) reviewed those recommendations in the context of higher ADTs and simulated additional Super 2 operational scenarios. The 0-6135 research found that passing lane lengths over 2 miles show less incremental benefit than higher frequency of lanes, particularly for ADT less than 10,000 vpd. Among the conclusions of the research was that providing additional passing lanes in a Super 2 corridor is preferable to adding length to a given passing lane. Much of the passing activity in a passing lane takes place in the first 1.0 to 1.5 miles, even if additional length is provided. More frequent passing lanes result in reduced delay as compared to longer passing lanes. Regardless of volume, it was recommended that passing lanes be 2 miles or less in general, longer than 3 miles should be used sparingly, and lengths of more than 4 miles should be avoided.

The traffic conditions simulated on Project 0-6135 compared scenarios with 10 percent truck volume and 20 percent truck volume. Results indicated that the truck percentage and terrain types (i.e., level or rolling) showed negligible impact on the measure of percent time spent following, but their impacts on the measure of average delay and number of passes were more pronounced. In most scenarios, the number of passes for 20 percent truck volume was higher than that for 10 percent trucks.

For More Details...

- [Super 2 Highways: Two-Lane Rural Highways with Passing Lanes](#) – Project Summary Report from TxDOT Project 0-4064
- [Operations and Safety of Super 2 Corridors with Higher Volumes](#) – Research Report from TxDOT Project 0-6135
- [0-6135: Super 2 Design for Higher Traffic Volumes](#) – Project Summary Report from TxDOT Project 0-6135
- [Design Guidelines for Passing Lanes on Two-Lane Roadways \(Super 2\)](#) – Research Report from TxDOT Project 0-4064

About TTI

TTI is recognized nationally for its expertise in all modes of transportation and has been extensively involved in mobility research for more than 60 years. The agency's researchers have developed a wide range of solutions to mobility issues, including managed lanes, improved public transportation services, and intelligent transportation systems. These studies have successfully assessed potential improvements, enhanced evaluation and prioritization processes, and resulted in the cost-effective implementation of numerous projects to improve mobility and quality of life.

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OPERATIONAL CHARACTERISTICS OF SUPER 2 CORRIDORS

*Two operational analyses were conducted (2001 and 2011) that analyzed conditions on existing Super 2 corridors and simulated results for additional scenarios. **The results showed that Super 2 highways, initially considered a treatment for two-lane roads with low to moderate volumes, can provide operational benefits for corridors approaching 15,000 ADT, especially with rolling terrain and/or increasing truck volumes.***

Background

Research has shown that periodic passing lanes on two-lane highways, called “Super 2” highways in Texas, can improve operations and provide many benefits of four-lane roadways with much lower costs. Thus, roadways with higher volumes and fewer passing opportunities can improve performance without widening to four lanes.

TxDOT Research

A 2001 TxDOT project (0-4064) focused on Super 2 design, signing, and markings for highways at or

below 5000 vehicles per day. The project recommended passing lane lengths and intervals, lane and shoulder widths, advance signing, and pavement markings in transition areas. Standard drawings were developed for sign and marking layouts, and recommendations for



Providing periodic passing lanes on two-lane rural highways provides a benefit in reduced delay and time spent following, which improves operations and reduces the need for drivers to pass on two-lane sections.

geometric design values were added to the TxDOT *Roadway Design Manual*.

A 2011 TxDOT project (0-6135) took a new look at Super 2 for higher volumes, reviewing operations and safety performance to consider changes to design guidance. Key items from that project are as follows

- ADT is not a limiting factor on installing passing lanes, but it can be used to prioritize sites.
- Passenger vehicles tend to complete most passing activity within the first 1.0 to 1.5 miles of a passing lane.
- Where terrain and available budget allow, adding another passing lane is preferred over adding length to an existing one. Passing lane lengths over 2 miles showed less incremental benefit than higher frequency of lanes, particularly for ADT less than 10,000.
- Avoid passing lanes upstream of locations with restrictive geometry or other impediments to traffic flow. Installing passing lanes downstream of these features, however, can be beneficial to dispersing platoons.
- Avoid terminating passing lanes on significant uphill grades. Coordinate passing lanes with climbing lane needs to improve operating characteristics.
- Improvements can be costly if additional right-of-way is needed for the project. Space restrictions (e.g., bridges, culverts, intersections, etc.) must be considered when choosing appropriate treatments that will meet future traffic needs.

For More Details...

