

Section 6: Freeways

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Overview

A freeway is defined as a controlled access multilane divided facility. Freeways are functionally classified as arterials but have unique design characteristics that set them apart from non-access controlled arterials. This section discusses the features and design criteria for freeways and includes the following subsections:

- [Basic Design Criteria](#)
- [Access Control](#)
- [Mainlane Access](#)
- [Vertical and Horizontal Clearance at Structures](#)
- [Frontage Roads](#)
- [Interchanges](#)

Anchor: #CHDIBHJC

Basic Design Criteria

Specific references to Freeway Geometric Design criteria are shown in Table 3-15:

Anchor: #i1065690Table 3-15: Freeway Geometric Design Criteria	
Design Criteria	Reference
General	
Horizontal Clearance	Table 2-11
Grades	Table 2-9
Minimum Horizontal Radius	Table 2-3 and 2-4
Superelevation	Tables 2-6 , 2-7 and 2-8
Vertical Curvature	2-7 , 2-8 , 2-9 , and 2-10
Pavement Cross Slope	Chapter 2, Pavement Cross Slope
Freeways	
Design Speed Mainlanes (urban and rural)	Table 3-17
Design Speed Frontage Roads (urban and rural)	Chapter 3, Frontage Roads
Capacity and LOS Analysis	<i>Highway Capacity Manual</i>

Anchor: #CHDEHIJC

Access Control

This subsection discusses access control and includes the following topics:

- [General](#)
- [Mainlane Access](#)
- [Frontage Road Access](#)
- [Driveways and Side Streets](#)
- [Methods](#)

Anchor: #CHDHCHCJ

General

The entire Interstate Highway System and portions of the State Highway System have been designated by the Commission as Controlled Access Highways, thereby making it necessary along certain sections of said highways to either limit or completely deny the abutting owner's access rights, which include the right of ingress and egress and the right of direct access to and from said owner's abutting property to said highway facility. Such access may be controlled under the State's Police Power, which is an inherent right of a sovereignty. However, the existing right of access to an existing public way is an increment of ownership and a part of the bundle of rights vested in the owner of abutting property. It is a legal right, and though such right may be limited or completely denied under the State's Police Power, the owner is entitled to be paid whatever damages may be suffered by reason of the loss of such access.

The abutting owners are denied access to any controlled access highway on new location, unless there is a specific grant of access, and no damages may be claimed for the denial of access to the new facility; the theory being that the owner cannot be damaged by the loss of something which the owner never had.

If an existing road is converted into a controlled access facility, the design of which does not contemplate the initial construction of frontage roads, and the abutting owner is to be denied access to such facility pending frontage road construction, there is a taking of the owner's access rights. If an existing road is converted into a controlled access facility, the design of which does contemplate frontage road(s) in the initial construction, and the abutting owner is not to be denied access to such frontage road(s), there is not taking or denial of access rights. Access to the frontage road(s) constitutes access to the facility. Further control of movements, once upon the frontage road, such as one-way traffic, no U-turns, no left or right turns, denial of direct access to the through lanes, and circuitous routes are all controlled under police power and inflict no more control over the abutting owner than is inflicted upon the general public.

If an existing road is converted into a controlled access facility and no part of the abutting owner's property is taken for right of way, but access is to be denied to the controlled access facility, and by reason of such denial of access it is found that such owner will suffer damages measured by the diminution of the market value of said abutting land, said owner should be requested to release and relinquish said access rights for consideration equal to the State's approved value for such damages. If the owner is not willing to negotiate on these terms, then the access right may be acquired through eminent domain proceedings. In some instances, the State's appraisal and approved value may indicate that there is no diminution in value by reason of the access denial, and in those cases the abutting owner should be requested to release and relinquish access rights for no cash consideration. If the owner refuses to do so, then the access rights should be acquired through eminent domain proceedings with the State testifying to a zero value for such rights.

Anchor: #CHDGJDJC

Mainlane Access

Freeway mainlane access, either to or from abutting property or cross streets, is only allowed to occur through a ramp. This control of mainlane access may be achieved through one of the following methods:

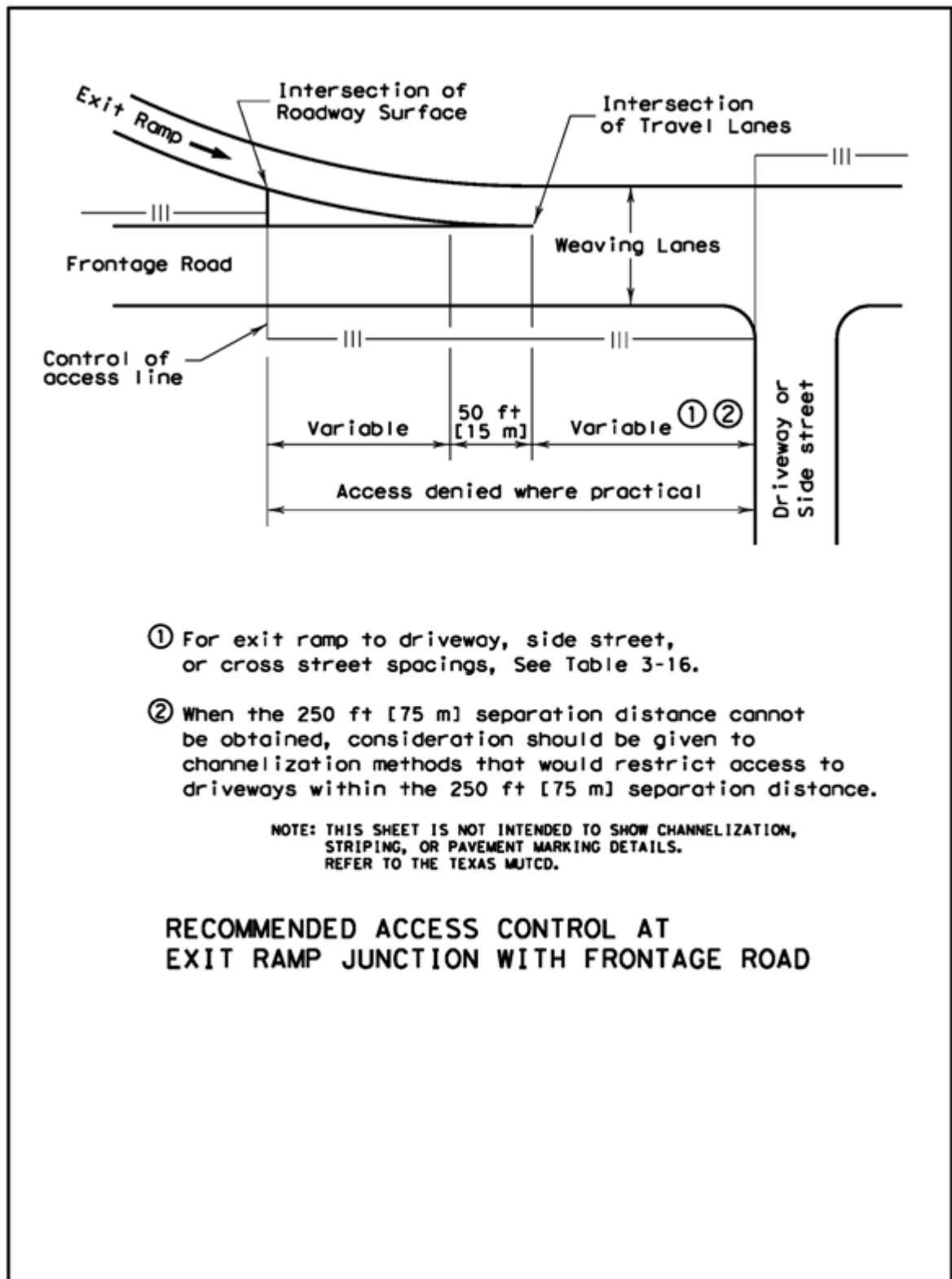
- through access restrictions whereby the access to the highway from abutting property owners is denied with ingress and egress to the mainlanes only at selected freeway or interchange ramps
- through construction of frontage roads permitting access to the mainlanes only at selected ramps.

In either case, direct access from private property to the mainlanes is prohibited without exception.

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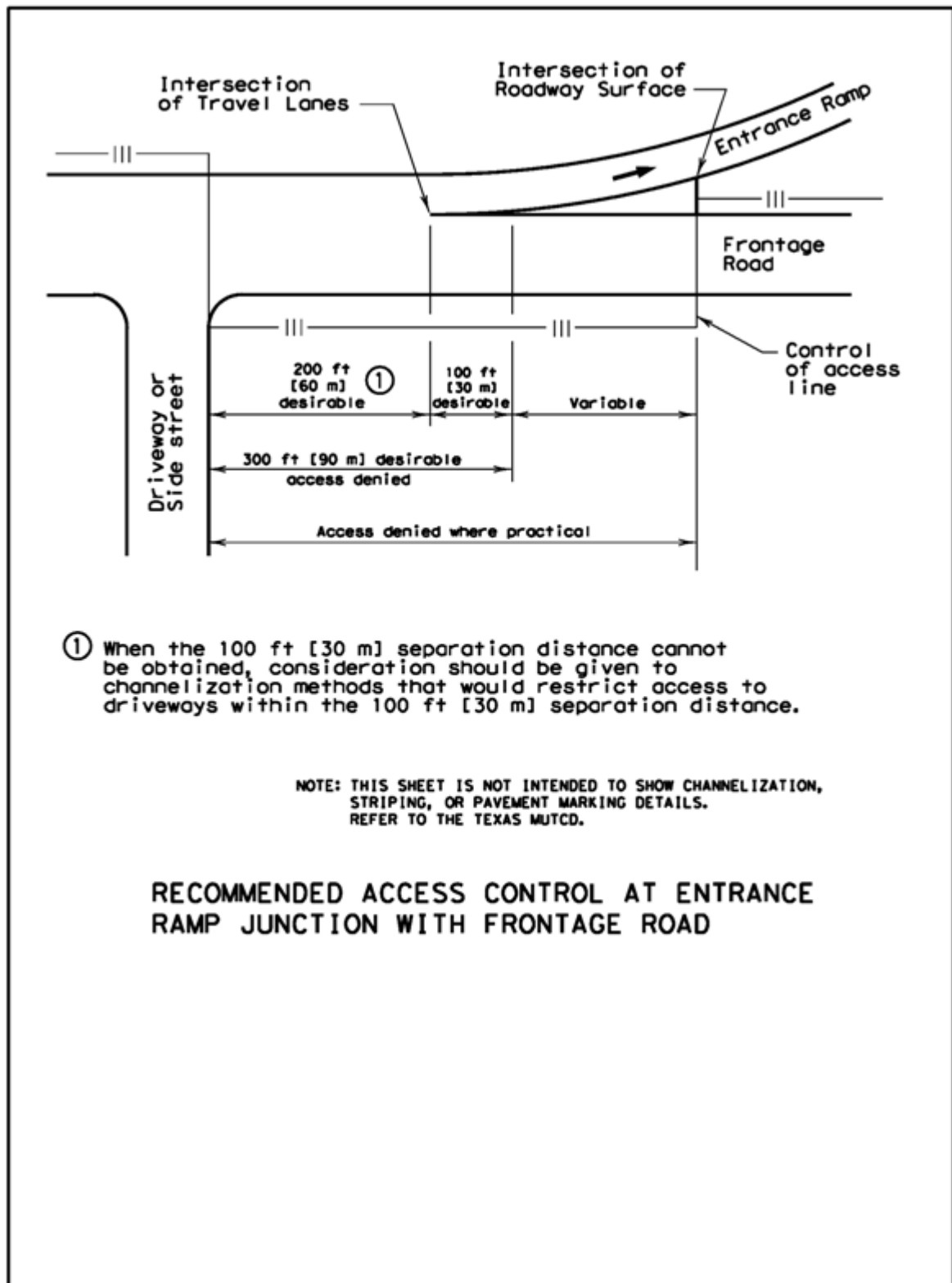
Frontage Road Access

In the case where frontage roads are provided, access should be controlled for operational purposes at ramp junctions with frontage roads through access restrictions or the use of the State's police powers to control driveway location and design. Figures 3-13 and 3-14 show recommended access control strategies for planned exit and entrance ramps, respectively, and should be used where practical.



Anchor: #i1032526grtop

Figure 3-13. Recommended Access Control At Exit Ramp Junction With Frontage Road. Click [here](#) to see a PDF of the image.



Anchor: #i1032528grtop

Figure 3-14. Recommended Access Control At Entrance Ramp Junction With Frontage Road. Click [here](#) to see a PDF of the image.

Anchor: #CHDBFFDC

Driveways and Side Streets

The placement of streets and driveways in the vicinity of freeway ramp/frontage road intersections should be carefully considered and permitted only after local traffic operations are considered. Information on the driveway clearance from the cross street intersection is contained in the *TxDOT Access Management Manual* and should be considered in the locating of any driveways on projects involving the construction or reconstruction of ramps and/or frontage roads.

Table 3-16 shows the spacing to be used between exit ramps and driveways, side streets, or cross streets if practical. The number of weaving lanes is defined as the total number of lanes on the frontage road downstream from the ramp.

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Table 3-16: Desirable Spacing between Exit Ramps and Driveways, Side Streets, or Cross Streets				
Total Volume (Frtg + Ramp) (vph)	Driveway or Side Street Volume (vph)	Spacing (ft [m])		
--	--	Number of Weaving Lanes		
--	--	2	3	4
< 2500	< 250	460 [140]	460 [140]	560 [170]
--	> 250	520 [160]	460 [140]	560 [170]
--	> 750	790 [240]	460 [140]	560 [170]
--	> 1000	1000 [300]	460 [140]	560 [170]
> 2500	< 250	920 [280]	460 [140]	560 [170]
--	> 250	950 [290]	460 [140]	560 [170]
--	> 750	1000 [300]	600 [180]	690 [210]
--	> 1000	1000 [300]	1000 [300]	1000 [300]

Driveway or side street access on the frontage road in close downstream proximity to exit ramp terminals increases the weaving that occurs on the frontage road and may lead to operational problems. For this reason, it is important to maintain appropriate separation between the intersection of the exit ramp and frontage road travel lanes, and downstream driveways or side streets where practical.

It is recognized that there are occasions when meeting these exit ramp separation distance values may not be possible due to the nature of the existing development,

such as a high number of closely spaced driveways and/or side streets especially when in combination with closely spaced interchanges. In these cases, at least 250 ft [75 m] of separation should be provided between the intersection of the exit ramp and frontage road travel lanes and the downstream driveway or side street. Since the use of only 250 ft [75 m] of separation distance may negatively impact the operation of the frontage road, exit ramp, driveway and/or side street traffic, careful consideration should be given to its use. When the 250 ft [75 m] separation distance cannot be obtained, consideration should be given to channelization methods that would restrict access to driveways within this 250 ft [75 m] distance. Refer to the Texas [MUTCD](#) for specific types of channelization.

There will be similar occasions when meeting the entrance ramp separation distance values may not be possible due to the same existing development conditions associated with exit ramps. In these cases, at least 100 ft [30 m] of separation distance should be provided between the intersection of the entrance ramp and frontage road travel lanes and the upstream driveway or side street. Since the use of only 100 ft [30 m] of entrance ramp separation distance may also negatively impact the operation of the frontage road, entrance ramp, driveway, and/or side street traffic, careful consideration should be given to its use. As with exit ramps, when the 100 ft [30 m] entrance ramp separation distance cannot be obtained, consideration should be given to channelization methods that would restrict access to driveways within this 100 ft [30 m] distance. Refer to the Texas MUTCD for specific types of channelization.

Relocating driveways. On reconstruction projects, it may be necessary to close or relocate driveways in order to meet these guidelines. However, if the closure/relocation is not feasible, and adjustment of the location of the ramp gore along the frontage road is not practical, then deviation from these recommended guidelines may be necessary.

Ramp Location. In the preparation of schematic drawings, care should be exercised to develop design in sufficient detail to accurately tie down the locations of ramp junctions with frontage roads and thus the location of access control limits. These drawings are often displayed at meetings and hearings and further become the basis for right-of-way instruments or, in some cases, the Department's regulation of driveway location.

In some instances, ramps must be shifted to satisfy level of service considerations or geometric design controls. When this is necessary, the access control limits should also be shifted if right-of-way has not been previously purchased.

Anchor: #CHDBHJFB

Methods

A controlled access highway may be developed in either of two ways:

- [Designation](#) (Transportation Code §203.031 and access restrictions)
- [Design](#) (continuous frontage road and State's police power)

Anchor: #CHDBJACG

Designation

When the Texas Transportation Commission designates a freeway to be developed as a controlled access facility under Transportation Code §203.031, the State is empowered to control access through access restrictions. All Interstate Highways are designated as controlled access and certain other routes have been or may be designated. These designated freeways may or may not have frontage roads, whichever arrangement is determined to be appropriate as discussed in [Planning](#). Development of freeways by designation, rather than solely by design, is the preferred design approach especially for all new location freeways.

Under Transportation Code §203.031, Not Along An Existing Public Road. Whenever designated controlled access freeways include frontage roads and the planned location is not along an existing public road, preferably access should be controlled through access restrictions at ramp junctions with frontage roads as shown on [Figure 3-13](#) and [Figure 3-14](#).

Where no frontage roads are provided, access is controlled to the mainlanes by access restriction.

Under Transportation Code §203.031, Along An Existing Public Road. Whenever a designated controlled access freeway is to be provided along the location of an existing public road, generally (subject to discussion in [Planning](#)) frontage roads are provided to retain or restore existing access.

Frontage road access should be controlled by imposing access restrictions in accordance with [Figure 3-13](#) and [Figure 3-14](#) whenever all of the following conditions prevail:

- Right-of-way is being obtained from the abutting property owner(s).
- A landlocked condition does not result.
- Recommended control of access as shown in [Figure 3-13](#) and [Figure 3-14](#).

Access may be controlled by use of the State's police power to control driveway location and design where any of the following conditions prevail:

- No right of way is obtained from the abutting property owner(s).
- Restricting access results in landlocking an abutting property.

Whenever the State's police powers are used, the denial of access zone should be free of driveways insofar as practical.

Anchor: #CHDCIEGB

Design

If an existing highway is to be developed as a controlled access facility solely by design (not designated by the Transportation Commission), the Texas Department of Transportation is not empowered to purchase access rights but must achieve access control by construction of continuous frontage roads and by the utilization of the State's police power to control driveways, particularly at locations such as ramp junctions with frontage roads.

In the interest of providing for highway safety and utility, the State may regulate driveway location and design through its police powers. Landlocking through complete denial of access is beyond the State's regulatory power (without Commission designation under the Transportation Code). The State, however, may effectively regulate driveway location in accordance with Statewide policy as long as the following two conditions are met:

- Reasonable access is provided.
- Landlocking of an abutting property does not result.

The Departmental publication entitled *TxDOT Access Management Manual* governs design and location of driveways.

Whenever new or relocated ramps are to be provided along existing freeways, the design philosophy shown in [Frontage Roads](#) applies. Access should therefore be controlled at frontage road junctions through access restriction as illustrated in Figures 3-13 and 3-14 if practical and feasible.

Whenever access is to be controlled solely by provision of frontage roads, departmental power to regulate driveway location and design should be used to control access near ramp junctions. However, where designation by the Transportation Commission is practical, it is preferred over controlling access solely by design.

Anchor: #i1084372

Mainlanes

This subsection discusses mainlanes and includes information on the following topics:

- [Design Speed](#)
- [Level of Service](#)
- [Lane Width and Number](#)
- [Shoulders](#)
- [Medians](#)
- [Outer Separation](#)
- [Crossing Facilities](#)

Anchor: #CHDFBGBJ

Design Speed

The design speed of urban freeways should reflect the desired operating conditions during non-peak hours. The design speed should not exceed the limits of prudent construction, right-of-way, and socioeconomic costs because a large proportion of vehicles are accommodated during periods of peak flows when lower speeds are tolerable. Design speeds for rural freeways should be high, providing a design speed that is consistent with the overall quality and safety of the facility.

