

Project Summary Report O-1846-S

Project O-1846: Development of Design Guidelines for  
the Provision of Median Access on Principal Arterials

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## DESIGN OF MEDIANS FOR PRINCIPAL ARTERIALS

### WHAT WE DID ...

Public highways and streets have dual but competing roles: to provide property access and to move through traffic. Highway functional classification systems recognize the competition between access and flow, generally specifying that principal arterial streets primarily move traffic and secondarily provide access, while local streets primarily provide access and secondarily move traffic. Access provision is problematic for traffic flow because right turns, and especially left turns, into and out of driveways create traffic stream friction that often totally blocks through movements. Practical ways of controlling flow potential loss include limiting the number of property access driveways, restricting left-turn opportunities, and using good driveway geometric standards. Although the current criteria are appropriate, they lack the specificity needed by busy designers dealing with property owners and developers. This study provides specific guidance about safety, mobility, and economic impacts regarding:

1. Divided roadway and continuous center left-turn lane treatments,
2. Acceleration and deceleration lane design,
3. Raised and flush median treatments, and
4. Spacing between adjacent access points.

This process is applicable to four-lane, two-directional cross sections. The application method will follow a step-by-step instructional pattern that mimics the decision process that would be executed by a designer.

### WHAT WE FOUND ...

#### Necessary Information

Information required to complete the application process includes:

- Directional 24-hour volume (two-lanes)
- Arterial speed
- Left-turn demand
- Driveway location(s) and distance(s) from the upstream intersection

This process assumes that the necessary right-of-way is available for left-turn treatment if it is required.

#### Task 1: Determining Whether Left-Turn Treatment is Required

The first step in median design, provided that the necessary right-of-way is available, is to determine whether left-turn treatment is required, given the roadway and adjacent driveway characteristics. There are several ways to accomplish this task.

#### 1a: Safety Criteria

Several studies have determined that median treatment, regardless of type, is a safer alternative to no median treatment (Stover 1994). Therefore, if a disproportionate number of accidents occur in the vicinity of the driveway location as a result of left-turn-related maneuvers, then left-turn treatment is warranted without regard to operational criteria.

The Manual on Uniform Traffic Control Devices (MUTCD) uses five or more accidents within a 12-month period as a threshold for intersection signalization. Therefore, the four accidents per year criterion could appropriately be applied to an unsignalized intersection consisting of a driveway and a street.

If the left-turn-related accident rate is equivalent or exceeds 4/year, median treatment is warranted. If the safety criterion is satisfied, then proceed to Task 2; otherwise continue with 1b.

#### 1b: Operational Criteria

The researchers developed three sets of decision charts to indicate if median treatment is required based on operational criteria. One chart set addresses excessive delay problems experienced by left turners. The delay threshold considered as excessive is average left-turn delays exceeding 35 seconds per vehicle (sec/veh). A second chart set relates

operational problems incurred by the through-traffic stream. These charts identify conditions causing unacceptable through-traffic delay increases.

If a box is shaded, median treatment is warranted. If the operational criterion is satisfied, then proceed to Task 2.

### 1c: Calculation of Capacity and Delay

The designer may wish, however, to obtain more detail or may be unsure of the results given by the charts. In this situation, the decision can be made through a series of calculations that have been developed in this research effort. The first step is to determine the left-turn capacity of the driveway opening, which may be determined by using provided equations. Once the capacity of the driveway has been determined, the utility ratio (UR), which is the left-turn driveway demand divided by the capacity, is calculated. In cases where left-turn driveway demands have been unknown, the ITE Trip Generation Manual has been used to estimate left-turn driveway demands for selected land-use scenarios.

If the UR is equivalent to or exceeds 1, left-turn treatment is warranted. The designer should proceed to Task 2.

The next step is to predict the delay that will be experienced by left-turning vehicles or through traffic. This step is accomplished through the use of two sets of equations that were developed through the study. The designer can use either set of equations to determine if treatment is warranted or choose to compute both delays to identify a “worst case” scenario.

If  $Delay_L$  or  $Delay_T$  is equivalent to or exceeds 35 sec/veh, median treatment is warranted. The designer should proceed to Task 2.