- [Design Guidelines for Passing Lanes on Two-Lane Roadways \(Super 2\)](#) – Research Report from TxDOT Project 0-4064

- [Super 2 Highways: Two-Lane Rural Highways with Passing Lanes](#) – Project Summary Report from TxDOT Project 0-4064
- [Operations and Safety of Super 2 Corridors with Higher Volumes](#) – Research Report from TxDOT Project 0-6135
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SAFETY CHARACTERISTICS OF SUPER 2 CORRIDORS

*A safety analysis was conducted that used twelve years (1997-2001 and 2003-2009) of Texas data, and that considered fatal (K), incapacitating injury (A), non-incapacitating injury (B), and minor injury (C) crashes (i.e., property damage only crashes were not included). The safety analyses were carried out for five corridors of about 53 centerline-miles. **The results showed that the installation of Super 2 highways led to a statistically significant crash reduction of 35 percent for segment-only crashes (KABC) and 42 percent for segment-and-intersection crashes (KABC) on the study corridors.***

Background

In Texas, a “Super 2” highway is defined as a two-lane rural highway in which periodic passing lanes have been added to allow passing of slower vehicles and the dispersal of traffic platoons. It is

often designed as an alternate solution to a four-lane roadway due to fiscal constraints.



The provision of Super 2 highways decreases the number of crashes on those facilities.

With the provision of periodic passing lanes, they allow motorists increased opportunities to safely and easily pass slower vehicles, thus improving traffic flow at a much lower cost than a traditional expansion to four lanes.

TxDOT Research

A previous TxDOT project (0-6135) investigated the safety effectiveness of Super 2 Highways in Texas using twelve years (1997-2001 and 2003-2009) of Texas data. The analyses were carried out for five corridors of about 53 centerline-miles (see Table 1) using fatal, incapacitating injury, non-incapacitating injury, and minor injury crashes (i.e., property damage only crashes were not included). The results showed that the installation of Super 2 highways led to a statistically significant crash reduction of:

- 35 percent for segment-only crashes.
- 42 percent for segment-and-intersection crashes.

These findings are consistent with findings of previous safety-related studies of passing lanes.

Table 1. Passing Lanes in Texas Included in Research Study

District (County) Highway	Control-Section	# ^a	Length (mile)	'07 AADT ^b (veh/d ay)
Paris (Fannin) SH 21	549-1	4	6.73	6500~6900
	549-2	6	9.34	6300~7700
Wichita Falls (Wilbarger) US 83	124-2	10	17.2	1850
Yoakum (Gonzales) US 183	153-2	4	11.6	5000
Bryan (Grimes) SH 30	212-4	4	7.52	4300

NOTES:

^aNumber of passing lane segments
^bAADTs were obtained from the TxDOT Statewide Planning Map, located at:
http://www.dot.state.tx.us/apps/statewide_mapping/StatewidePlanningMap.html

For More Details...

- [Operations and Safety of Super 2 Corridors with Higher Volumes](#) – Research Report from TxDOT Project 0-6135
- [0-6135: Super 2 Design for Higher Traffic Volumes](#) – Project Summary Report from TxDOT Project 0-6135

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SIGNING AND MARKING ON SUPER 2 CORRIDORS

*Previous TxDOT-sponsored research observed operations on existing Super 2 corridors in three states and surveyed drivers on their preferences and understanding of selected signs and markings. **Researchers concluded that advance notice of upcoming passing lanes and positive guidance in taper areas can improve operations on Super 2 corridors.***

Background

The use of periodic, short-term passing lanes is known in Texas as a “Super 2” design. The passing lanes may be alternating or side-by-side, but they are placed at regular intervals. Passing lanes are often constructed on two-lane roadways to improve overall traffic operations by breaking up traffic platoons and by reducing delays caused by inadequate passing opportunities over substantial lengths of roadway. It is important that these passing lanes have appropriate signs and markings to maximize their potential benefits.

TxDOT Research

A previous TxDOT project (0-4064) was tasked with developing Super 2 design criteria. Site evaluations were conducted in Texas, Kansas, and Minnesota, including before-and-after studies of driver behavior for variations in pavement markings. Laptop-based surveys were also



Drivers showed better comprehension and better compliance in lane selection with use of dotted lines in the approach taper. The addition of a left arrow pavement marking can supplement the “merge right” sign.

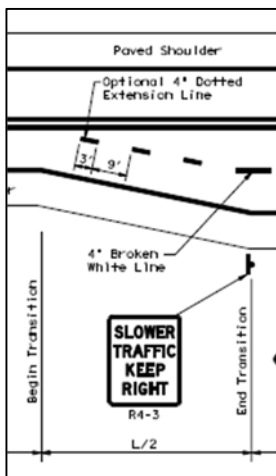
conducted to determine driver reaction to wording on signs and pavement markings entering a passing lane section.

Researchers concluded that advance signing should be provided regarding the upcoming passing lane so that drivers are aware of its presence. The preferred sign (and associated sign placement) is that the passing lane is upcoming in 2 miles (i.e., PASSING LANE 2 MILES). Another sign should be provided at the end of the passing lane declaring the distance to the next passing lane (i.e., NEXT PASSING LANE X MILES) when that distance is 12 miles or less.