Table 3-17 provides minimum design speeds for freeways:

Anchor: #i1065800Table 3-17: Design Speed for Controlled Access Facilities (mph [km/h])	
Facility	Minimum
Mainlanes - Urban	50 [80]
Mainlanes - Rural	70 [110]

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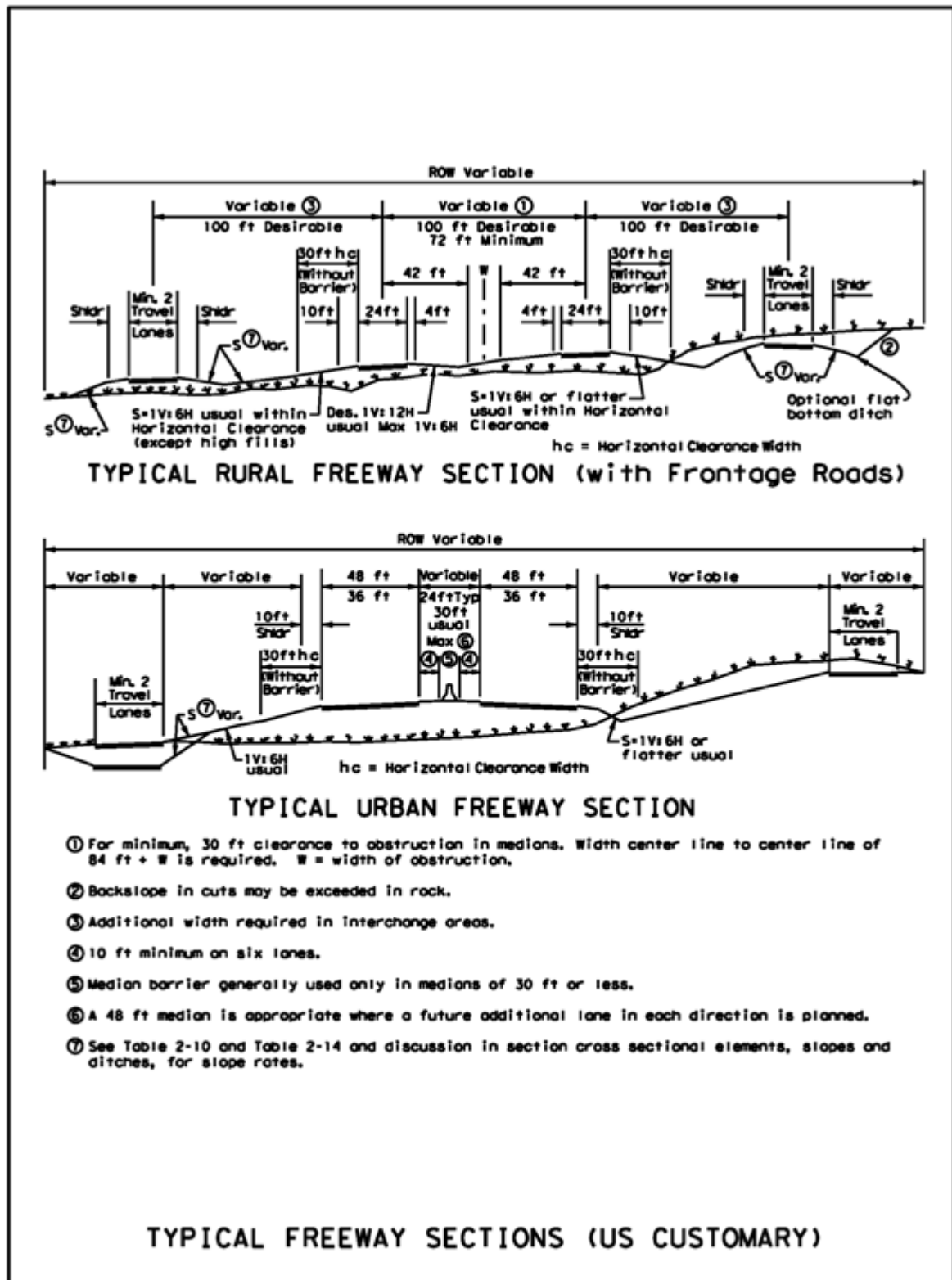
Level of Service

For acceptable degrees of congestion, urban freeways and their auxiliary facilities should generally be designed for level of service C, as defined in the *Highway Capacity Manual*, in the design year. In heavily developed urban areas, level of service D may be acceptable. In rural areas, level of service B is desirable for freeway facilities; however, level of service C may be acceptable for auxiliary facilities (i.e., ramps, direct connections and frontage roads) carrying unusually high volumes.

Anchor: #CHDDIICJ

Lane Width and Number

The minimum and usual mainlane width is 12 ft [3.6 m]. The number of lanes required to accommodate the anticipated traffic in the design year is determined by the level of service evaluation as discussed in the *Highway Capacity Manual*. See [Table 3-18: Roadway Widths for Controlled Access Facilities](#) and [Figure 3-11](#) for further information.



Anchor: #i1034630grtop

Figure 3-15. (US). Typical Freeway Sections. Click [US Customary](#) or [Metric](#) to see a PDF of the image.

Anchor: #CHDEJFHG

Shoulders

Continuous surfaced shoulders are provided on each side of the mainlane roadways, both rural and urban, as shown in Figure 3-15. The minimum widths should be 10 ft [3.0 m] on the outside and 4 ft [1.2 m] on the median side of the pavement for four-lane freeways. On freeways of six lanes or more, 10 ft [3.0 m] inside shoulders for emergency parking should be provided. A 10 ft [3.0 m] outside shoulder should be maintained along all speed change lanes with a 6 ft [1.8 m] shoulder considered in those instances where light weaving movements take place. See [Table 3-18: Roadway Widths for Controlled Access Facilities](#) and [Figure 3-11](#) for further information.

Anchor: #CHDDGDCE

Medians

The width of the median is the distance between the inside edges of the travel lanes. For depressed freeway sections, medians 76 ft [22.8 m] in width are generally used. Where topography, right-of-way, or other special considerations dictate, depressed freeway median width may be reduced from 76 ft [22.8 m] to a minimum of 48 ft [14.4 m]. A median width of 24 ft to 30 ft [7.2 m to 9.0 m] is generally used on freeway sections with flush medians. On freeways including six or more travel lanes and a flush 24 ft [7.2 m] median, the resulting section provides for 10 ft [3.0 m] inside shoulders and a usual 2 ft [0.6 m] offset to barrier centerline. See [Figure 3-11](#) for further information.

Because of high speed and volume traffic on urban freeways and the resulting adverse environment for accomplishing construction improvements thereon, it is the usual practice to construct the ultimate freeway section initially. Under those unusual circumstances where future additional lanes will be provided in the median area, the usual median width of 24 ft [7.2 m] should be increased by the appropriate multiple of 12 ft [3.6 m] in anticipation of need for additional lanes. Provisions should be made, or retained, for any future high occupancy vehicle lanes in the median.

At horizontal curves on freeways with narrow medians, a check should be made to insure that the median barrier does not restrict stopping sight distance to less than minimum values.

For information on freeway median crossings, refer to Chapter 7, Emergency Median Openings on Freeways.

Anchor: #CHDIICJI

Outer Separation

The portion of the freeway between the mainlanes and frontage road, or right-of-way line where frontage roads are not provided, should be wide enough to accommodate shoulders, speed change lanes, side slopes and drainage, retaining walls and ramps, as well as the necessary signs and other appurtenances necessary for traffic control. Because of right-of-way limitations in urban areas, the outer separation may

oftentimes be narrower than desired; however, in rural areas, where opposing headlights along a two-way frontage road tend to reduce a driver's comfort and perception on the freeway, the outer separation should be as wide as possible.

Anchor: #CHDHIEJE

Crossing Facilities

The following exhibits show the appropriate widths for facilities crossing the freeway:

- Urban Streets: [Table 3-1: Geometric Design Criteria for Urban Streets](#)
- Suburban Roadways: [Table 3-5: Geometric Design Criteria for Suburban Roadways](#)
- Rural Two-Lane Highways: [Table 3-7: Geometric Design Criteria for Rural Two-Lane Highways](#) and [Table 3-8: Width of Travel Lanes and Shoulders on Rural Two-lane Highways](#)
- Multilane Rural Highways : [Table 3-12: Design Criteria For Multilane Rural Highways \(Non-controlled Access\) \(All Functional Classes\)](#)

The Bridge Project Development *Manual* should also be referenced for appropriate structure widths.

Anchor: #CHDGBIHC

Vertical and Horizontal Clearance at Structures

Vertical. All controlled access highway grade separation structures, including railroad underpasses, should provide 16.5 ft [5.0 m] minimum vertical clearance over the usable roadway.

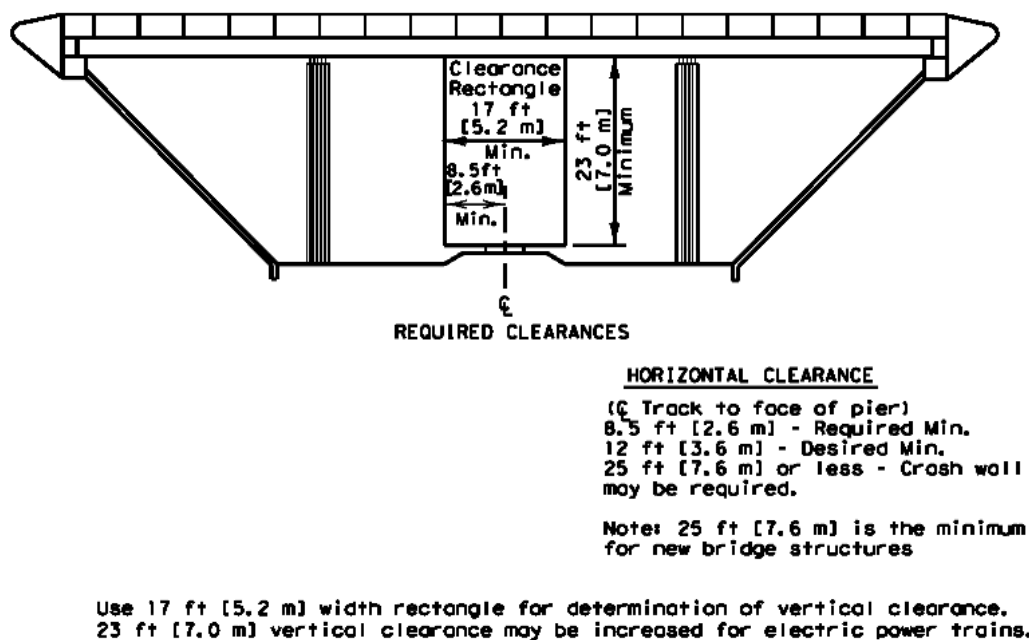
Structures over the mainlanes of interstate or controlled access highways must meet the minimum vertical clearance requirement except within cities where the 16.5 ft [5.0 m] vertical clearance is provided on an interstate loop around the particular city. Less than 16 ft [4.9 m] vertical clearance on rural interstate and single priority defense interstate routes, including ramps and collector-distributor roads, requires approval through the Design Division with the Federal Highway Administration and/or the Military Traffic Management Command Transportation Engineering Agency (MTMCTEA) of the Department of Defense (DOD).

Roadways under the mainlanes of interstate or controlled access highways must meet the minimum vertical clearance requirements for the appropriate undercrossing roadway classification.

Vertical clearances for pedestrian crossover structures should be approximately 1 ft [0.3 m] greater than that provided for other grade separation structures. This is due to the increased risk of personal injury upon impact by over-height loads and the relative weakness of such structures to resist lateral loads from vehicular impact.

The above-specified clearances apply over the entire width of roadway including usable shoulders and include an allowance of 6 inches [150 mm] for future pavement overlays. It is recognized that it is impractical to arrive at the exact clearance dimensions on the structure plans. However, the above clearances should not generally be exceeded by more than approximately 3 inches [75 mm].

Vertical clearance for railroad overpasses is shown in Figure 3-16, and is discussed further in the [Bridge Project Development Manual](#).



TYPICAL HIGHWAY RAILWAY RAILROAD OVERPASS

Anchor: #i1034692grtop

Figure 3-16. Typical Highway Railway Railroad Overpass. Click [here](#) to see a PDF of the image.

Horizontal. The minimum horizontal clearance to bridge parapets and piers should be as shown in [Table 2-11: Horizontal Clearances](#) and [Figure 3-12](#).

Anchor: #CHDJJHITable 3-18: Roadway Widths for Controlled Access Facilities (US Customary)			
Type of Roadway	Inside Shoulder Width (ft)	Outside Shoulder Width ² (ft)	Traffic Lanes (ft)
Mainlanes:	-	-	-
4-Lane Divided	4	10	24

6-Lane or more Divided	10	10		361
1-Lane Direct Conn.2	2 Rdwy.; 4 Str.	8		14
2-Lane Direct Conn.	2 Rdwy.; 4 Str.	8		24
Ramps ² (uncurbed)	2 Rdwy.; 4 Str.	Min.	Des.	14
-	-	6	8	-
Ramps ³ (curbed)	—	—		22
(Metric)				
Type of Roadway	Inside Shoulder Width (m)	Outside Shoulder Width ² (m)		Traffic Lanes (m)
Mainlanes:	-	-		-
4-Lane Divided	1.2	3.0		7.2
6-Lane or more Divided	3.0	3.0		10.81
1-Lane Direct Conn.2	0.6 Rdwy.; 1.2 Str.	2.4		4.2
2-Lane Direct Conn.	0.6 Rdwy.; 1.2 Str.	2.4		7.2
Ramps ² (uncurbed)	0.6 Rdwy.; 1.2 Str.	Min.	Des.	4.2
-	-	1.8	2.4	-
Ramps ³ (curbed)	—	—		6.6

¹ For more than six lanes, add 12 ft [3.6 m] width per lane.

² If sight distance restrictions are present due to horizontal curvature, the shoulder width on the inside of the curve may be increased to 8 ft [2.4 m] and the shoulder width on the outside of the curve decreased to 2 ft [0.6 m] (Rdwy) or 4 ft [1.2 m] (Str).

³ The curb for a ramp lane will be mountable and limited to 4 inches [100 mm] or less in height. The width of the curbed ramp lane is measured face to face of curb. Existing curb ramp lane widths of 19 ft [5.7 m] may be retained.

Anchor: #CHDJCDDD

Frontage Roads

This subsection discusses frontage roads and includes information on the following topics:

- [Function and Uses](#)
- [Planning](#)
- [Design Speed on Frontage Roads](#)
- [Capacity and Level of Service](#)

Anchor: #CHDHAGIF

Function and Uses

Frontage roads serve a multitude of purposes in addition to controlling or providing access. Urban frontage roads are multi-functional. They reduce the “barrier” effect of urban freeways since they provide for some of the circulation of the local street system. They provide invaluable operational flexibility, serving as detour routes when mainlane accidents occur, during mainlane maintenance activity, for over-height loads, as bus routes, or during inclement weather. For freeways that include freeway surveillance and control, continuous frontage roads provide the operational flexibility required to manage saturation.

In addition to the above-described purposes of frontage roads, many times they prove advantageous when used as the first stage of construction for an ultimate freeway facility. By constructing frontage roads prior to the mainlanes, interim traffic demands very often can be satisfied and a usable section of highway can be opened to the traveling public at a greatly reduced cost.

Anchor: #CHDFIGBA

Planning

Frontage roads may be incorporated into a project at various points during the project development, however, later incorporation of frontage roads will be more difficult. Frontage roads may be included:

- during the planning stage
- subsequent to the planning stage
- after the freeway has been constructed.

Frontage road construction may be funded by TxDOT, a local government, or shared by both. The Texas Transportation Commission has adopted rules governing the construction and funding of frontage roads. All frontage road development must be in accordance with the rules contained in 43 Texas Administrative Code (TAC) §15.54. The *Project Development Policy Manual* can also be referenced for additional information.

Changes in control of access must be in accordance with 43 TAC §15.54(d)(4).

As specified in the *Right of Way Manual*, Volume 1, subsequent changes in the control of access will be as shown on approved construction plans or as provided in instruments conveying right-of-way on authorized projects, or as may be authorized by Commission Minute Order. Where access is permitted to adjacent properties, ingress and egress will be governed by the issuance of permits to construct access driveway facilities as set forth in established Departmental policy which is designed to provide reasonable access, to insure traffic safety, and preserve the utility of highways.

Anchor: #CHDFIAGH

Design Speed on Frontage Roads

Design speeds for frontage roads are a factor in the design of the roadway. For consistency, design speeds should be used that match values used for collector streets or highways. For urban frontage roads, the desirable design speed is 50 mph [80 km/h] and the minimum design speed is 30 mph [50 km/h]. See [Table 3-5: Geometric Design Criteria for Suburban Roadways](#) for design speeds for suburban frontage roads, and [Table 3-6: Minimum Design Speed for Rural Two-lane Highways](#) for rural frontage roads.

Anchor: #CHDFEBJA

Capacity and Level of Service

Although techniques to estimate capacity and level of service on freeways and urban arterials are detailed in the *Highway Capacity Manual*, these procedures should not be applied directly to frontage roads, as frontage roads have features characteristic of both freeways (i.e., exit and entrance ramps) and urban arterials (i.e., driveways, cross streets and signalized intersections). The following report was developed to suggest techniques for estimating capacity and level of service on frontage roads.

Kay Fitzpatrick, R. Lewis Nowlin, and Angelia H. Parham. *Procedures to Determine Frontage Road Level of Service and Ramp Spacing*. Research Report 1393-4F, Texas Department of Transportation, Texas Transportation Institute, 1996.

Research Report 1393-4F contains procedures for the following:

- determining level of service on a continuous frontage road section
- analyzing frontage road weaving sections
- determining spacing requirements for ramp junctions.

Anchor: #i1084755

Frontage Road Design Criteria

Design criteria for urban frontage roads are shown in [Table 3-1: Geometric Design Criteria for Urban Streets](#) using the collector criteria. Design criteria for suburban frontage roads are shown in [Table 3-5: Geometric Design Criteria for Suburban Roadways](#) using the collector criteria. Design criteria for rural frontage roads are shown in [Table 3-19: Design Criteria for Rural Frontage Roads](#). Horizontal clearances are given in [Table 2-11: Horizontal Clearances](#).

Any frontage road constructed will be designed to provide one-way operation initially. There may be exceptions in certain isolated instances; however, such exceptions will be considered only where, due to extraordinary circumstances, a one-way pattern would impose severe restrictions on circulation within an area. In those cases where such exceptions are considered, they must be approved by the Design Division at the schematic stage.

Anchor: #CHDIAGBITable 3-19: Design Criteria for Rural Frontage Roads				
(US Customary)				
Design Speed ² (mph)	Min. Width ¹ for Future Traffic Volume of			
-	0-400 ADT	400-1,500 ADT	1,500-2,000 ADT	2,000 or more ADT
LANES (ft)				
20	10	10	11	12
25	10	10	11	12
30	10	10	11	12
35	10	10	11	12
40	10	11	11	12
45	10	11	11	12
50	10	11	12	12
55	10	11	12	12
60	11	11	12	12
65	11	11	12	12
70	11	11	12	12
75	11	12	12	12
80	11	12	12	12

SHOULDERS (ft) ⁴				
Each Shoulder				
Two-Way Operation	2 ³	4	8	8 – 10
Inside Shoulder				
One-Way Operation	2 ³	2 ³	4	4 ⁴
Outside Shoulder				
One-Way Operation	2 ³	4	8	8 – 10
¹ May retain existing paved width on a reconstruction project if total paved width is 24 ft and operating satisfactorily. ² Use rural collector criteria (Table 3-6) for determining minimum design speed. ³ At locations where roadside barriers are provided, use minimum 4 ft offset from travel lane edge to barrier face. ⁴ If the one-way frontage road section contains three or more travel lanes, then minimum inside shoulder width is 8 – 10 ft.				

