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16. Abstract

In Texas, high-occupancy vehicle (HOV) lanes have emerged as an integral part of the state's current and future transportation system to aid urban mobility. As a result, the issue of HOV lane design and the influence of design on safety has become the focus of much attention in the transportation community. This document provides guidance for future design of freeways with HOV lanes based on an analysis of crash data from Dallas, Texas. This guidance indicates desirable corridor characteristics when considering HOV lane implementation and recommends roadway cross-sections when implementing HOV lanes similar to those in operation in Dallas, Texas.

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# GUIDANCE FOR FUTURE DESIGN OF FREEWAYS WITH HIGH-OCCUPANCY VEHICLE (HOV) LANES BASED ON AN ANALYSIS OF CRASH DATA FROM DALLAS, TEXAS

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## DISCLAIMER

# TABLE OF CONTENTS

**Page**

# LIST OF FIGURES

**Page**

# INTRODUCTION

In Texas, high-occupancy vehicle (HOV) lanes have emerged as an integral part of the state's current and future transportation system to aid urban mobility. As a result, the issue of HOV lane design and the influence of design on safety has become the focus of much attention in the transportation community.

This guidance for future design of freeways with HOV lanes is based on an analysis of injury crash data from Dallas, Texas. The injury crash data are from three corridors in the Dallas area that have HOV lanes. The IH-30 corridor east of downtown Dallas includes a moveable barrier-separated contraflow HOV lane that has been in operation since 1991. The IH-35E North and IH-635 corridors both include buffer-separated concurrent flow HOV lanes. Both facilities are bi-directional and have a painted buffer separation. They have been in operation since the mid 1990s. All of these HOV lanes are considered interim projects by the Federal Highway Administration (FHWA) because they were retrofitted into the existing freeway facility resulting in design exceptions from normally required standards.

Injury crash rates from Dallas corridors with an HOV lane were analyzed over multiple years. Using injury crash rates, the research team looked for changes in crash occurrence in these corridors after implementing HOV lanes. The crash data from the IH-30 corridor does not indicate a change in injury crash occurrence, except during the years 1995 and 1996, when it appears that several large construction projects resulted in more crashes in the corridor. Dallas corridors with buffer-separated concurrent flow HOV lanes did show a change in crash occurrence with an increase in injury crash rates.

The research team reviewed crash reports and speed data from the buffer-separated HOV lane corridors. The research team found that many of the crashes that were occurring in the buffer-separated concurrent flow HOV lane and the adjacent general-purpose lane were related to the speed differential between the two lanes.

Based on the analysis of crash data and the copies of crash reports, the research team developed guidance for future design of HOV lanes in the Dallas area. This guidance includes suggestions for corridor characteristics and HOV lane cross-sections for barrier-separated contraflow HOV lanes and painted buffer-separated concurrent flow HOV lanes. In the case of buffer-separated concurrent flow HOV lanes, the cross-sections are intended to lessen the influence of speed differential between the HOV lane and the general-purpose lanes by providing greater width cross-sections in the HOV lane area (i.e., inside shoulder, HOV lane, and painted buffer). This increased width provides room for two vehicles to be side by side and may prevent many of the types of crashes studied.

## MOVEABLE BARRIER-SEPARATED CONTRAFLOW HOV LANES

Consideration of corridor characteristics is important when deciding on the type of HOV lane to employ. The corridor characteristics of IH-30 in the Dallas area include limited right-of-way and low traffic in the off-peak direction. The crash data from the IH-30 corridor does not indicate a change in injury crash occurrence, except during the years 1995 and 1996, when it appears that several large construction projects resulted in more crashes in the corridor. With this in mind, the following items identify suggested corridor characteristics to use when choosing to implement a moveable barrier-separated contraflow HOV lane similar to the one on IH-30 east of downtown Dallas:

### Suggested Corridor Characteristics for Implementation

- Radial corridor
- Long distance trips
- Limited right-of-way
- At least three general-purpose lanes in each direction
- Highly directional traffic flow
- Relatively low traffic in the off-peak direction allowing one lane in the off-peak direction to be used as the contraflow HOV lane
- Number of general-purpose lanes in the peak direction remains unchanged by implementation of contraflow lane
- Corridors in need of interim congestion mitigation until future highway geometric design changes can be implemented

### Cross-Section for Operation of Moveable Barrier-Separated HOV Lanes (Desirable)

Figure 1 provides a recommended desirable cross-section to use when implementing a moveable barrier-separated contraflow HOV lane.