### Task 2: Raised Median or Flush Median Design

There are several criteria one should consider when selecting a raised median or a flush median design. Many

attempts have been made to quantify the choice of median design, but there are many characteristics that are difficult to measure. Both types of designs have positive attributes and both have drawbacks.

Overwhelmingly, studies have favored raised medians over TWLTLs for safety considerations. However, all agree that some median treatment is better, in terms of both safety and operations, than the undivided cross section. Operationally, both designs are equivalent under low driveway density, low traffic volume, and moderate speed conditions. The literature states that raised medians are generally preferred when through volumes and driveway densities are high. TWLTLs are preferred under lighter through-volume conditions, though there is some debate surrounding the preferred driveway spacing and left-turn volume.

### 2a: Safety Considerations (Raised vs. Flush Median)

Flush median designs, continuous one- or two-way left-turn lanes (OWLTL, TWLTL), are not recommended where through-traffic speeds exceed 45 mph. A study of accident occurrence on continuous-turn lanes found accident rates only marginally higher compared to raised median sections. However, that study recommended limited continuous left-turn lane use under high-speed conditions because of the potentially catastrophic results of high-speed accidents.

If through-traffic speeds are greater than 45 mph, the designer should choose the “raised median” design.

As previously mentioned, research efforts have also shown that raised medians are safer at higher traffic volume conditions than TWLTLs. One criterion that has been used as a threshold value for choosing median designs is a 24-hour design volume of 24,000 vehicles.

If the 24-hour design volume is equivalent to or exceeds 24,000 vehicles, the designer should choose the “raised median” design.

### 2b: Operational Considerations

Flush median designs are generally not recommended along facilities that have significant traffic congestion. Since potential flow along arterials is limited by intersection capacity, congestion usually propagates upstream and downstream from intersections. One criterion for congestion identification is queues of more than ten vehicles in all intersection approach lanes or queues that cannot be dissipated during the green signal phase.

If intersection queues are greater than ten vehicles or queues are not dissipated during the signal green time, the designer should choose the “raised median” design.

If the median design is being developed for a new facility, or for any reason queues cannot be counted, congestion potential can be estimated using the ratio of demand to capacity. *The Highway Capacity Manual* is recommended as an easier way to estimate intersection capacity. If expected demand approaches calculated capacity, significant queues can be expected and conditions would likely exceed the threshold for significant congestion. Experience indicates, however, that a demand-to-capacity ratio exceeding 0.9 for a planned facility should be adequate justification for choosing a raised median design.

If intersection demand-to-capacity ratio exceeds 0.9, the designer should choose the “raised median” design. For the flush median design, proceed with tasks followed by an F and for raised median designs follow tasks marked with an R.

### Task 3R: Determining the Necessity of Left-Turn Bays at Intersections

The flow of traffic on the network should take precedence over midblock turning movements. Therefore, once the general type of median design has been determined, it is important to establish the necessity of a left-turn bay at the intersection because it will affect the design of upstream median



openings. This task can be accomplished by a number of means. Criteria for determining the requirement of left-turn bays have been outlined in numerous documents, such as the Highway Capacity Manual, Center for Transportation Research Report 258-1, and many state agency design manuals. The complete procedure described in the CTR 258 study is included in the 1846-1 report.

If left-turn demand is greater than the warranted left-turn volume  $Q_w$ , a left-turn bay is required at the intersection. The designer should proceed to the next task. Otherwise skip to task 5R.

#### **Task 4R: Calculating the Length of the Intersection Left-Turn Bay**

If a left-turn bay is necessary at an adjacent intersection, then it is important to size the bay before proceeding with median design, as this will directly impact driveway openings and placement along the roadway. Once again, this procedure has been well documented in other research efforts. The procedure that was developed in Research Report 258-1 from the Center for Transportation Research at The University of Texas at Austin is included in the complete 1846 report.