Anchor: #i1066079Table 3-19: Design Criteria for Rural Frontage Roads				
(Metric)				
Design Speed ² (km/h)	Min. Width ¹ for Future Traffic Volume of			
-	0-400 ADT	400-1,500 ADT	1,500-2,000 ADT	2,000 or more ADT
LANES (m)				
30	3.0	3.0	3.3	3.6
40	3.0	3.0	3.3	3.6
50	3.0	3.0	3.3	3.6
60	3.0	3.3	3.3	3.6
70	3.0	3.3	3.3	3.6
80	3.0	3.3	3.6	3.6

90	3.0	3.3	3.6	3.6
100	3.3	3.3	3.6	3.6
110	3.3	3.3	3.6	3.6
120	3.3	3.6	3.6	3.6
130	3.3	3.6	3.6	3.6
SHOULDERS (m) ⁴				
Each Shoulder Two-Way Operation	0.6 ³	1.2	2.4	2.4 – 3.0
Inside Shoulder One-Way Operation	0.6 ³	0.6 ³	1.2	1.2 ⁴
Outside Shoulder One-Way Operation	0.6 ³	1.2	2.4	2.4 – 3.0
¹ May retain existing paved width on a reconstruction project if total paved width is 7.2 m and operating satisfactorily. ² Use rural collector criteria (Table 3-6) for determining minimum design speed. ³ At locations where roadside barriers are provided, use minimum 1.2 m offset from travel lane edge to barrier face. ⁴ If the one-way frontage road section contains three or more travel lanes, then minimum inside shoulder width is 2.4 – 3.0 m.				

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Conversion of Frontage Roads from Two-Way to One-Way Operation

Existing frontage roads in some areas are currently operating as two-way facilities. Such two-way operation has the following disadvantages:

- Higher crash rates are normally experienced when the frontage roads are two-way. In large part, this is because of the risk of essentially head-on collisions at the ramp terminals.
- Increased potential for wrong-way entry to the mainlanes.

- The intersections of the frontage roads with the arterials are much more complicated. Left turns from the arterial onto the frontage road must be accommodated from both directions. Accordingly, the signal phasing and sequencing options normally available at signalized diamond interchanges cannot be used.
- The overall traffic-carrying capacity of the frontage roads is substantially less than if the same facility were re-stripped for one-way operation.

Existing two-way frontage roads should be converted to one-way operation when one or more of the following conditions occur.

- Queuing on the frontage road approach routinely backs up from the arterial intersection to within 100 ft. of a freeway entrance or exit ramp gore.
- The level-of-service of a signalized intersection of the frontage road and the arterial drops below level-of-service C.
- Queuing in the counter-flow direction (i.e. that which would not exist if the frontage road were one-way) routinely backs up from the stop line at a freeway entrance or exit ramp to within 100 ft. of the arterial street.
- Accident rate comparisons are above the statewide average accident rate for two-way frontage roads.
- Major freeway reconstruction or rehabilitation is occurring in a developed or developing area.

Conversion of two-way frontage roads located in urbanizing rural areas, where distances between crossover interchanges are relatively long, will require consideration of additional crossovers to minimize the distance traveled for adjacent residents and business patrons. The existence of an adequate local street system in the area will also facilitate traffic circulation and minimize the travel time impact of converting frontage roads from two-way to one-way operation.

The simple conversion of two-way to one-way frontage roads will be accomplished with ramp and terminal design based on reconstruction criteria shown in Chapter 3, Section 6, Freeways, Frontage Roads, while the balance of the existing frontage road lanes may retain dimensions that meet rehabilitation criteria shown in Chapter 4, Section 4, Frontage Roads. However, if the frontage roads are being reconstructed, then reconstruction design criteria shown in Chapter 3, Section 6, Freeways, will be applicable throughout the section.

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Interchanges

The decision to develop a facility to freeway standards becomes the warrant for providing highway grade separations or interchanges at the most important intersecting roadways (usually arterials and some collectors) and railroads. A grade separation refers to the crossing of two roadways by a physical separation so that neither roadway interferes with the other. An interchange is a grade separation with connecting roadways (ramps, loops, or connections) that move traffic between the intersecting highways.

Effect on community. An interchange or series of interchanges on a freeway through a community may affect large continuous areas or even the entire community. For this reason, interchanges must be located and designed so that they will provide the best possible traffic service. Drivers who have exited from a freeway expect to be able to re-enter in the same vicinity; therefore, partial interchanges that do not serve all desired traffic movements should be avoided.

Classifications. Interchanges are classified in a general way, according to the number of approach roadways or intersection legs, as 3-leg, 4-leg and multi-leg interchanges. Through common usage, interchanges are descriptively called “Tee” (or Trumpet) for 3-leg design. Cloverleaf (full or partial) and Diamond for 4-leg, and Directional interchanges with three or more legs including direct connectors.

The following subsections include a brief description and some of the advantages and disadvantages of each of the following types of interchanges:

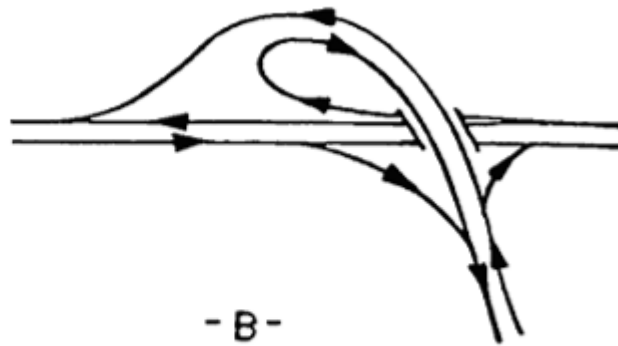
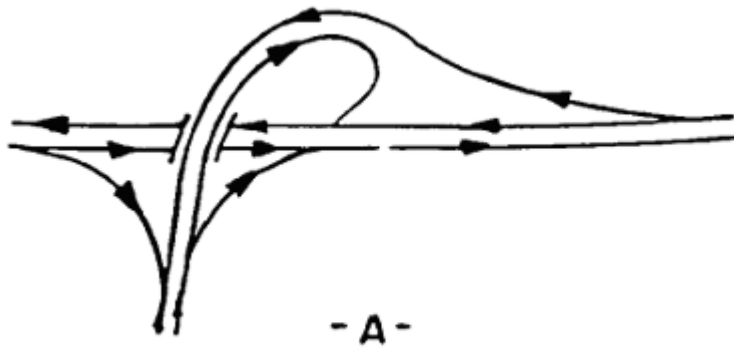
- [Three Leg Interchanges](#)
- [Four Leg Interchanges](#)

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Three Leg Interchanges

Three-leg interchanges can take any of several forms, although all of the forms provide connections for the three intersecting highways. Three-leg interchanges should be used only after careful consideration because expansion to include a fourth leg is usually very difficult. If the potential exists that a fourth leg will ultimately be included, another type of interchange may be appropriate.

Trumpet. The most widely used 3-leg interchange is the trumpet type, as shown in Figure 3-17. This type of interchange is particularly suitable for the connection of a major facility and a freeway. Preference should be given to the major turning movements so that the directional roadway handles higher traffic volume and the loop the lower traffic volume.

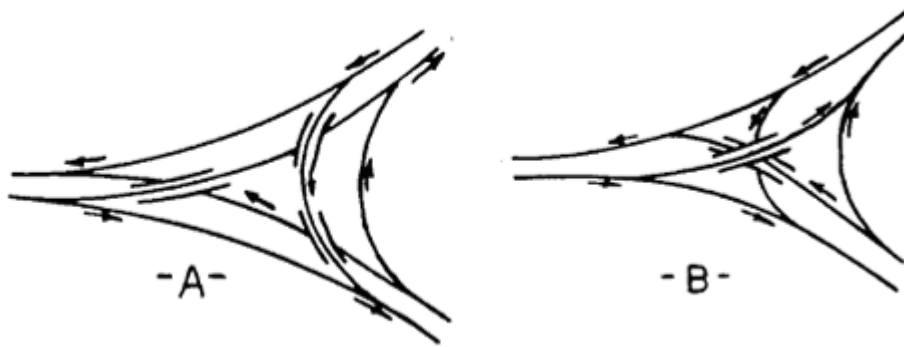


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Figure 3-17. Trumpet Three Leg Interchange.

Direct. High-type directional three-leg interchanges are those in which all movements are provided without the use of loops. These interchanges should be used only where all movements are large. They contain more than one structure or, alternatively, a three-level structure. Both variations are illustrated in Figure 3-18.



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Figure 3-18. Directional Three Leg Interchange.

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Four Leg Interchanges

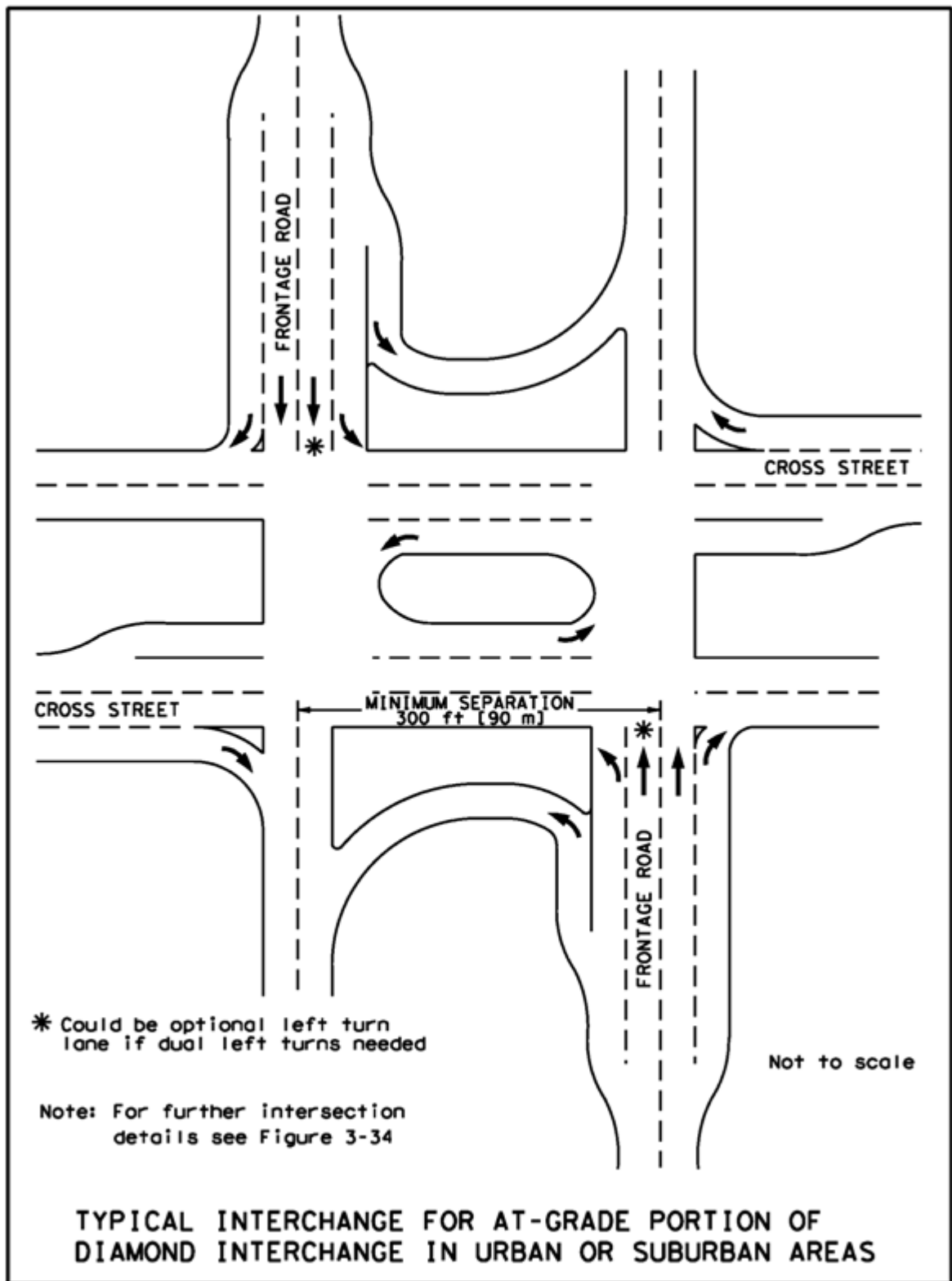
Four-leg interchanges can take a wide variety of forms. The choice of interchange type is generally established after careful consideration of dominant traffic patterns and volumes, ROW requirements, and system considerations. The three primary types of four-leg interchanges are as follows:

- [Diamond Interchanges](#)
- [Cloverleaf Interchanges](#)
- [Directional Interchanges](#)

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Diamond Interchanges

The diamond interchange is the most common interchange, especially in urban areas, since it requires less area than any other type. The diamond interchange is used almost exclusively for major-minor crossings since left-turn movements are made at-grade across conflicting traffic on the minor road. Separation between frontage road intersections in diamond interchanges in urban or suburban conditions should be 300 ft [90 m] as a minimum, as shown in Figure 3-19.



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Figure 3-19. Typical Interchange For At-Grade Portion Of Diamond Interchange In Urban Or Suburban Areas. Click [here](#) to see a PDF of the image.

The diamond interchange may have several different configurations, as discussed in the following paragraphs and shown in Figure 3-20:

Conventional diamond without frontage roads. The conventional diamond (Figure 3-20 A) is the most common application of a diamond interchange. Traffic exits in advance of and near the cross street. Entering vehicles quickly access the freeway beyond or past the cross street. Its disadvantages include exiting vehicles backing up onto the freeway when long queues form on the ramp.

Conventional diamond with frontage roads. The conventional diamond with frontage roads (Figure 3-20 B) is a common variation of a diamond interchange. Traffic exits in advance of and near the cross street. Entering vehicles quickly access the freeway past the cross street. Its disadvantages include 1) exiting vehicles backing up onto the freeway when long queues form on the ramp or frontage road, and 2) most vehicles must go through the intersection to gain access to most frontage road property.

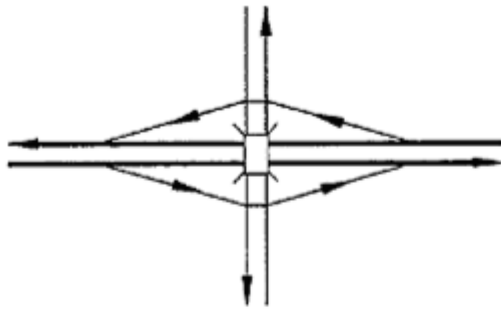
Reverse diamond or x- pattern. The reverse diamond or “X” interchange pattern (Figure 3-20 C) has primary application to locations with significant development along the frontage road. It provides access between interchanges and exiting queues do not back up onto the freeway. However, entering vehicles may have to accelerate on an upgrade and exiting maneuvers occur just beyond the crest vertical curve where weaving also takes place. The “X” ramp pattern also encourages frontage road traffic to bypass the frontage road signal and weave with the mainlane traffic. The “X” ramp pattern may cause some drivers to miss an exit located well in advance of the cross street.

Spread diamond. The spread diamond (Figure 3-20 D) involves moving the frontage roads outward to provide better intersection sight distance at the cross street and improved operational characteristics with signalized intersections, due to the separation between intersections. However, more additional right-of-way is required, which may limit its usage.

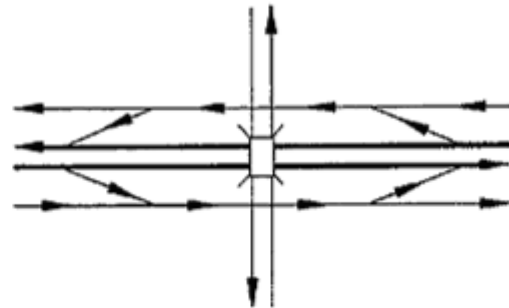
Stacked diamond. Sometimes access to and from the mainlanes is needed on two closely-spaced cross streets. Insufficient distance for consecutive entrance and exit ramps can be resolved by using grade separated ramps, resulting in a “stacked diamond” (Figure 3-20 E).

Split diamond. In some locations, it may be feasible and desirable to “split” the diamond by having one-way streets for the arterial movement (Figure 3-20 F). (This is especially true near central business districts where one-way street systems are common.) However, the split diamond can also be used to accommodate two closely-spaced two-way arterial roadways crossing a freeway.

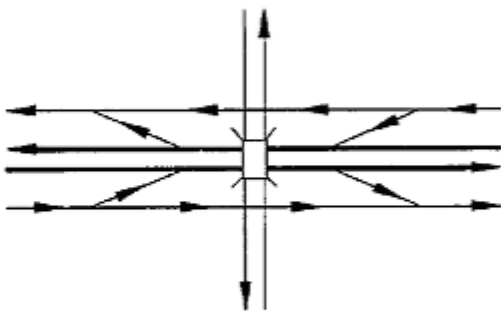
A - Conventional Diamond



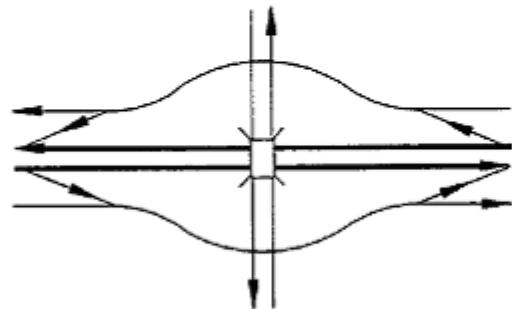
B - Conventional Diamond with Frontage Roads



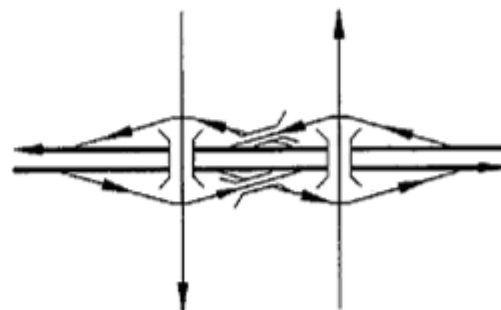
C - Reverse Diamond or X



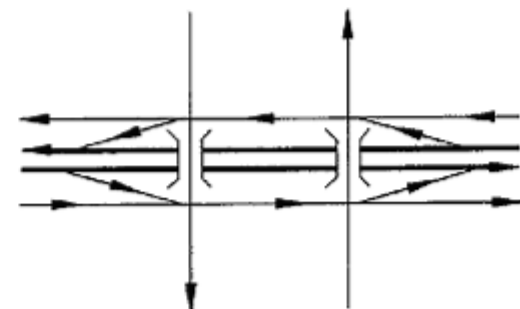
D - Spread Diamond



E - Stacked Diamond



F - Split Diamond

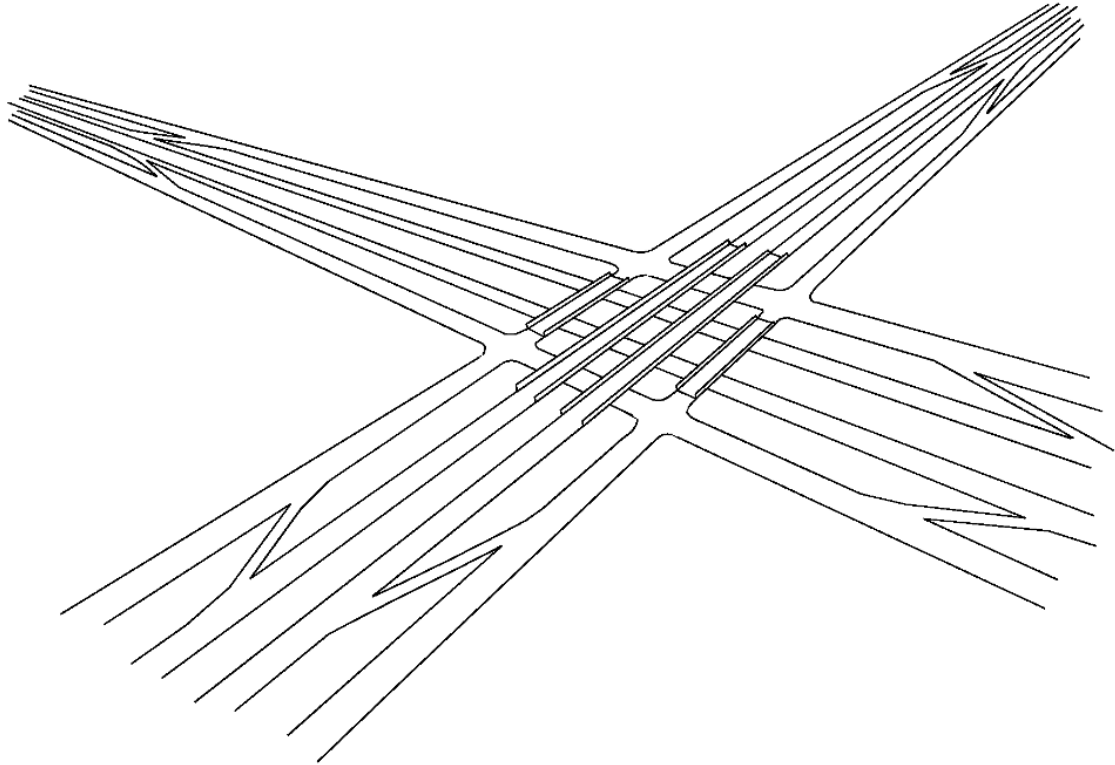


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Figure 3-20. Typical Diamond Interchanges.