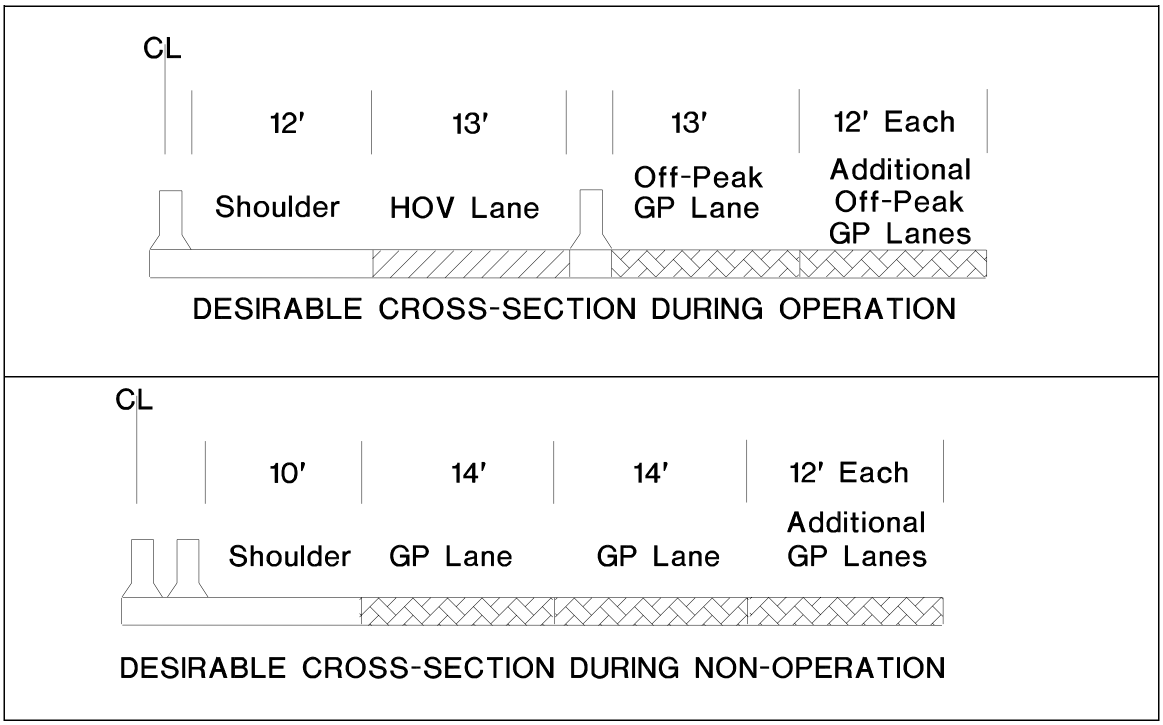


**Figure 1. Moveable Barrier-Separated HOV Lanes (Desirable).**

**Cross-Section for Operation of Moveable Barrier-Separated HOV Lanes (Minimum)**

Figure 2 provides a recommended minimum cross-section to use when implementing a moveable barrier-separated contraflow HOV lane. The minimum cross-section is currently being used in the IH-30 corridor in Dallas.