#### **Task 5R: Assessment of Midblock Opening**

In determining the location of a midblock opening, the designer must first ensure that the proposed opening will not infringe on the left-turn bay that has been established for the intersection. The placement of a median opening is infeasible if the proposed median location encroaches on the intersection left-turn bay. Provided that the median opening is viable, the operational characteristics of the driveway can be examined. There are three criteria to consider: the delay incurred by the left-turning vehicle, the storage area, and the distance between the intersection and other median openings.

#### **Task 5Ra: Delay to the Left-Turner**

Theoretically, if a left-turner waits for a traffic-stream gap in a bay or storage lane, then operationally there is no reduction in the level of service to the network through traffic if the vehicle driver waits indefinitely to complete his/her maneuver. Realistically, however, the driver will become impatient after a period of time and risk an accident by choosing a gap of insufficient size. The researchers developed a series of decision charts based on delays incurred by the left turner. These charts describe conditions under which unacceptable levels of delay are experienced.

If box is shaded, the designer should not provide a median opening; left-turn delays will likely exceed 96 seconds/vehicle.

If the designer is unsatisfied with the results of the charts because roadway conditions require interpolation between shaded and unshaded boxes, then he or she may calculate the left-turn delay with equations that were also developed.

If  $Delay_L$  equals or exceeds 96 sec/veh, the designer should not provide a median opening.

#### **Task 5Rb: Storage Area or Bay Length**

Adequate procedures for determining the length of storage for the medians are similar to those used in determining the left-turn bay length at the intersection. The pocket length should be sized according to the entrance speed and to the ability of a vehicle to come to a stop before reaching the end of the queue. If the left-turn demand is unknown, estimates based on the *ITE Trip Generation Manual* are provided. See Task 4R for instructions on proper left-turn bay sizing.

#### **Task 5Rc: Distance to the Intersection or Additional Median Opening**

No median opening should be allowed to interfere with the functional area of another median opening or intersection left-turn bay. The functional area is defined as the distance required for channelization markings, queuing, and storage of vehicles wishing to complete a left-turn maneuver. Additionally, median openings should be prohibited in locations where a queue from an adjacent intersection would habitually form across the opening. The Florida DOT has defined a classification system of its roadways that is based on function. Using these access classes, the Florida engineers have set the following minimum median opening spacing criteria for arterials with both directional and full movements.

#### **Task 5F: (OWLTL or TWLTL) Choosing One-Way or Two-Way Left-Turn Lanes**

Few studies have been conducted concerning the choice between OWLTL and TWLTL. A TWLTL is generally chosen in areas of strip commercial development. An OWLTL is more beneficial at major intersections having high left-turn demand or where there are driveways on only one side of the street.

## **THE RESEARCHERS RECOMMEND ...**

This document summarizes a process that can be used by the practitioner to design median treatments for a four-lane, bi-directional arterial roadway. The tasks required to complete this process are described with supporting information.



### *For More Details ...*

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The research is documented in the following reports:  
Report 1846-1, *Design Guidelines for Provision of Median Access on Principal Arteries*,  
Draft February 2001

**To obtain copies of the report, contact: CTR Library, Center for Transportation  
Research, phone: 512/232-3138, email: [ctrlib@uts.cc.utexas.edu](mailto:ctrlib@uts.cc.utexas.edu).**

## TXDOT IMPLEMENTATION STATUS AUGUST 2001

The research developed new design guideline criteria to aid in the decision making process for selecting the proper median type for principal arterials.

The research resulted in a decision tree and implementation guide for the application of various types of median design and geometric guidelines for median openings. The median design decision tree is being incorporated into TxDOT geometric design practices.

For more information, please contact Bill Knowles, P.E., Research and Technology Implementation Office (512) 465-7648 or email: [wknowle@dot.state.tx.us](mailto:wknowle@dot.state.tx.us).

## YOUR INVOLVEMENT IS WELCOME!

## DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation and the U. S. Department of Transportation, Federal Highway Administration. The content of this report reflects the views of the authors, who are responsible for the facts and 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, nor is it intended for construction, bidding, or permit purposes. Trade names were used solely for information and not for product endorsement. The engineer in charge was Dr. Randy B. Machemehl, P.E. (Texas No. 41921).