Three level diamond. In urban areas, where the cross street carries a high volume of traffic, the three-level diamond interchange, illustrated in Figure 3-21, may be warranted. The through movements of both the controlled access facility and the cross street flow is uninterrupted with only the turning movements requiring regulation by

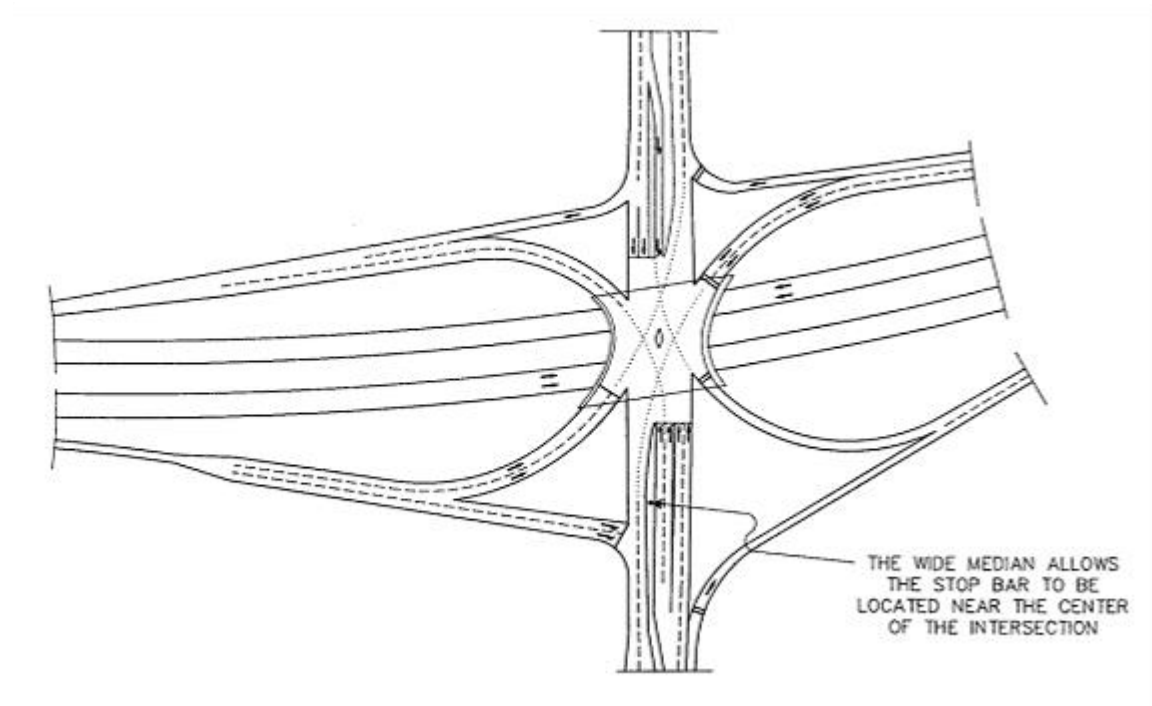
stop signs or traffic lights. This type interchange is not usually recommended for use as the ultimate design at the crossing of two controlled access facilities since it requires left-turn interchanging traffic to negotiate three traffic signals or stop controls. However, as stage construction for a fully directional interchange between two controlled access facilities, the three-level diamond can be effective.



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Figure 3-21. Three Level Diamond Interchange.

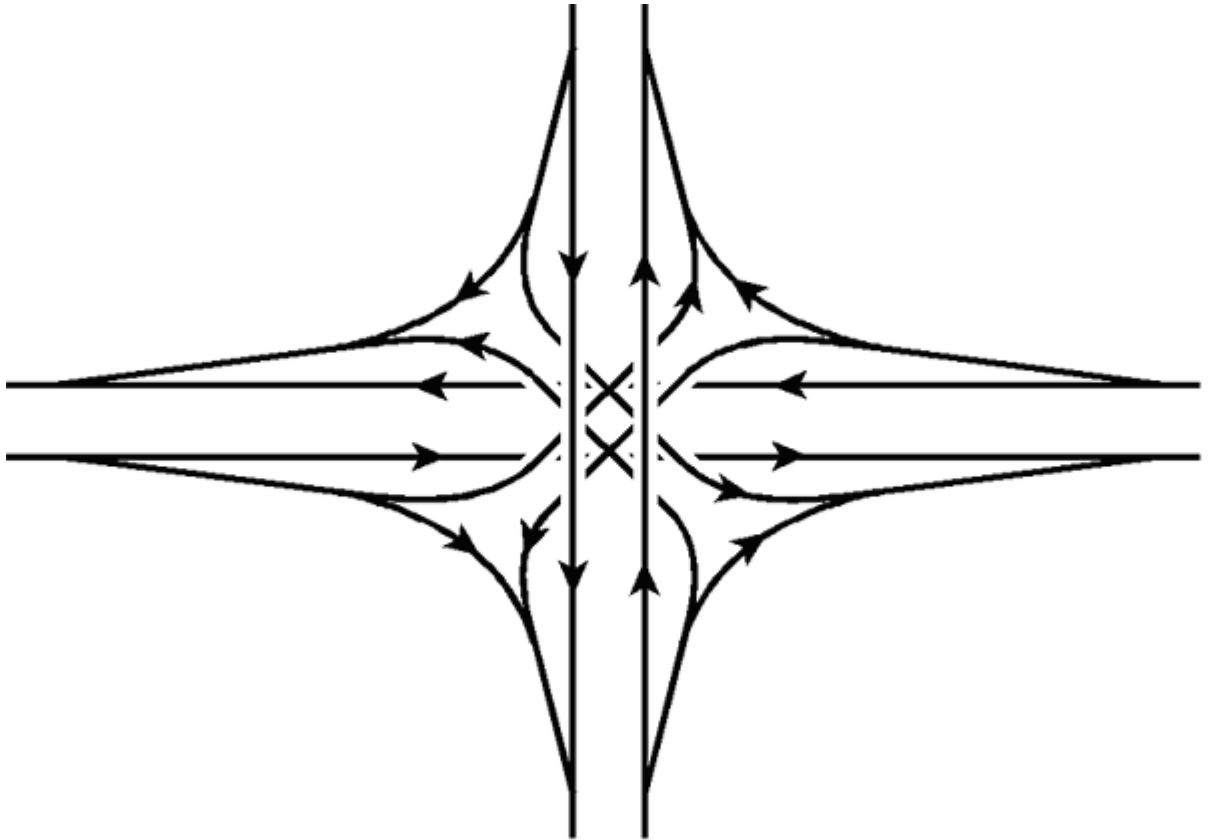
Single point diamond. A special type of freeway-to-arterial interchange has received attention during recent years and is worthy of discussion. AASHTO's *A Policy on Geometric Design of Highways and Streets* refers to it as a "single point diamond" or "single point urban" interchange. In this type of interchange, the freeway mainlanes may go either over or under the crossing arterial and the turn movements occur at-grade on the arterial, as illustrated in Figure 3-22. This type of interchange has application only in specialized locations. Traffic operations and signalization must be carefully modeled prior to final design selection of the single point urban interchange.



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Figure 3-22. Single Point Diamond Interchange.

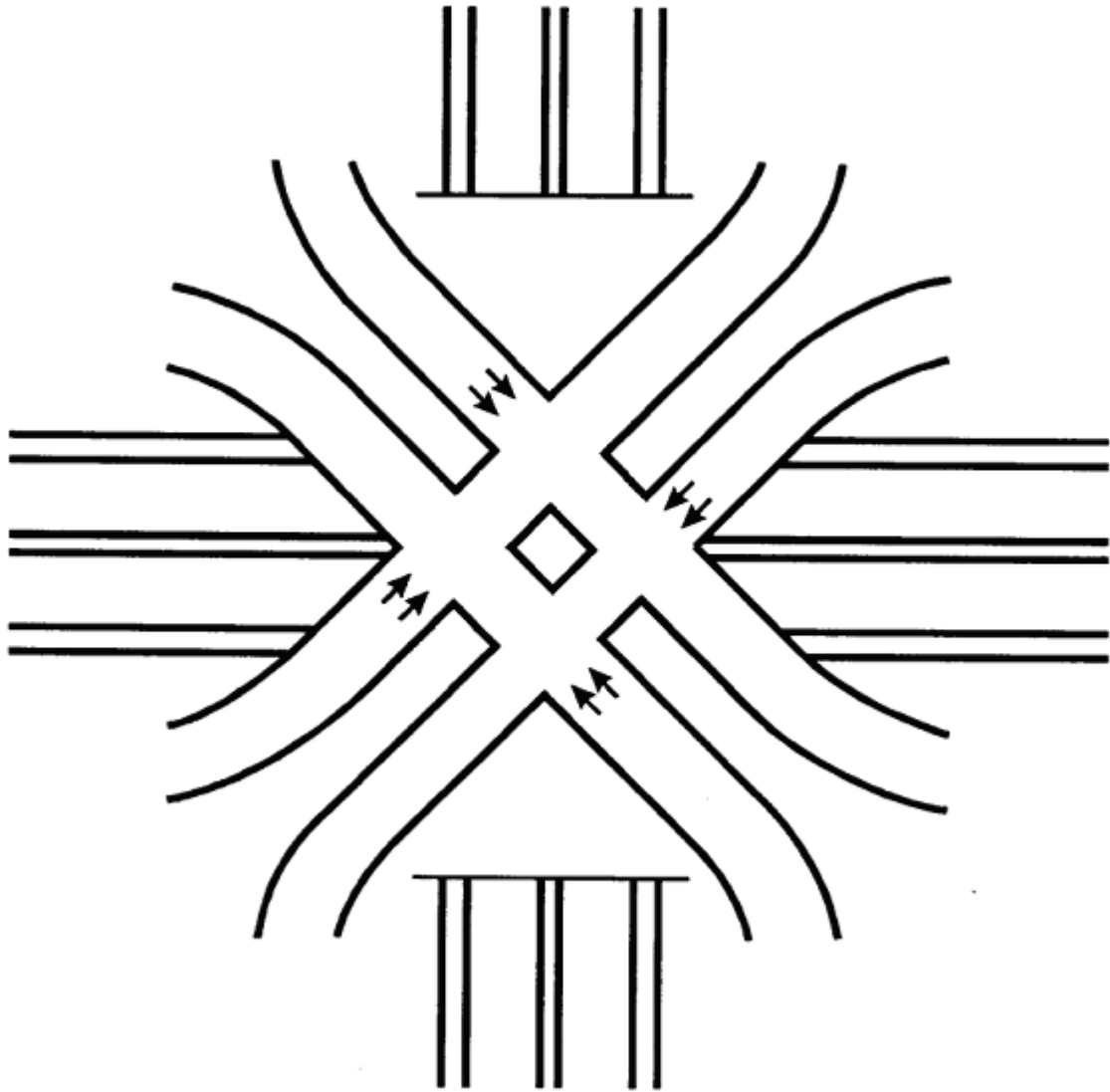
Three level stacked diamond. The three-level stacked diamond interchange is also an interchange requiring only one signalized intersection. In a sense, it is a three-level version of the “single point diamond” configuration, as illustrated in Figure 3-23. This design grade separates both roadways, and accommodates turning movements with signal operations requiring only one signalized intersection. The two-phase signal operation at the intersection typically provides a level of throughput on the turning movements between a conventional diamond interchange and a fully directional interchange. Furthermore, it works best at separating high arterial cross-street and freeway traffic. It has the same shortcomings as the “single point diamond” in the way it brings the left turn movements together.



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Figure 3-23. Three Level Stacked Diamond Interchange (see Figure 3-24 for At-Grade Portions of the Interchange).

As indicated in Figure 3-24, vehicles enter the intersection with oncoming vehicles to the right in contrast to the left as is the case on conventional diamond interchange intersections. Also, the design is less attractive with continuous frontage roads.



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Figure 3-24. Three Level Stacked Diamond At-Grade Interchange.

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Cloverleaf Interchanges

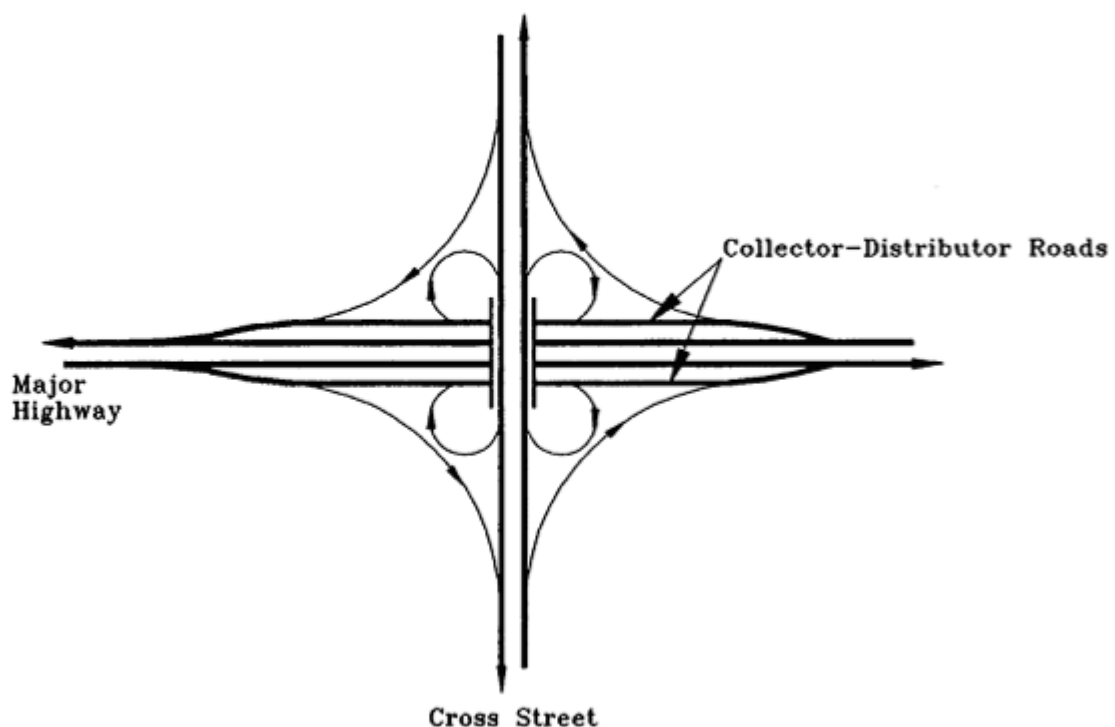
Cloverleaf interchanges are very common in many states. These types of interchanges were popular in the early era of freeway construction, but are usually no longer considered preferable for freeway to freeway movement, especially when interchange volumes are high. However, in some instances they may be appropriate when interchanging a freeway with a non-controlled access facility in a location away from an urban or urbanizing area. Cloverleaves should not be used where left-turn volumes are high (exceed 1200 pcph) since loop ramps are limited to one lane of operation and have restricted operating speeds.

Primary disadvantages of the cloverleaf design include the following:

- large right-of-way requirements
- capacity restrictions of loops, especially if truck volumes are significant
- short weaving length between loops
- trucks have difficulty with weaves and acceleration

When used, cloverleaf designs should include collector-distributor roads to provide more satisfactory operations as further noted in the section on [Collector-Distributor Roads](#).

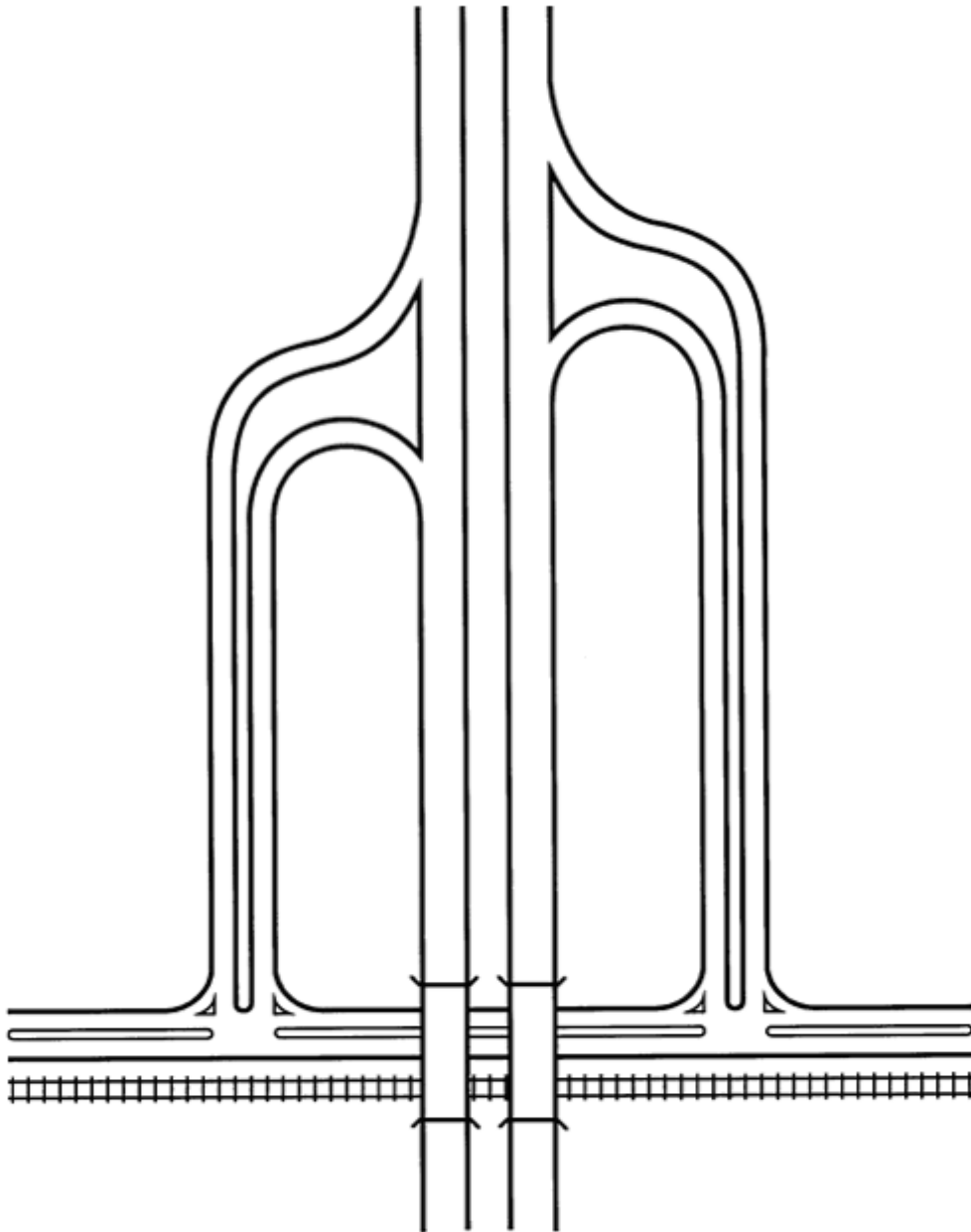
Full cloverleaf. The four-quadrant, full cloverleaf, illustrated in Figure 3-25, eliminates all left-turn conflicts through construction of a two-level interchange.



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Figure 3-25. Full Cloverleaf Interchange.

Partial cloverleaf. A cloverleaf without ramps in all four quadrants, illustrated in Figure 3-26, is sometimes used when site controls (such as railroads or streams running parallel to the crossroad) limit the number of loops and/or the traffic pattern is such that the left-turn conflicts caused by the absence of one or more loops are within tolerable limits. With such an arrangement, left-turn conflicts at the ramp intersections require that satisfactory approach sight distance be provided. Several variations on partial cloverleaves are also discussed in the AASHTO's *A Policy on Geometric Design of Highways and Streets*.