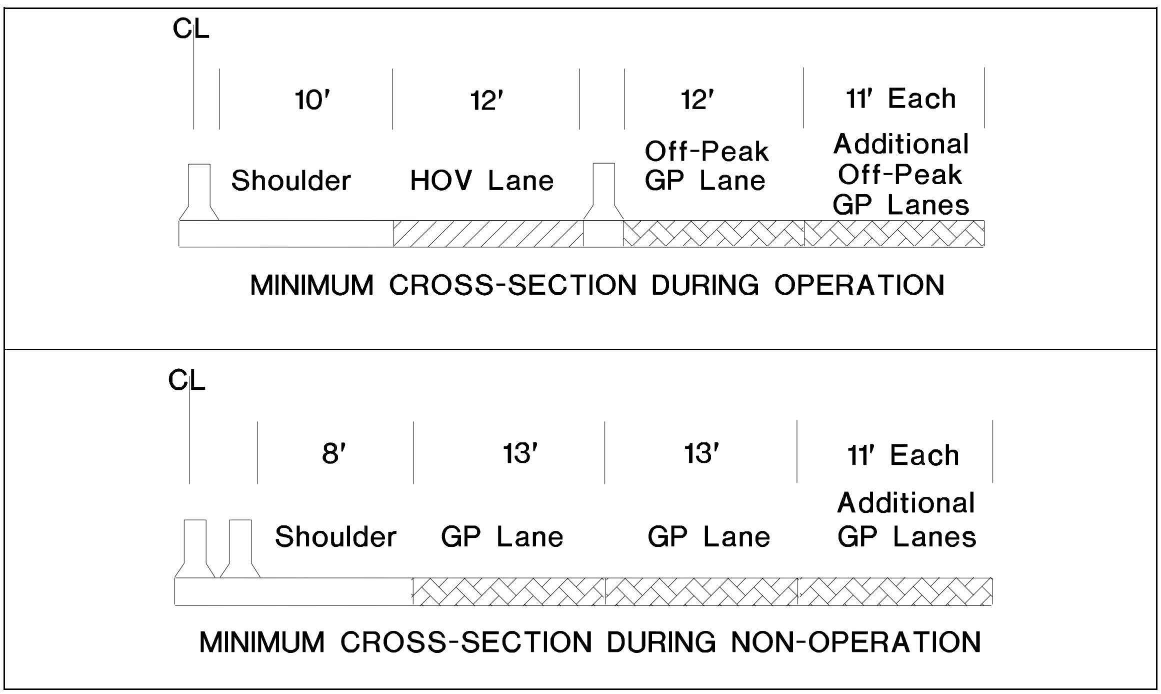


**Figure 2. Moveable Barrier-Separated HOV Lanes (Minimum).**

## BUFFER-SEPARATED CONCURRENT FLOW HOV LANES

Consideration of corridor characteristics is important when deciding on the type of HOV lane to employ. IH-635 (LBJ) is a highly congested circumferential corridor around northern Dallas serving eastbound and westbound traffic. The traffic characteristics are known to be mostly short trips that cause a great deal of weaving of vehicles from lane to lane. Numerous freeway ramps and ramp spacing are thought to contribute to the weaving in the corridor.

Based on the freeway characteristics and a review of crash data within the corridor, it appears that the excessive congestion in the general-purpose lanes (i.e., bumper-to-bumper traffic) makes it difficult for vehicles in the HOV lane to find gaps in Lane 1 to easily change lanes. Also, vehicles in the slow moving general-purpose lanes wishing to enter the HOV lane must first change lanes into the HOV lane and then accelerate up to speed. In either situation, the speed differential between the HOV lane and Lane 1 appears to be a factor in crash occurrence.