A dotted white line in the transition area extending from near the highway centerline to the beginning of the white broken line separating the passing lane from the right lane should be provided, to improve compliance with slower vehicles traveling in the right lane.

Current Practice

The current Traffic Standards from TxDOT's Traffic Operations Division contain typical sheets for different configurations of Super 2 passing lanes, including recommended signs and markings. These typical sheets [TS2(PL-1)¹² and TS2(PL-2)¹²] show signs, markings, taper lengths, and other key dimensions developed from TxDOT research.



Portion of TS2 (PL-1)-12

A marking not shown on the typical sheets is a large left arrow that is sometimes used at the end of a passing lane to supplement the “merge right” signs that notify the driver that the lane is ending. The arrow is commonly applied as a set of two. An example is shown in the inset photo on the first page.

For More Details...

- [Design Guidelines for Passing Lanes on Two-Lane Roadways \(Super 2\)](#) – Research Report from TxDOT Project 0-4064
- [Super 2 Highways: Two-Lane Rural Highways with Passing Lanes](#) – Project Summary Report from TxDOT Project 0-4064
- [Traffic Standards \(English\)](#) – Online file storage from TxDOT Traffic Operations

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TURN LANES ON RURAL HIGHWAYS

*Left-turn and right-turn lanes at rural intersections can be useful for removing slowing traffic from high-speed through lanes. The Texas Roadway Design Manual contains some guidance on the installation of turn lanes on rural intersections. **Additional guidance—available from recent national research—provides suggested warrants for turn lanes on rural two-lane and four-lane highways.***

Background

Highway intersections create conflict points for turning and slowing traffic as vehicles enter and exit the intersecting roadways. While dedicated turning lanes and speed-change lanes are often considered for urban streets and freeways, respectively, they have a purpose on rural highways as well to help separate turning and slowing traffic from through traffic, reducing opportunities for delay and crashes.



A lack of a left-turn lane can result in long queues waiting to turn.

TxDOT Guidance

The TxDOT *Roadway Design Manual* (RDM) provides guidance on where to install turn lanes on rural two-lane and multilane highways. The RDM states that 10-ft shoulders generally provide sufficient area for right-turning vehicles to accelerate or decelerate, though guidelines are provided for adding a dedicated turn lane and associated speed-change lane.

In Chapter 3, Section 5, the RDM provides detailed guidance on the design of left-turn and right-turn lanes for multilane rural highways; much of that guidance is very similar to the American Association of State Highway and Transportation Officials' (AASHTO) *A Policy on Geometric Design of Highways and Streets* (commonly known as the Green Book).

Recent Research

The RDM and Green Book do not contain the findings from the most recent research, however. Three NCHRP projects on auxiliary lanes have provided suggested changes for guidance on installing left- and right-turn lanes. NCHRP Project 3-91 developed guidance for left-turn lanes, and Project 3-72 did the same for right-turn lanes. NCHRP Project 3-102 combined the guidance from those projects, along with research on deceleration length and design of double left-turn lanes, to produce a comprehensive set of recommendations on auxiliary lane design, including a set of warrants for left-turn lane installation, an example of which is shown in Figure 1.

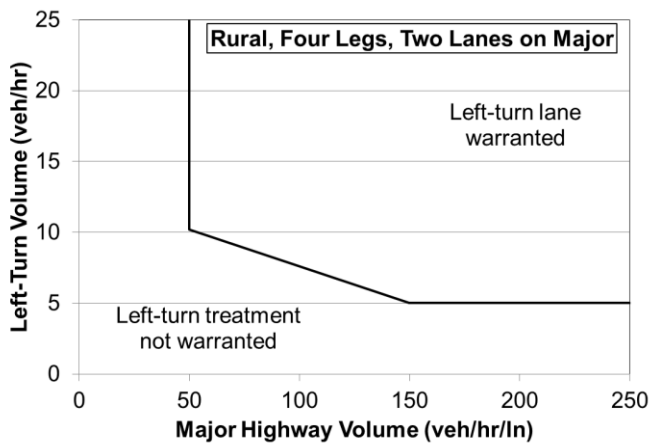


Figure 1. Left-Turn Lane Warrant for a Four-Leg Intersection on a Rural Two-Lane Highway

For More Details...

- [Roadway Design Manual](#) – Official TxDOT Manual Online
- NCHRP Web-Only Document 208: [Design Guidance for Channelized Right-Turn Lanes](#)

- [Transportation Research Record 2023: Operational and Safety Effects of Right-Turn Deceleration Lanes on Urban and Suburban Arterials](#)
- NCHRP Report 745: [Left Turn Accommodations at Unsignalized Intersections](#)
- NCHRP Report 780: [Design Guidance for Intersection Auxiliary Lanes](#)

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