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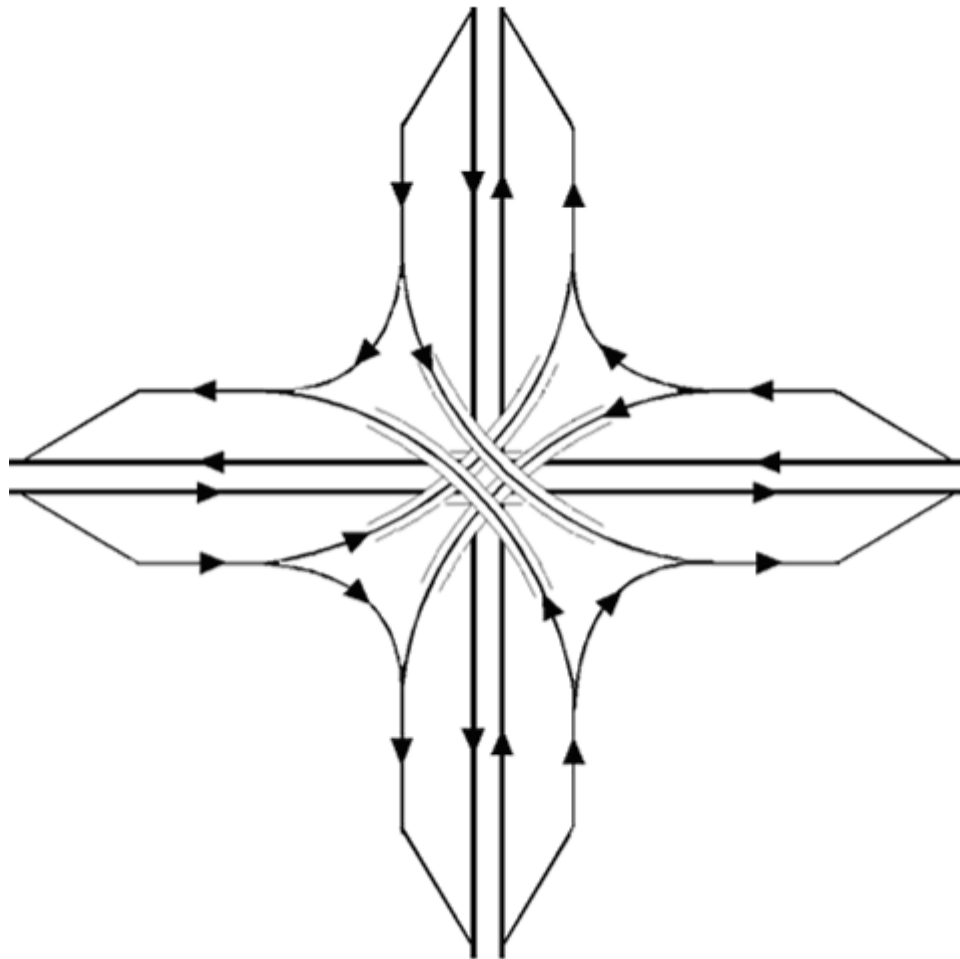
Figure 3-26. Partial Cloverleaf Interchange.

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Directional Interchanges

Interchanges that use direct or semi-direct connections for one or more left-turn movements are called “directional” interchanges (Figure 3-27). When all turning movements travel on direct or semi-direct ramps or direct connections, the

interchange is referred to as “fully directional”. These connections are used for important turning movements instead of loops to reduce travel distance, increase speed and capacity, reduce weaving and avoid loss of direction in traversing a loop. “Fully directional” interchanges are usually justified at the intersection of two freeways.



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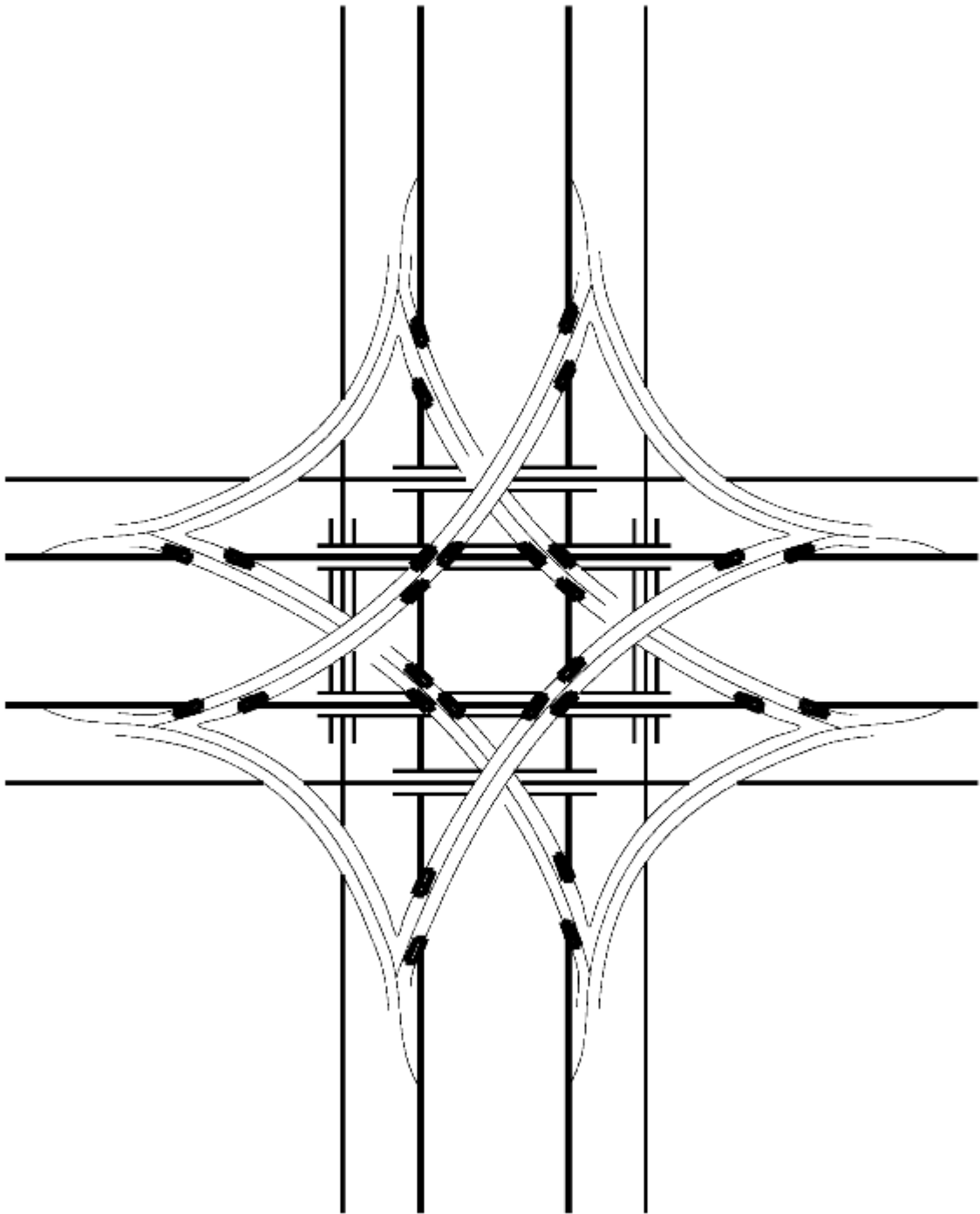
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Figure 3-27. Four Level Fully Directional Interchange Without Frontage Roads.

Four level without frontage roads. The four-level directional interchange as depicted in Figure 3-27 includes direct connections for all freeway-to-freeway movements, without continuation of any frontage roads through the interchange.

Five level with frontage roads. In some instances, it may be desirable to continue the frontage roads through the interchange at the first or second level, producing a five-level directional interchange. Where frontage roads are made continuous through the interchange, the lower three levels are a three-level diamond configuration. Where stage construction is desired, the three-level diamond will adequately serve moderate traffic volumes until the upper two levels of direct connections are constructed to

complete the five-level interchange. Figure 3-28 depicts a five level interchange with frontage roads.



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Figure 3-28. Five Level Fully Directional Interchange with Frontage Roads.

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Ramps and Direct Connections

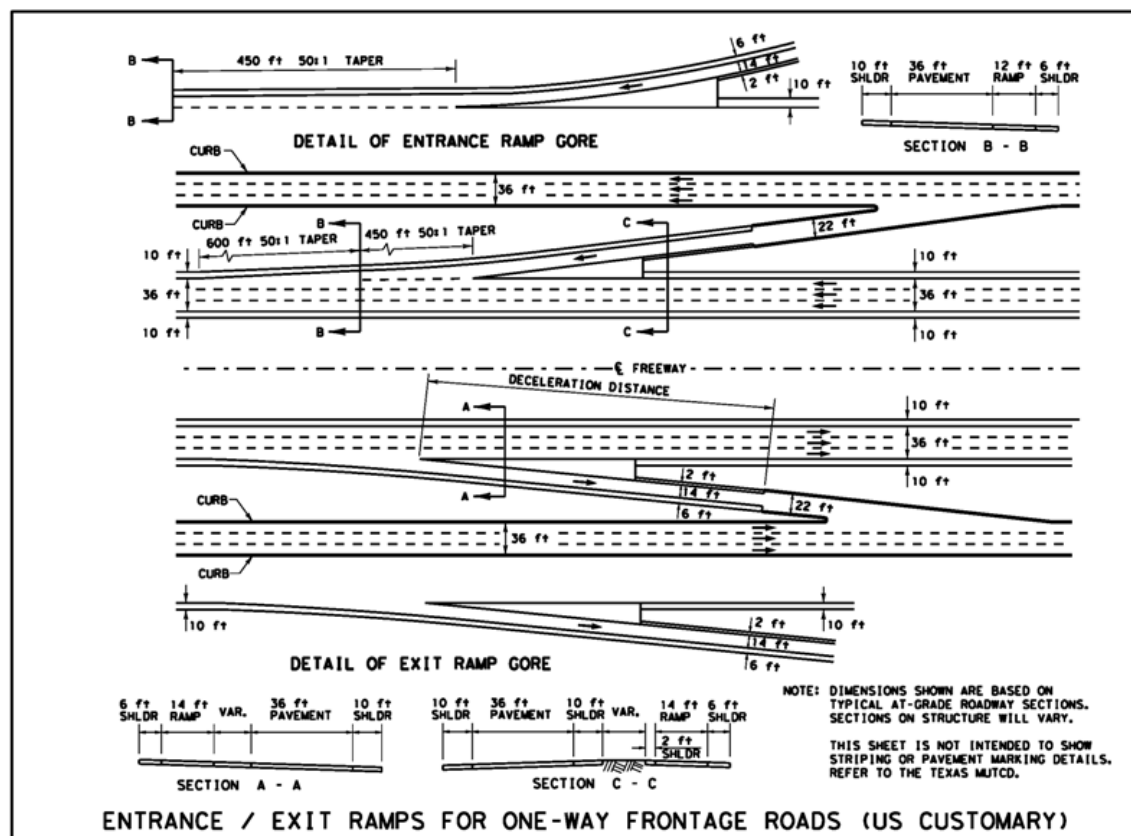
This subsection discusses ramps and direct connections and includes information on the following topics:

- [General Information](#)
- [Design Speed](#)
- [Horizontal Geometrics](#)
- [Distance Between Successive Ramps](#)
- [Cross Section and Cross Slopes](#)
- [Sight Distance](#)
- [Metered Ramps](#)

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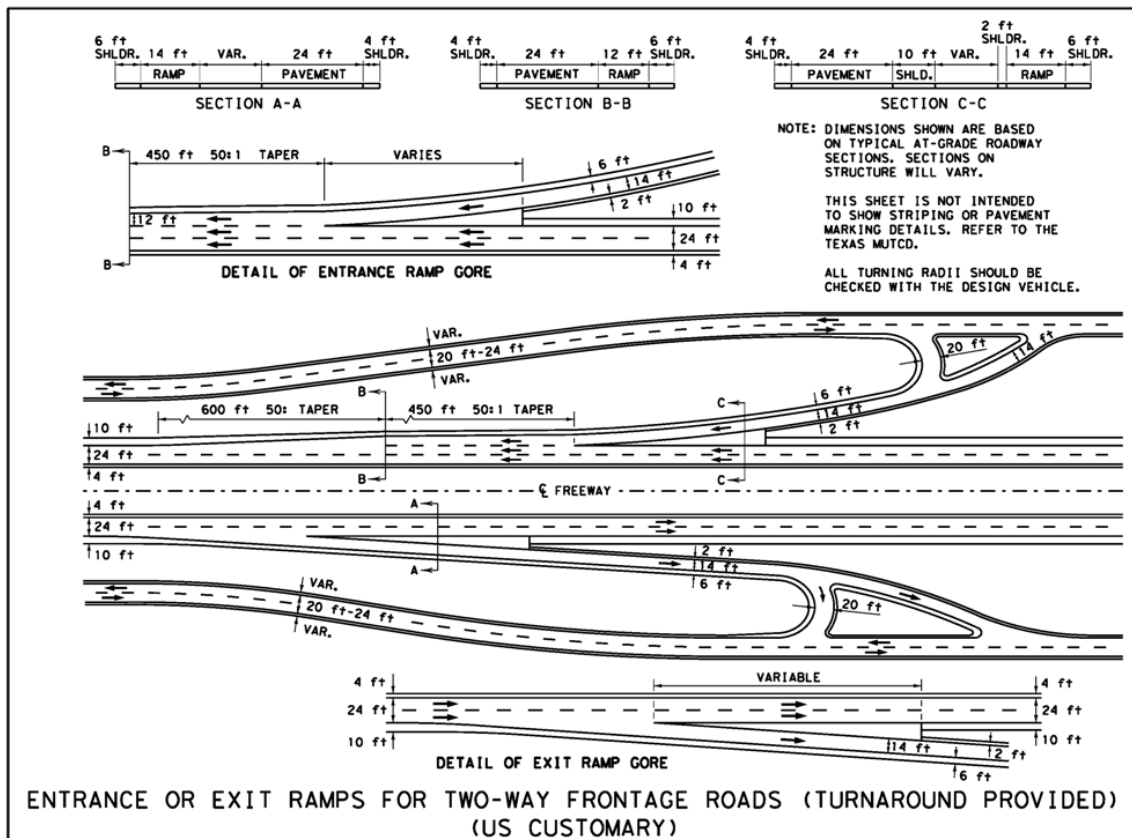
General Information

All ramps and direct connections should be designed for one-lane operation with provision for emergency parking; however, if the anticipated volume exceeds the capacity of one freeway lane, two-lane operation may be provided with consideration given to merges and additional entry lanes downstream. Several examples of ramps and connecting roadway arrangements are shown in Figures 3-29 through 3-35.



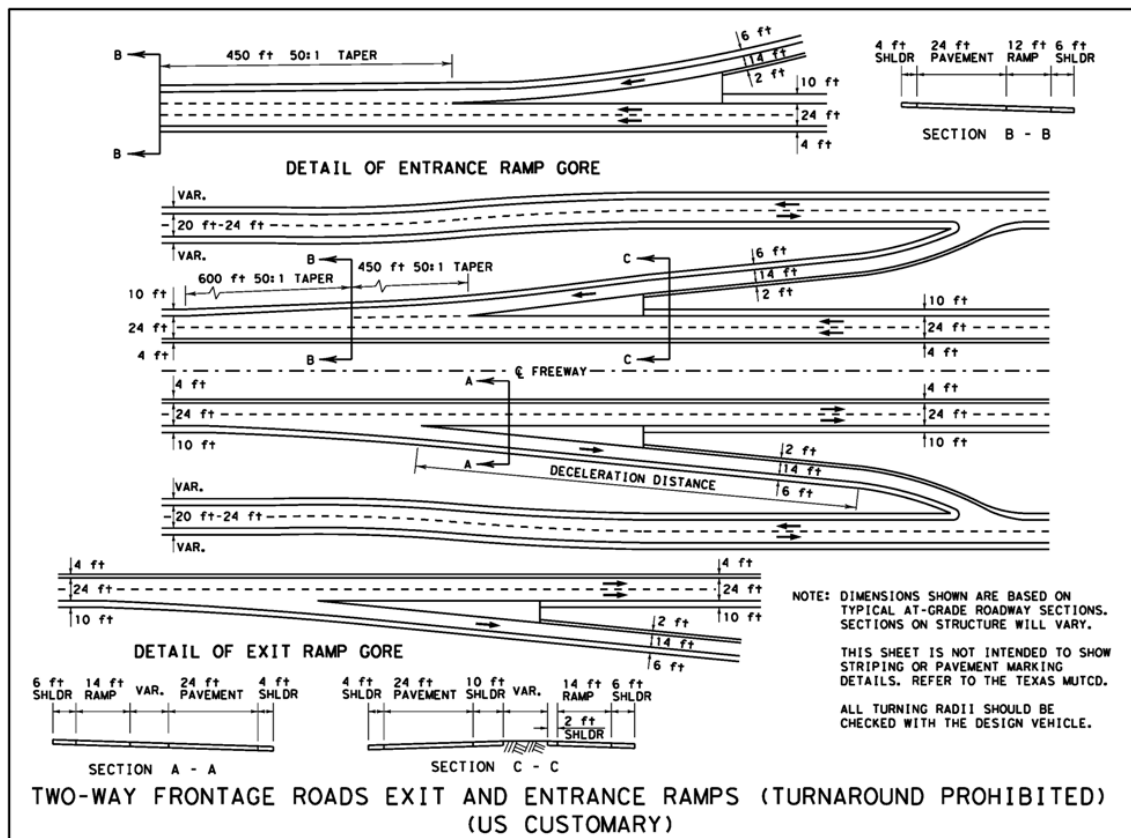
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Figure 3-29. (US). Entrance/Exit Ramps For One-Way Frontage Roads. Click [US Customary](#) or [Metric](#) to see a PDF of the image.



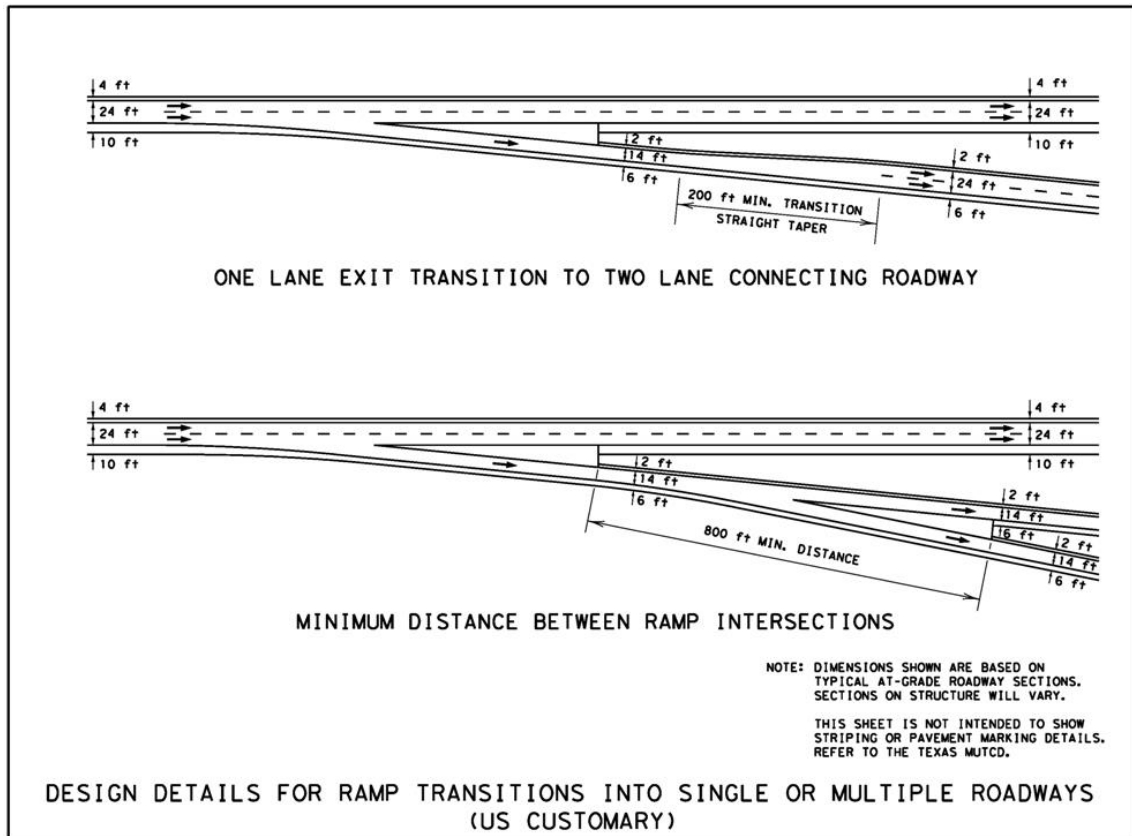
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Figure 3-30. (US). Entrance Or Exit Ramps For Two-Way Frontage Roads (Turnaround Provided). Click [US Customary](#) or [Metric](#) to see a PDF of the image.