These characteristics have probably contributed to the corridor's injury crash rate increase since implementation of the buffer-separated concurrent flow HOV lane. With this in mind, the following items identify suggested corridor characteristics to use when choosing to implement a buffer-separated concurrent flow HOV lane in the Dallas area in the future:

### Suggested Corridor Characteristics for Implementation

- Radial corridor
- Long distance trips
- Minimum cross-section can be used for interim installations
- Minimum cross-section can be used across a narrow bridge structure or around columns
- Good freeway ramp spacing that meets or exceeds current AASHTO guidelines
- Opportunity for enforcement locations

**Cross-Section for Buffer-Separated Concurrent Flow HOV Lanes (Desirable/Minimum)**

Figure 3 provides recommended desirable and minimum cross-sections to use when implementing a buffer-separated HOV lane. The minimum cross-section provides enough room for two 8 foot wide vehicles to be in the HOV lane area (inside shoulder, HOV lane, and painted buffer) of the freeway without encroaching on the general-purpose lanes. This is important because it allows opportunity to avoid collisions due to the large speed differential between the HOV lane and the general-purpose lanes.

Vehicles in the Dallas buffer-separated HOV lanes experience difficulties moving to the general-purpose lanes due to the high level of congestion in the general-purpose lanes. The gaps are not available to do this maneuver at high speeds. With at least the minimum cross-section shown in Figure 3, HOV lane vehicles can slow or stop if necessary to wait for gaps in the general-purpose lanes and to see if enough room remains for another HOV vehicle to pass.

The minimum cross-section also provides enough room for a slow moving vehicle in the general-purpose lanes to move into the HOV lane and accelerate without completely obstructing the HOV lane or Lane 1. Again, a faster moving vehicle in the HOV lane can move past a slower moving vehicle that has not yet gotten up to speed.

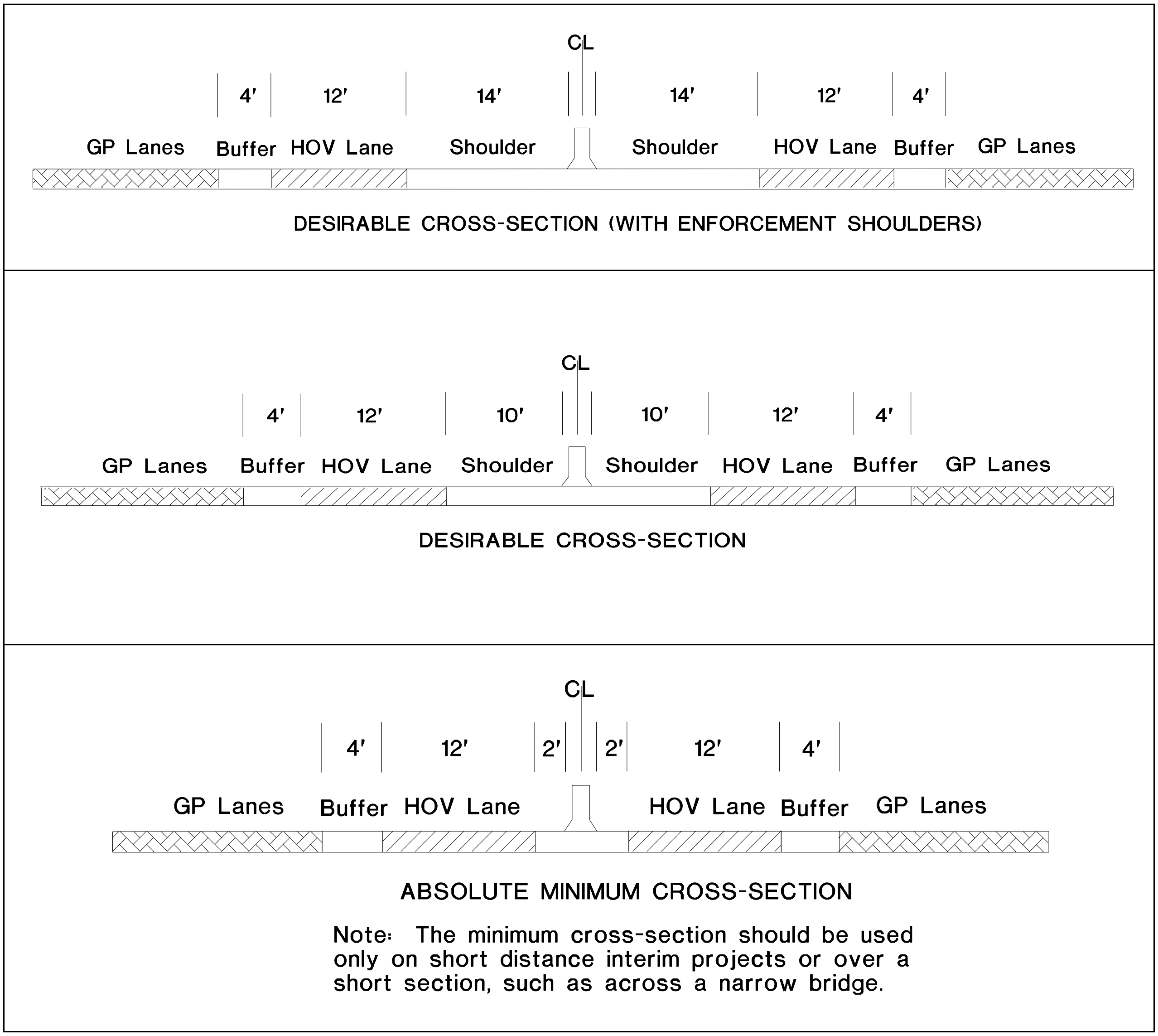


**Figure 3. Buffer-Separated Concurrent Flow HOV Lanes (Desirable/Minimum).**

## OTHER GEOMETRIC DESIGN CONSIDERATIONS

In addition to corridor characteristics and cross-sections, there are two additional treatments to be considered and, if possible, included in the design of a proposed HOV lane facility. The location of the endpoint or terminus of an HOV lane, as well as the location of the ingress/egress points on a lane, can contribute to crash occurrence if not properly designed. Therefore, designers should consider these geometric design treatments when designing a facility.

### Endpoint/Terminus of HOV Lane

- Do not end/terminate an HOV lane in an area of congestion.

- Provide, if possible or feasible, the HOV lane its own travel lane as vehicles exit the facility into the general-purpose lanes, either at an intermediate access point or at the terminus. If providing their own travel lane requires that a general-purpose lane be dropped, it should be dropped as an exit-only lane to a freeway exit ramp at a known location with high exiting volumes. This plan provides lane balance for the general-purpose lanes immediately before and after the access location.

### Ingress/Egress

- Direct connection ramps are the preferred access type. Other access types require weaving across general-purpose lanes. Therefore, the maximum distance available should be provided between the HOV lane access point and the nearest freeway entrance or exit ramp to safely accommodate the weaving vehicles. Vehicles should have a minimum of 800 feet per lane change to accomplish the weaving maneuver.

- Intermediate access openings, or merge areas, of 1,300 to 1,500 feet in length are desirable for buffer-separated concurrent flow HOV lanes. These openings should safely accommodate vehicles weaving to and from the HOV lane. The merge area is effectively a Type A weave and the total weaving volume should, if possible, be estimated to determine if a longer opening is required. A large volume of weaving vehicles may require a separate weave lane between the HOV lane and the inside general-purpose lane to facilitate acceleration and deceleration of vehicles.

- HOV lane ingress/egress should not be located on a horizontal curve due to sight distance issues. The horizontal sight distance problem is compounded when there is a speed differential between adjacent lanes, as is the case with buffer-separated concurrent flow HOV lanes. A vertical curve also poses a potential sight distance problem; however, this is not as critical as horizontal sight distance problems.

- The preferred location of an HOV lane ingress/egress is between a freeway exit ramp and entrance ramp configuration. If an HOV lane ingress occurs after a freeway entrance ramp, drivers are tempted to quickly merge across multiple traffic lanes. The reverse scenario is also a problem when an HOV lane egress precedes a freeway exit ramp, which tempts drivers to quickly merge across multiple traffic lanes.

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