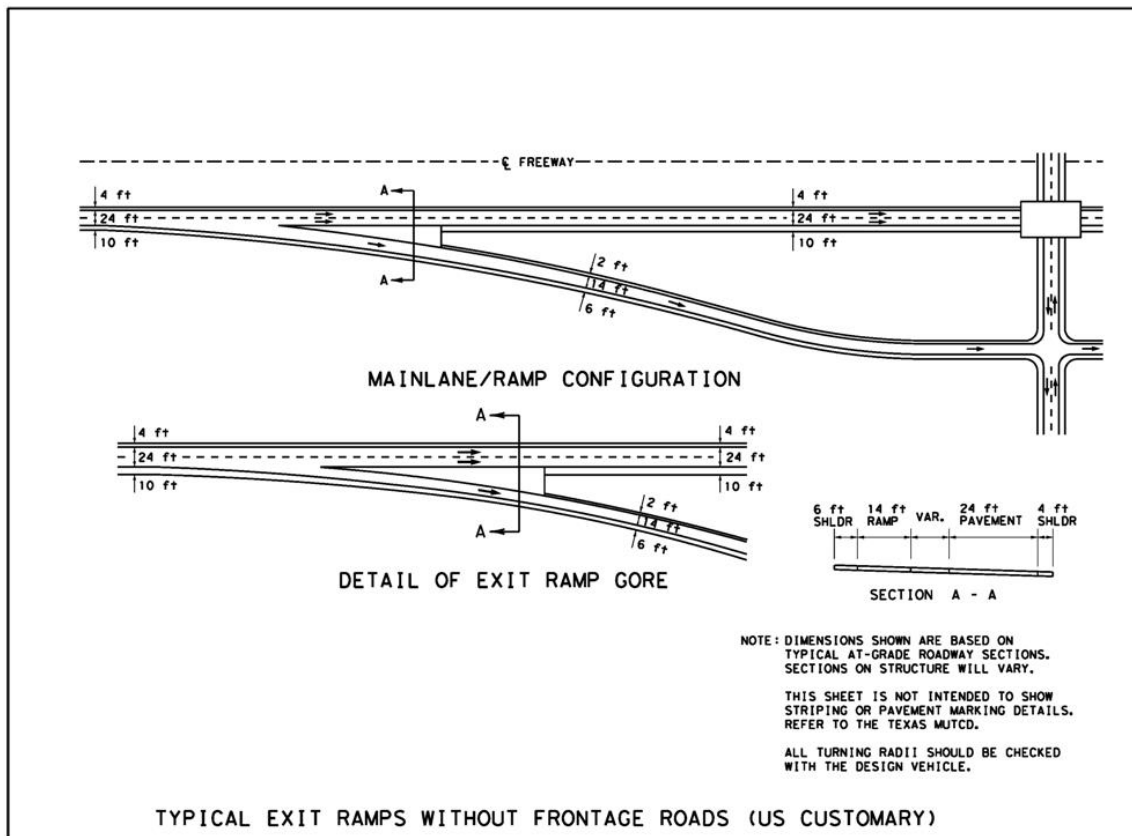
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Figure 3-31. (US). Two-Way Frontage Roads Exit and Entrance Ramps (Turnaround Prohibited). Click [US Customary](#) or [Metric](#) to see a PDF of the image.



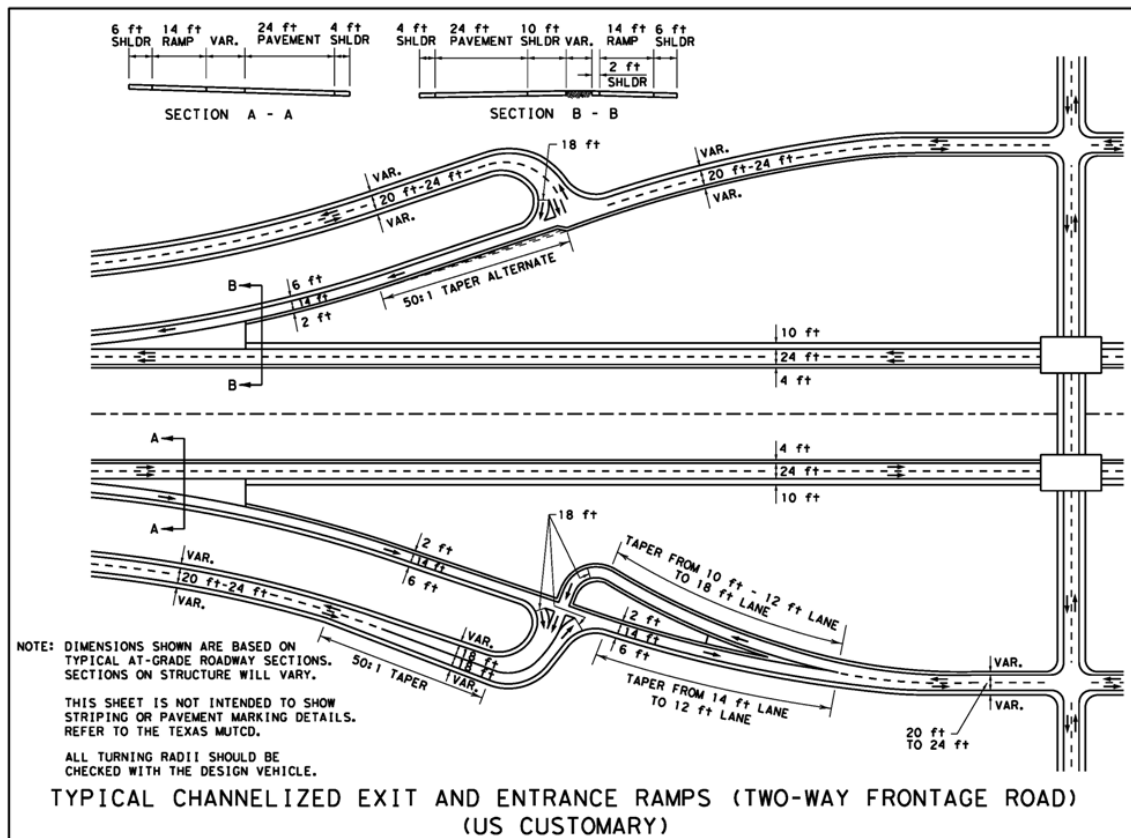
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Figure 3-32. (US). Design Details For Ramp Transitions Into Single or Multiple Roadways. Click [US Customary](#) or [Metric](#) to see a PDF of the image.



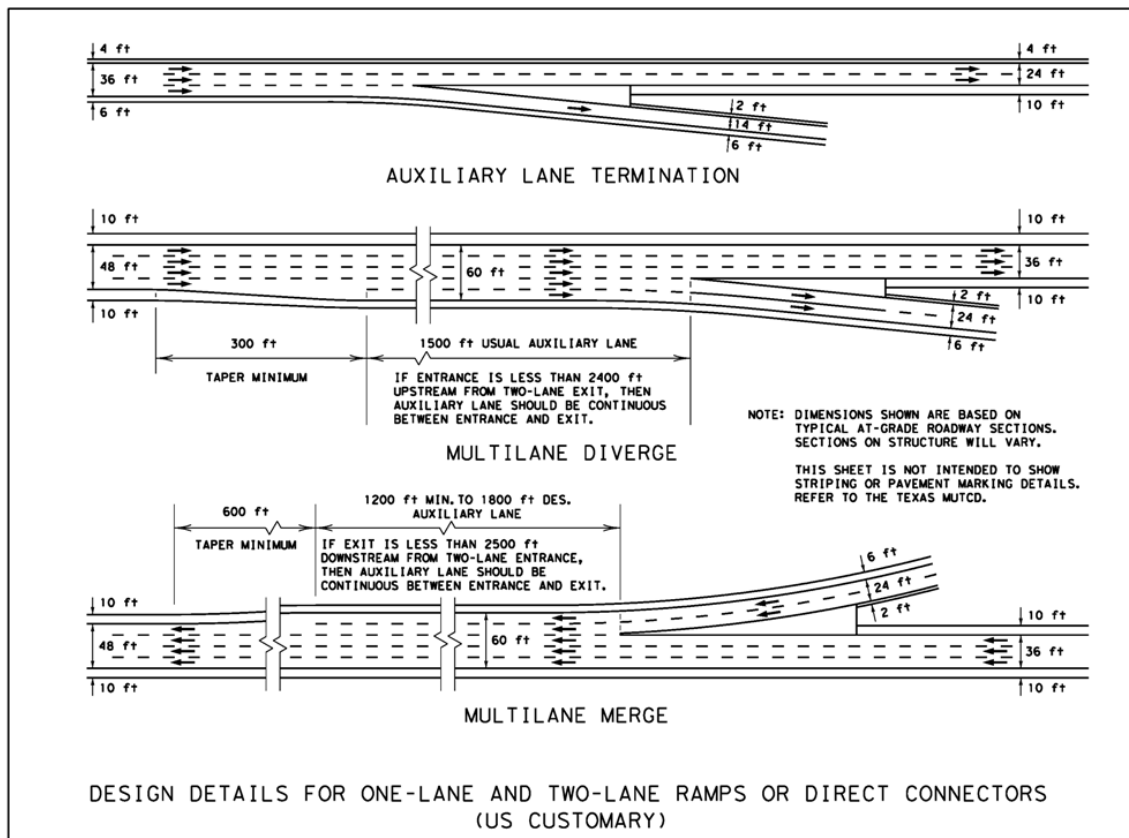
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Figure 3-33. (US). Typical Exit Ramps Without Frontage Roads. Click [US Customary](#) or [Metric](#) to see a PDF of the image.



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Figure 3-34. (US). Typical Channelized Exit and Entrance Ramps (Two-Way Frontage Road). Click [US Customary](#) or [Metric](#) to see a PDF of the image.



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Figure 3-35. (US). Design Details for One-Lane and Two-Lane Ramps or Direct Connectors. Click [US Customary](#) or [Metric](#) to see a PDF of the image.

Once ramps have been located on a schematic layout and the same has been exhibited at a public hearing or the design has otherwise become a matter of public record, extreme caution should be exercised in making any subsequent changes in ramp location to better serve areas that may have developed after the original design was determined. In all cases, proposed changes should be submitted to the Design Division, and another public hearing may be required.

Right-side ramps are markedly superior in their operational characteristics and safety to those that leave or enter on the left. With right-side ramps, merging and diverging maneuvers are accomplished into or from the slower moving right travel lane. Since a high majority of ramps are right-side, there is an inherent expectancy by drivers that all ramps will be right-side, and violations of driver expectancy may adversely affect operation and safety characteristics.

Direct access to and from ramps or direct connections can seriously impair safety and traffic operations and, therefore, should not be permitted.

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Design Speed

There should be a definite relationship between the design speed on a ramp or direct connection and the design speed on the intersecting highway or frontage road. All ramps and connections should be designed to enable vehicles to leave and enter the traveled way of the freeway at no less than 50 percent (70 percent usual, 85 percent desirable) of the freeway's design speed. Table 3-20 shows guide values for ramp/connection design speed. The design speed for a ramp should not be less than the design speed on the intersecting frontage roads. AASHTO's *A Policy on Geometric Design of Highways and Streets* provides additional guidance on the application of the ranges of ramp design speed shown in Table 3-20:

Anchor: #i1066203Table 3-20: Guide Values for Ramp/Connection Design Speed as Related to Highway Design Speed*												
(US Customary)												
Highway Design Speed (mph)	30	35	40	45	50	55	60	65	70	75	80	
Ramp** Design Speed (mph):	-											
Upper Range (85%)	25	30	35	40	45	48	50	55	60	65	70	
Mid Range (70%)	20	25	30	33	35	40	45	45	50	55	60	
Lower Range (50%)	15	18	20	23	25	28	30	30	35	40	45	
(Metric)												
Highway Design Speed (km/h)	50	60	70	80	90		100	110	120	130		
Ramp** Design Speed (km/h):	-											
Upper Range (85%)	40	50	60	70	80		90	100	110	120		
Mid Range (70%)	30	40	50	60	60		70	80	90	100		
Lower Range (50%)	20	30	40	40	50		50	60	70	80		
* For corresponding minimum radius, see Table 2-6.												
**Loops: Upper and middle range values of design speed generally do not apply. The design speed on a loop should be no less than 25 mph [40 km/h] (185 ft [55 m] minimum radius) based on an e_{max} of 6%. Particular attention should be given to controlling superelevation on loops due to the tight turning radii and speed limitations.												

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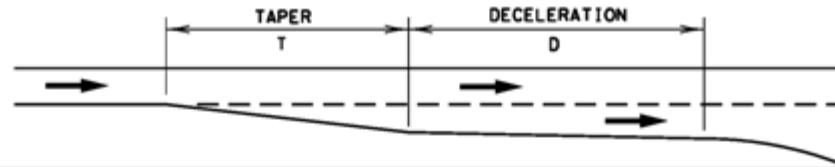
Horizontal Geometrics

Lane and shoulder widths for ramps and direct connections are shown in Table 3-18.

[Figure 3-36](#) provides design criteria for entrance and exit ramp acceleration, deceleration, and taper lengths; adjustment factors for grade effects are shown in [Table 3-14: Speed Change Lane Adjustment Factors as a Function of a Grade](#)

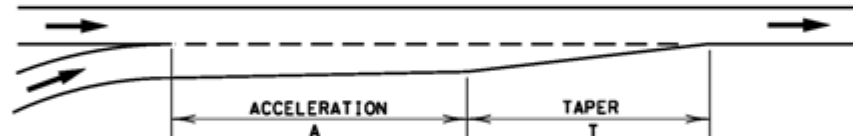
Exit and entrance ramp typical details are shown in [Figure 3-23](#), [Figure 3-24](#), [Figure 3-25](#), [Figure 3-26](#), [Figure 3-27](#), [Figure 3-28](#), and [Figure 3-29](#).

Channelized (braided) entrance and exit ramps, as typified in [Figure 3-28](#), should be used only where ramp volumes are considerably greater than frontage road traffic such as where stub frontage roads occur. Where used, the exit ramp desirably should cross the frontage road at approximately 90 degrees to minimize wrong-way entry. Passing should be restricted between the crossroad and the channelized area.



HIGHWAY DESIGN SPEED (mph)	MINIMUM LENGTH OF TAPER T (ft)	DECELERATION LENGTH, D (ft) FOR ENTRANCE CURVE DESIGN SPEED (mph)								
		STOP CONDITION	15	20	25	30	35	40	45	50
		AND INITIAL SPEED (mph)								
		0	14	18	22	26	30	36	40	44
30	150	235	200	170	140	-	-	-	-	-
35	165	280	250	210	185	150	-	-	-	-
40	180	320	295	265	235	185	155	-	-	-
45	200	385	350	325	295	250	220	-	-	-
50	230	435	405	385	355	315	285	225	175	-
55	250	480	455	440	410	380	350	285	235	-
60	265	530	500	480	460	430	405	350	300	240
65	285	570	540	520	500	470	440	390	340	280
70	300	615	590	570	550	520	490	440	390	340
75	330	660	635	620	600	575	535	490	440	390

Note: Where providing desirable deceleration length is impractical, it is acceptable to allow for a moderate amount of deceleration (10 mph) within the through lanes and to consider the taper as part of the deceleration length.



HIGHWAY DESIGN SPEED (mph)	MINIMUM LENGTH OF TAPER T (ft)	ACCELERATION LENGTH, A (ft) FOR ENTRANCE CURVE DESIGN SPEED (mph)								
		STOP CONDITION	15	20	25	30	35	40	45	50
		AND INITIAL SPEED (mph)								
		0	14	18	22	26	30	36	40	44
30	150	180	140	-	-	-	-	-	-	-
35	165	280	220	160	-	-	-	-	-	-
40	180	360	300	270	210	120	-	-	-	-
45	200	560	490	440	380	280	160	-	-	-
50	230	720	660	610	550	450	350	130	-	-
55	250	960	900	810	780	670	550	320	150	-
60	265	1200	1140	1100	1020	910	800	550	420	180
65	285	1410	1350	1310	1220	1120	1000	770	600	370
70	300	1620	1560	1520	1420	1350	1230	1000	820	580
75	330	1790	1730	1630	1580	1510	1420	1160	1040	780

Note: Uniform 50:1 to 70:1 tapers are recommended where lengths of acceleration lanes exceed 1,300 ft.

LENGTHS OF RIGHT-TURN SPEED CHANGE LANES (US CUSTOMARY)

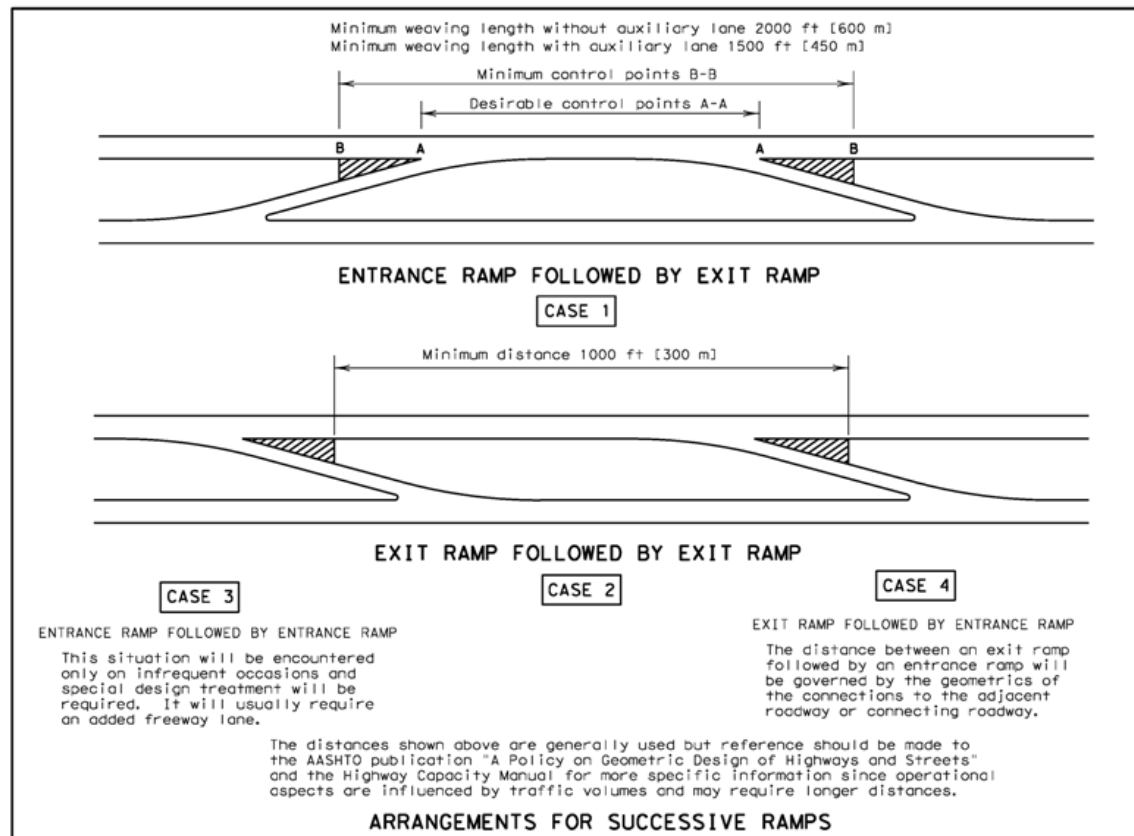
Anchor: #i1044264grtop

Figure 3-36. (US). Lengths of Exit and Entrance Ramp Speed Change Lanes. Click [US Customary](#) or [Metric](#) to see a PDF of the image.

Anchor: #CHDDICBH

Distance Between Successive Ramps

The minimum acceptable distance between ramps is dependent upon the merge, diverge and weaving operations that take place between ramps as well as distances required for signing. For analysis of these requirements, see the *Highway Capacity Manual*. Figure 3-37 shows minimum distances between ramps for various ramp configurations.



Anchor: #i1044270grtop

Figure 3-37. Arrangements For Successive Ramps. Click [here](#) to see a PDF of the image.

Anchor: #CHDGGFFH

Cross Section and Cross Slopes

Superelevation rates, as related to curvature and design speed of the ramp or direct connector, are given in Table 3-21. While connecting roadways represent highly variable conditions, as high a superelevation rate as practicable should be used, preferably in the upper half or third of the indicated range, particularly in descending grades. Superelevation rates above 8% are shown in Table 3-21 only to indicate the limits of the range. Superelevation rates above 8% are not recommended and a larger radius is preferable.

Anchor: #i1066480Table 3-21: Superelevation Range for Curves on Connecting Roadways

(US Customary)

Radius (ft)	Range in Superelevation Rate (percent) For Connecting Roadways With Design Speed, mph, of:					
-	20	25	30	35	40	45
90	2-10	-	-	-	-	-
150	2-8	4-10	-	-	-	-
230	2-6	3-8	6-10	-	-	-
310	2-5	3-6	5-9	8-10	-	-
430	2-4	3-5	4-7	6-9	9-10	-
540	2-3	3-5	4-6	6-8	8-10	10-10
600	2-3	2-4	3-5	5-7	7-9	8-10
1000	2	2-3	3-4	4-5	5-6	7-9
1500	2	2	2-3	3-4	4-5	5-6
2000	2	2	2	2-3	3-4	4-5
3000	2	2	2	2	2-3	3-4

* See Tables [2-6](#) and [2-7](#) for design speeds greater than 45 mph.

(Metric)

Radius (m)	Range in Superelevation Rate (percent) For Connecting Roadways With Design Speed, km/h, of:					
-	20	30	40	50	60	70
15	2-10	-	-	-	-	-
25	2-9	2-10	-	-	-	-
50	2-8	2-8	4-10	-	-	-
80	2-6	2-6	3-8	6-10	-	-
100	2-5	2-4	3-6	5-8	-	-
115	2-3	2-4	3-6	5-8	8-10	-
150	2-3	2-3	3-5	4-7	6-8	-
160	2-3	2-3	3-5	4-7	6-8	10-10
200	2	2-3	2-4	3-5	5-7	6-8

300	2	2-3	2-3	3-4	4-5	5-7
500	2	2	2	2-3	3-4	4-5
700	2	2	2	2	2-3	3-4
1000	2	2	2	2	2	2-3
* See Tables 2-6 and 2-7 for design speeds greater than 70 km/h.						

The cross slope on portions of connecting roadways or ramps on tangent normally is sloped one way at a practical rate of 1.5% to 2%.

The change in pavement edge elevation per given length of connecting roadway or ramp should be that as shown in [Table 2-8: Maximum Relative Gradient for Superelevation Transition](#). The maximum algebraic difference in pavement cross slope at connecting roadways or ramps should not exceed that set forth in Table 3-22:

Anchor: #i1066740Table 3-22: Maximum Algebraic Differences in Pavement Cross Slope at Connecting Roadway Terminals			
(US Customary)		(Metric)	
Design Speed of Exit or Entrance Curve (mph)	Maximum Algebraic Difference in Cross Slope at Crossover Line (%)	Design Speed of Exit or Entrance Curve (km/h)	Maximum Algebraic Difference in Cross Slope at Crossover Line (%)
Less than or equal to 20	5.0 to 8.0	Less than or equal to 30	5.0 to 8.0
25 to 30	5.0 to 6.0	40 to 50	5.0 to 6.0
Greater than or equal to 35	4.0 to 5.0	Greater than or equal to 60	4.0 to 5.0

The cross section of a ramp or direct connector is a function of the following variables:

- number of lanes determined by traffic volume
- minimum lane and shoulder width
- lane balance
- where two lanes are required by volume, the provision of parallel merging two lanes onto the mainlanes must be provided at the terminal

Anchor: #CHDCICAH

Sight Distance

On all ramps and direct connections, the combination of grade, vertical curves, alignments and clearance of lateral and corner obstructions to vision shall be such as to provide sight distance along such ramps and connections from terminal junctions along the freeway, consistent with the probable speeds of vehicle operation. Sight distance and sight lines are especially important at merge points for ramps and mainlanes or between individual ramps. [Table 2-1: Stopping Sight Distance](#) shows recommended stopping sight distances for ramps and direct connections.

The sight distance on a freeway preceding the approach nose of an exit ramp should exceed the minimum stopping sight distance for the freeway design speed, preferably by 25 percent or more. Decision sight distance, as discussed in Decision Sight Distance in Chapter 2, is a desirable goal.

Anchor: #i1085605

Grades and Profiles

Design controls for crest and sag vertical curves on ramps and direct connectors may be obtained from Figures 2-7 through 2-10. Longer vertical curves with increased stopping sight distances should be provided wherever possible.

The tangent or controlling grade on ramps and direct connectors should be as flat as possible, and preferably should be limited to 4 percent or less. AASHTO's *A Policy on Geometric Design of Streets and Highways* has additional discussion on ramp gradients.

Anchor: #CHDEJABH

Metered Ramps

Where ramps are initially, or subsequently, expected to accommodate metering, the geometric design features shown in Design Criteria for Ramp Metering may be considered. Ramp metering, when properly designed and installed, has been shown to have potential benefits for the operation of the mainlanes. However, since ramp meters are installed to control the number of vehicles that are allowed to enter the mainlanes, an analysis of the entire roadway network area should be done to determine any adverse operational impacts to other roadways. It is suggested that the analysis specifically include both frontage road and adjacent cross street operations of through traffic, turning movements, and queue lengths.

Anchor: #CHDCFJEE

Collector-Distributor Roads

A collector-distributor road may be warranted within an interchange, through two adjacent interchanges or continuous for some distance along the freeway through

several interchanges. Collector-distributor roads should be provided at all cloverleaf interchanges and particularly at such interchanges on controlled access facilities. A collector-distributor road is designed to meet the following goals:

- transfer weaving from the mainlanes
- provide single-point exits from the main lanes
- provide exit from the main lanes in advance of cross roads.

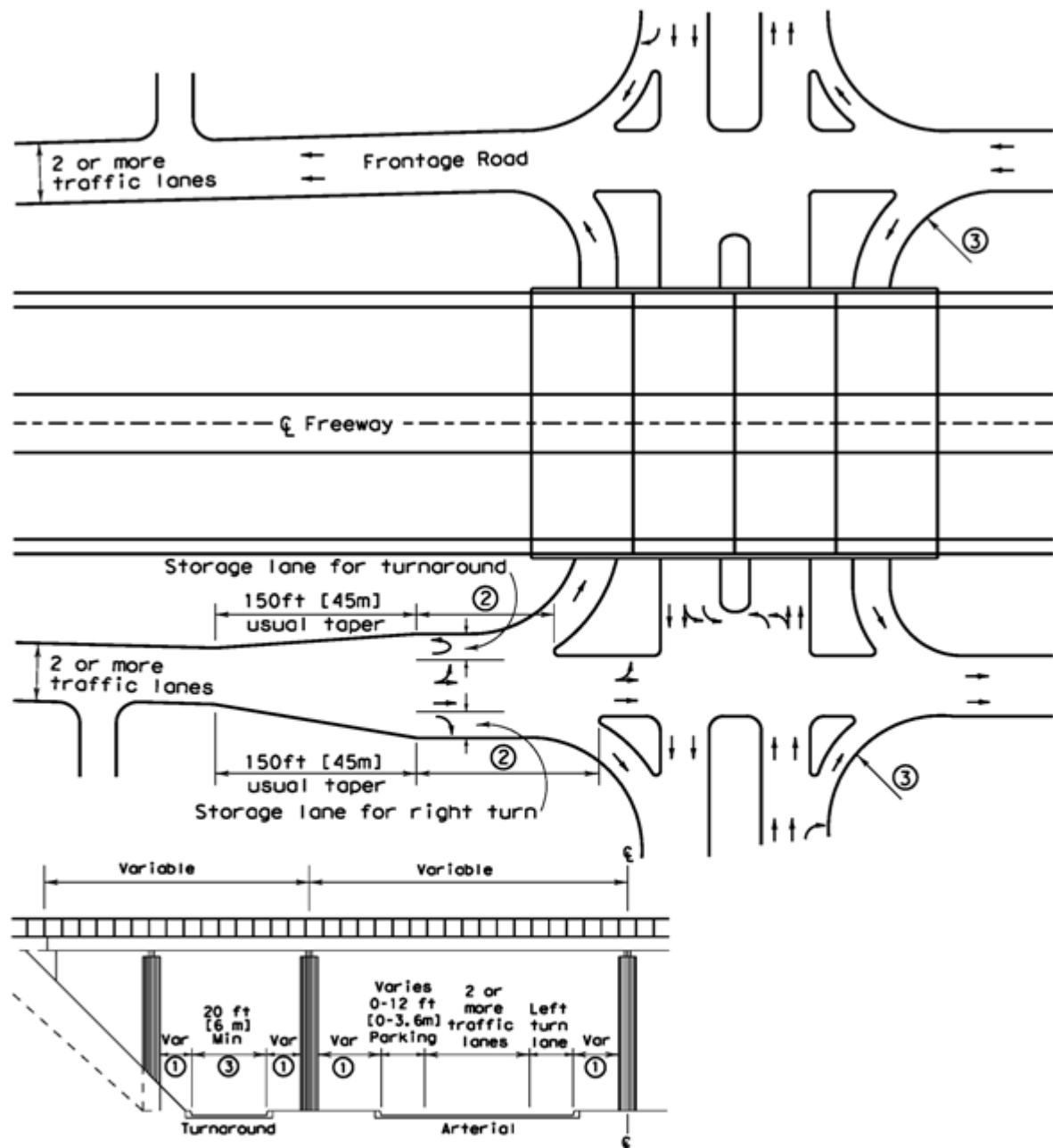
Where there is considerable demand for frequent ingress and egress, as in and near the business district of large cities, a collector-distributor road, continuous for some distance, should be provided.

Anchor: #i1085663

Frontage Road Turnarounds and Intersection Approaches

Turnaround lanes are to be provided at all interchanges with major arterials in urban and suburban areas where the freeway lanes are flanked by one-way frontage roads. Turnaround lanes are not to be provided where two-way frontage roads are used. In urban and suburban areas, overpasses should be arranged so that turnarounds may be added in the future. This includes provisions for end spans and vertical clearance for future turnarounds at overpasses. Underpass situations should also allow for vertical clearances on future elevated turnarounds. Figure 3-38 shows a typical turnaround at a diamond interchange.

When the cross street overpasses the freeway, the resulting turnarounds will be on bridge structures. In these cases, sight lines and distances should be carefully evaluated with respect to any bridge railing sight obstructions.



- ① If practical, the face of new bridge columns should be located 6 ft [1.8 m] or more from the face of curb. Where potential future expansion of the cross road exists, applicable new bridge columns should be located 16 ft [4.8 m] from the curb face.
- ② For desirable length of storage, multiply 0.63 (US Customary) [0.19 (Metric)] by peak hour volume on adjacent lane. Conditions may dictate use of shorter lengths.
- ③ Width and turning radius should be based on appropriate design vehicle.
- ④ See Figure 3-19 for lane layout option if dual left turn lanes are needed.

TYPICAL DIAMOND INTERCHANGE WITH FRONTAGE ROAD

Anchor: #i1047580grtop

Figure 3-38. Typical Diamond Interchange With Frontage Road. Click [here](#) to see a PDF of the image

Section 7: Freeway Corridor Enhancements

Anchor: #i1085695

Overview

This section discusses other transportation modes and includes discussions on where to find information on planning and design criteria for these modes.

Anchor: #i1085706

Freeways With High Occupancy Vehicle Treatments

High Occupancy Vehicles (HOV) lanes are becoming common in urban freeway environment as an approach to reducing congestion and travel times.

Guidelines for the planning and designs of HOV facilities are given in AASHTO's *Guide for the Design of High Occupancy Vehicle Facilities* and in the HOV Systems Manual, National Cooperative Highway Research Program Report 414, Transportation Research Board, National Research Council, Washington, D.C., 1998.

Anchor: #i1085724

Light Rail Transit

Light Rail Transit systems are being considered in some urban environments as an approach to reducing congestion and travel times.

Guidelines for the incorporation of light rail transit systems in the transportation network are given in the Federal Transit Administration publication by Korge, Farran, Mansel, Levinson, Chira-Chavala and Ragland, *TCRP Report 17, Integration of Light Rail Transit into City Streets*, Transportation Research Board, National Academy Press, Washington, D.C., 1996.

Section 4: Parking

Anchor: #i1012945

Overview

This section presents information on the following topics:

- fringe parking lots
- parking along highways and arterial streets

Anchor: #CHDFHIJH

Fringe Parking Lots

Fringe parking lots are congestion mitigation and energy conservation measures which TxDOT utilizes. Depending on the function which they are intended to serve, they may be one of the following types of facilities:

- park and pool lots
- park and ride lots, or
- combination park and pool/park and ride lot.

Park and Pool Lots. Park and Pool lots are usually located on the fringe of an urban area along an arterial roadway at a convenient point where a group of two or more drivers from a surrounding area can gather, leave their individual vehicle and proceed to a common destination in one of the group vehicles. The carpool may consist of two or more persons per vehicle. The lot may provide space for a small to large number of vehicles and serve many carpools involving several destinations.

Park and pool lots are located within the highway right-of-way except where they may be in combination with a park and ride lot as discussed below. They are eligible for Federal-aid participation. The lots should be simply designed to accommodate the passenger vehicle with regard to parking stall widths, drive through isles and turning movements.

Park and Ride Lots. Park and ride lots are generally constructed along express bus routes and are designed to intercept automobiles from low density suburban development of outlying locations along transitway corridors. The quality of transit service must be attractive. The time required to reach the destination point by bus must be comparable to or better than driving one's own car.

The facility should be located with regard to the following criteria:

- along a corridor which experiences 20,000 vehicles per day per lane
- in advance of the point where intense traffic congestion routinely occurs
- 4 to 5 miles [6.4 to 8.0 kilometers] from the activity center (usually the Central Business District (CBD)) served by the transit way and at least 4 to 5 miles [6.4 to 8.0 kilometers] from another park and ride facility
- downstream from, but in the immediate area of, sufficient demand for travel to the activity center being served
- on the right hand side of the inbound roadway.

Other desirable general features include the following:

- good accessibility to the adjoining street system
- no parking fees
- space for future expansion
- fencing.

Typical park and ride layouts include the following design features:

- bus travel area designed to accommodate the Bus or A-Bus for all turning movements
- bus loading areas located to reduce conflict between buses and private vehicles
- maximum walking distance of 650 ft [200 m]
- separate bus access points from private vehicle access points if demand exceeds 500 all day spaces
- parking placed in the following order with respect to proximity of the bus loading area:
 - disabled persons
 - bicycles
 - motorcycles
 - kiss and ride
 - private vehicular parking.
- ingress and egress located near midblock on collector and local streets; direct access to arterials and freeway ramps should only be used if projected queues do not interfere with functional areas of nearby intersections; at least two ingress/egress points should be provided to the park and ride facility; right and left turn lanes with adequate storage should be added to all ingress/egress locations
- parking lanes in the park and ride lot placed approximately 90 degrees to the bus loading area to facilitate safe, convenient walking to buses
- curbs depressed and wheelchair ramps provided where necessary; disabled parking spaces and pedestrian facilities should be in accordance with the Americans with Disabilities Act Accessibility Guidelines and the *Texas Accessibility Standards*.

Combination Park and Pool/Park and Ride Lot. These combination type lots serve the purposes and combine the features of each of the two types of facilities discussed above.

References. Further information on the planning and design of park and ride facilities may be found in the following publications:

- AASHTO *Policy on Geometric Design of Streets and Highways*
- AASHTO *Guide for the Design of Park and Ride Facilities*
- TxDOT *Revised Manual for Planning, Designing and Operating Transitway Facilities in Texas*.

Authority and Funding. For fringe parking areas within highway right-of-way, projects are generally developed as any other multiple use project. Where parking lots are proposed that are located outside of existing or proposed highway right-of-way, commission approval is required.

Park and pool lots are eligible for Federal-aid participation. Projects are usually located within or adjacent to highway right-of-way outside the central business district, but inside the urbanized area, and consistent with the urban transportation planning process. Operation and maintenance responsibilities should be assigned to local transit or government or agencies by agreement.

Anchor: #i1013173

Parking Along Highways and Arterial Streets

This section deals with parking as it pertains to the mainlanes of a controlled access highway, the frontage roads for such a facility, and parking along urban and suburban arterials. Offstreet parking facilities provided within highway right-of-way are discussed in the previous section ([Fringe Parking Lots](#)) Rest areas as parking facilities are not considered in this section.

Emergency Parking. Parking on and adjacent to the mainlanes of a highway will not be permitted except for emergency situations. It is of paramount importance, however, that provision be made for emergency parking. Shoulders of adequate design provide for this required parking space.

Curb Parking. In general, curb parking on urban/suburban arterial streets and frontage roads should be discouraged. Where speed is low and the traffic volumes are well below capacity, curb parking may be permitted. However, at higher speeds and during periods of heavy traffic movement, curb parking is incompatible with arterial street service and desirably should not be permitted. Curb parking reduces capacity and interferes with free flow of adjacent traffic. Elimination of curb parking can increase the capacity of four-to-six lane arterials by 50 to 60 percent.

If curb parking is used on urban/suburban arterials or frontage roads under the conditions stated above, the following design requirements should be met:

- provide parking lanes only at locations where needed
- parallel parking preferred
- confine parking lanes to outer side of street or frontage road
- require that parking lane widths be 10 feet [3.0 meters]
- restrict parking a minimum of 20 feet [6 meters] back from the radius of the intersection to allow for sight distance, turning clearance and, if desired, a short right turn lane

Section 5: Shoulder Texturing

Anchor: #i1013228

Definition

Rumble strips are depressed or raised patterns used to provide auditory and tactile sensations to the driver to call attention to an upcoming change in conditions. Specifically, shoulder texturing is the use of rumble strips along the shoulder as a warning device to alert inattentive drivers that they are leaving the travelway.

Anchor: #i1013239

Types of Shoulder Texturing

Milled-in. Milled-in rumble strips are effective types of shoulder texturing at reducing the number of single vehicle run-off-the-road accidents. Milled-in rumble strips are shallow depressions perpendicular to the edge line. Machinery specifically adapted for this type of work is required. A minimum shoulder width of 8 ft [2.4 m] is required for the outside shoulder to be milled. A minimum shoulder width of 4 ft [1.2 m] is required for the inside shoulder to be milled. Milled-in texturing produces sufficient stimuli to alert inattentive drivers, but does not affect the maneuverability capabilities of vehicles.

Rolled-in. Rolled-in strips may produce less noise and vibration than milled-in rumble stripes; however, rolled-in rumble strips are also effective at reducing the number of single vehicle run-off-the-road accidents. Rolled-in rumble strips are produced by half sections of pipe welded on a steel wheel roller at the appropriate spacing and rolled-in during the placement of hot mix asphaltic concrete pavement. Considerations in evaluating rolled-in texturing include 1) placement must be in coordination with other asphaltic concrete pavement construction, and 2) the temperature of the asphaltic concrete pavement is critical for achieving the proper depth without affecting the remaining surface. A minimum shoulder width of 8 ft [2.4 m] is required for the outside shoulder to be treated. A minimum shoulder width of 4 ft [1.2 m] is required for the inside shoulder to be treated.

Traffic Buttons. Traffic buttons placed along the edge line may also be used as shoulder texturing when milled-in or rolled-in texturing is not feasible. Buttons should be limited to roadways where there is insufficient pavement structure or shoulder width to accommodate either of the depressed texturing treatments and where the accident experience justifies the cost for placing and maintaining buttons. Buttons, however, may be used to supplement other shoulder texturing treatments when appropriate. Buttons may not be suitable where snow plows are used.

Raised Profile Thermoplastic Marking. Raised profile thermoplastic markings installed as the edge line may be used as shoulder texturing when rolled-in or milled-in texturing is not feasible. Raised profile thermoplastic markings used as the shoulder texturing treatment should be limited to roadways where there is insufficient pavement structure or shoulder width to accommodate either of the depressed texturing treatments. Raised profile thermoplastic markings, however, may be used to supplement other shoulder treatments, when appropriate.

Jiggle Bars. Jiggle bar tiles placed in a pattern perpendicular to the edge line may also be used as shoulder texturing when rolled-in or milled-in texturing is not feasible. The use of jiggle bars as shoulder texturing is not encouraged due to the level of auditory and tactile sensations caused by the jiggle bars and the high cost of installing the jiggle bars. Also, jiggle bars may not be suitable where snow plows are used. A minimum shoulder width of 8 ft [2.4 m] is required for the outside shoulder to be treated. A minimum shoulder width of 4 ft [1.2 m] is required for the inside shoulder to be treated.

Anchor: #i1013270

Roadway Applications of Shoulder Texturing

For rural freeways and rural four-lane or more divided highways, the following guidelines are recommended:

- *Asphaltic Concrete Shoulders:* Rumble strips should be installed as part of new construction, reconstruction, and overlay projects on rural four-lane or more controlled and partially controlled access highways with asphaltic concrete shoulders.
- *Portland Cement Shoulders:* Rumble strips should be installed as part of new construction and reconstruction projects. If the concrete shoulder will be used in the near future as a permanent travel lane or a travel lane in a work zone, shoulder texturing should not be considered.

For rural four-lane or more undivided and rural two-lane highways, shoulder texturing on asphaltic concrete or portland cement shoulders is not recommended for these facilities except in special cases where a significant number of accidents, by frequency and percentage of total accidents, are run-off-the-road accidents and the installation of rumble strips is determined to be cost beneficial. The accident history, along with consideration of shoulder use by traffic, mail carriers, bicyclists, and/or farm equipment should be evaluated. If the concrete shoulder will be used in the near future as a permanent travel lane or a travel lane in a work zone, shoulder texturing should not be considered.

For urban highways, shoulder texturing on asphaltic concrete or portland cement shoulders is not recommended.

Bicyclists. When installing shoulder treatments, appropriate riding space for bicyclists needs to be a consideration. The standard details for shoulder texturing treatments provide appropriate riding space.

Placement. Rumble strips shall not be placed across exit or entrance ramps, acceleration and deceleration lanes, crossovers, gore areas or intersections with other roadways. Depressed rumble strips (i.e., milled-in or rolled-in) shall not be placed across bridge decks.

Section 6: Emergency Median Openings on Freeways

Anchor: #i1013318

Overview

Median crossings between the mainlanes are sometimes necessary for proper law enforcement or for performance of highway maintenance on rural freeways. The construction of such median crossings is not encouraged since the necessary U-turns by such vehicles should be accomplished by using ramps at interchanges to the maximum extent feasible.

Anchor: #i1013329

Conditions

Median crossings, as turnarounds, interfere with through traffic and should be avoided. Normally, the spacing of interchanges and layout of the highway provides for all necessary traffic movements, including those of emergency vehicles.

In unusual situations, where the distance between interchanges is great, emergency crossings may be provided with administrative approval.

Anchor: #i1013344

Spacing of Openings

Due to the close spacing of interchanges on urban freeways, emergency median openings are not needed for the operation of official vehicles and, in general, they should not be provided. In rural areas where the spacing of interchanges is greater than approximately 3 miles [4.8 km], a U-turn median opening may be considered at a favorable location about halfway between interchanges. In no case should emergency median openings be spaced at less than 1 mile [1.6 km] intervals. All emergency median openings should be at least 0.5 mile [0.8 km] from any structure that crosses over a freeway and at least 1 mile [1.6 km] from any ramp terminal or other access connection, such as those serving safety rest areas. Openings should be located where adequate stopping sight distance is available and where the median is sufficiently wide to permit an official vehicle to turn between the inner freeway lanes. Emergency median openings should also be as inconspicuous to the traveling public as possible.

Anchor: #i1013354

Construction

Location and type of emergency median openings should be made a part of the PS&E as a contract item and should be installed as such.

Section 6: Determining Length of Need of Barrier

Anchor: #i1005497

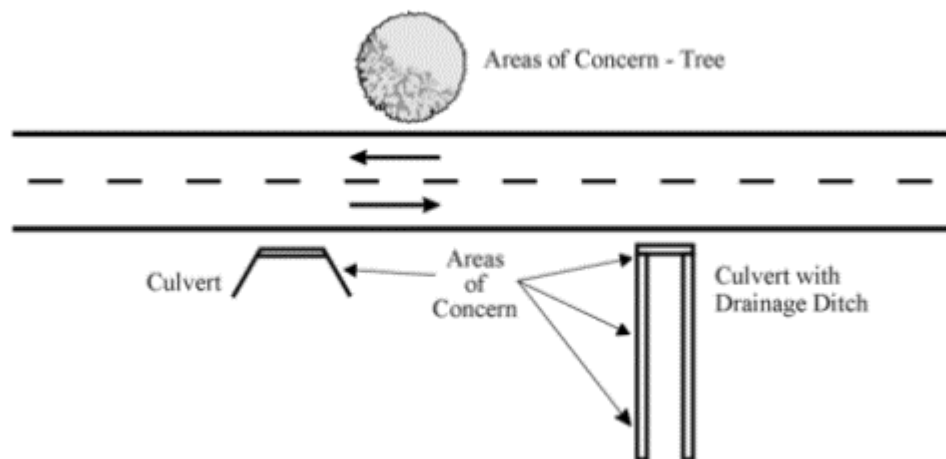
Overview

The shape of the obstacle, its location with respect to travel lanes, the volume of traffic and its corresponding horizontal clearance width are the primary variables influencing length of barrier need.

Anchor: #i1005508

Variables

After all practical means to free the roadside of obstacles have been exhausted, certain areas may remain which constitute an obstacle to errant vehicles. These areas, as illustrated in Figure A-6, will be referred to an “area of concern.”



Anchor:

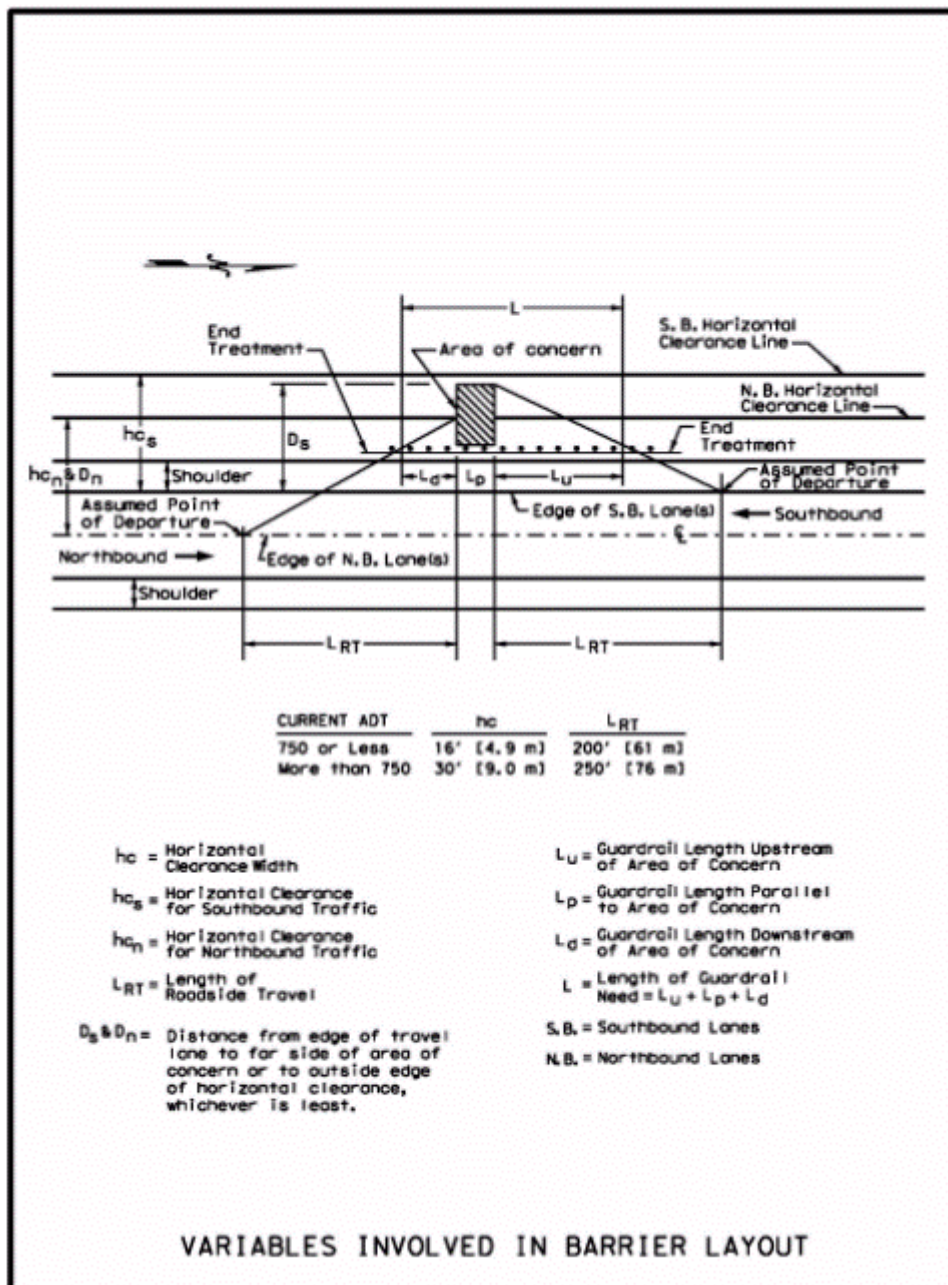
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Figure A-7. Areas of Concern

Figure A-7 illustrates the variables of interest in the layout of approach barrier to shield an area of concern. Length of need is equal to the sum of the following variables:

- length of upstream barrier, L_u ,
- length of barrier parallel to the area of concern, L_p ,
- the length of downstream barrier, L_d

For roadways serving one-way traffic operations, $L_d=0$. L_d is greater than zero for two-way operations when the area of concern lies within the horizontal clearance of opposing (northbound in Figure A-7) traffic as measured from the centerline pavement markings.



Anchor:

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Figure A-8. Variables Involved in Barrier Layout. Click [here](#) to see a PDF of the image.

In certain instances judgment should be exercised to supplement design chart solutions and provide for public safety. For example, high severity fixed objects (e.g., bridge columns) may warrant minimum guardrail treatment where located slightly outside the horizontal clearance if geometric conditions (i.e., steep fill slope, outside of horizontal curvature, etc.) increase the likelihood of roadside encroachments.

Anchor: #i1005574

Section 3: Driveway Design Principles

Anchor: #i1007221

General Guidelines

The following guidelines apply to all driveways to a state highway.

1. The driveway placement should be such that drivers approaching from the main roadway will have sufficient sight distance to ascertain the driveway's location in order to safely decelerate and complete the entry maneuver. Also, the driveway placement should be such that an exiting driver will have sufficient sight distance to judge a safe gap in oncoming traffic. For selecting appropriate driveway spacing distance, refer to the TxDOT Access Management Manual.
2. Each driveway radius should accommodate the appropriate design vehicle. This will generally be the passenger car (AASHTO P design vehicle) unless the driveway will routinely be expected to handle more than four larger vehicles per hour. Examples of facilities for which a larger design vehicle would normally be appropriate include truck terminals, bus terminals, and connections that serve the loading docks of shopping centers. Figure C-1 illustrates the effects of the radius on the right-turn entry and exit maneuver.
3. Figure C-2 illustrates various driveway design elements including return radius, entry width, exit width, throat width, and throat length.
4. With the exception of private residential driveways, farm/ranch driveways, field driveways, and driveways that are designed and signed for one-way operation (i.e. ingress or egress only but not both), driveways should be designed to accommodate simultaneous entry and exit by the appropriate design vehicle.
5. Driveways that cross sidewalks are located in a developing area where pedestrian traffic can be expected, should be designed to maintain an accessible route that is at least four feet wide across the driveway.
6. One-way driveways should have a minimum throat length of 50 feet (15 m) and preferably 75 feet (23 m).

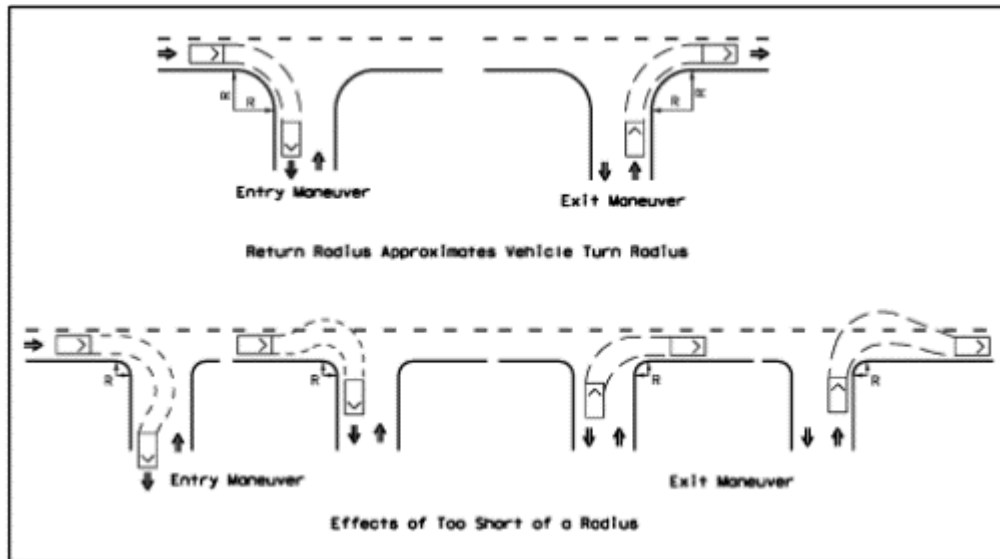


Figure C-1. Effects of Return Radius on the Right-Turn Maneuver

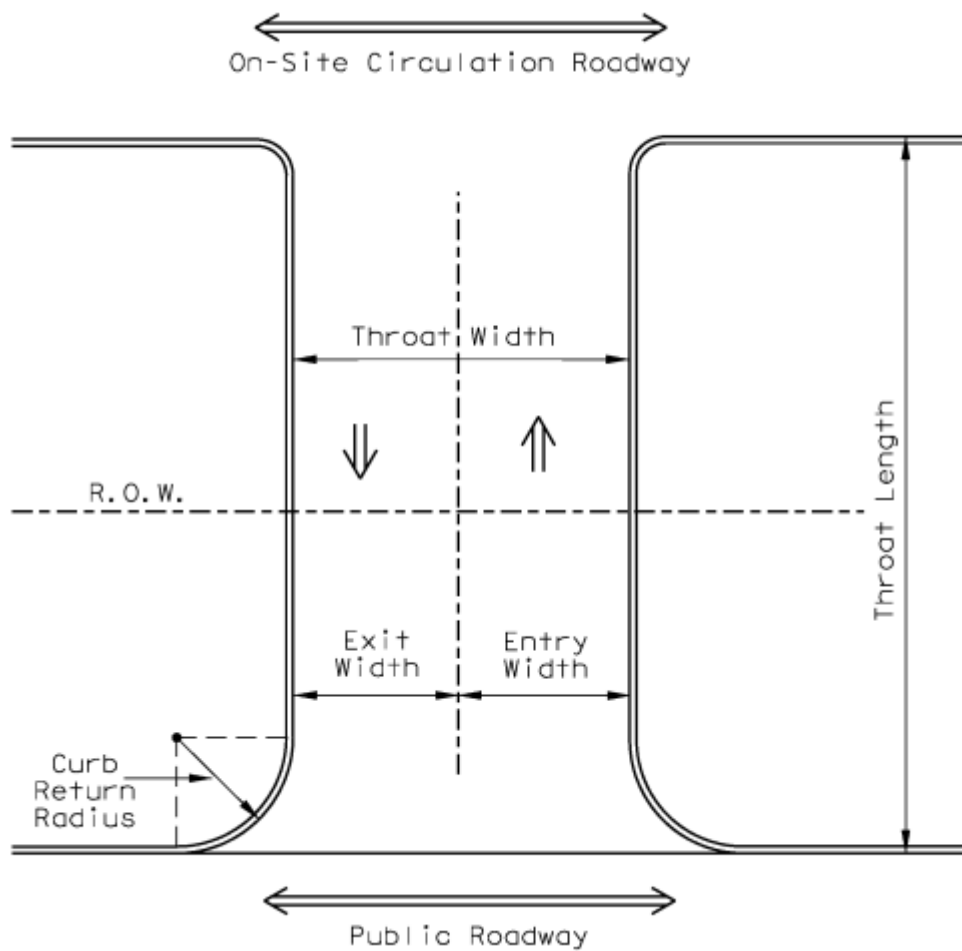


Figure C-2. Driveway Design Elements

Anchor: #i1007270

Geometrics for Two-Way Driveways

The following are standards for two-way driveways.

1. Private Residential Driveway – Driveways serving single-family or duplex residences are normally designed as non-simultaneous two-way driveways. Standard design criteria for private residential driveways are provided in Table C-1. However, for existing cases where the criteria cannot be obtained, every attempt should be made to match the existing driveway width at the ROW line.
2. Commercial Driveways – At locations where the expected volume of large vehicles is four or more per hour, the design should be based on the appropriate design vehicle. Such situations include, but are not limited to, truck stops, warehouses, concrete batch plants, sources of aggregate, RV sales/truck sales and RV parks. The design should also consider future roadway traffic and local conditions and incorporate simultaneous two-way driveways if justified.

Anchor: #i1006061Table C-1. Design Criteria for Private Residential Driveways					
Radiu s	Throat Width		Radiu s	Throat Width	
US Customary Units			Metric Units		
(ft.)	Standard(ft.)	Maximum(ft.)	(m)	Standard(m)	Maximum(m)
15 1.	14	24	4.5	4.2	7.2
1. Reference Regulations for Access Driveways to State Highways for suggested minimum values.					

- 3.
4. Two exit lanes are recommended when the expected driveway exit volume exceeds 200 vph.
5. In cases where one-way operation is appropriate, a condition of the driveway permit should require that appropriate one-way signing be installed and maintained.
6. Table C-2 provides standard design criteria for two-way commercial driveways that would be expected to accommodate only P and SU design vehicles.

Anchor: #i1006102Table C-2. Designs for Two-Way Commercial
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Driveways				
	US Customary Units		Metric Units	
Condition	Radius (R) (ft)	Throat Width (W) (ft)	Radius (R) (m)	Throat Width (W) (m)
One entry lane and one exit lane, fewer than 4 large vehicles per hour (see Fig. C-3)	25	28	7.5	8.4
One entry lane and one exit lane, 4 or more SU vehicles ³ per day (see Fig. C-3)	30	30	9.0	9.0
One entry lane and two exit lanes, without divider (see Fig. C-4)	25	40	7.5	12.0
One entry lane and two exit lanes, with divider (see Fig. C-5)	25	44 ⁽¹⁾ -50 ⁽²⁾	7.5	13.2 ⁽¹⁾ -15.0 ⁽²⁾
Two entry lanes and two exit lanes, with divider (see Fig. C-6)	25	56 ⁽¹⁾ -62 ⁽²⁾	7.5	16.8 ⁽¹⁾ -18.9 ⁽²⁾
(1)4 ft. [1.2 m] wide divider, face-to-face of curbs (2)10 ft. [3.0 m] wide divider, face-to-face of curbs (3)Driveway designs for larger vehicles will be considered on a case by case basis				

- 7.
8. Service Driveways – Service driveways should be designed considering the vehicle type and frequency of use, current and future traffic operations on the state highway, and other local conditions.
9. Field Driveways – The distance from the edge of the shoulder to a gate should be sufficient to accommodate the longest vehicle (or combination of vehicles

such as a truck and trailer) expected. At a minimum, this will normally be a truck with trailer.

10. Farm/Ranch Driveway – A typical design for a farm/ranch driveway should provide a 25-foot return radii and a 20-foot throat width. The distance from the edge of pavement must be sufficient to store the longest vehicle, or combination of vehicles, expected. At a minimum, this will normally be a truck with trailer.

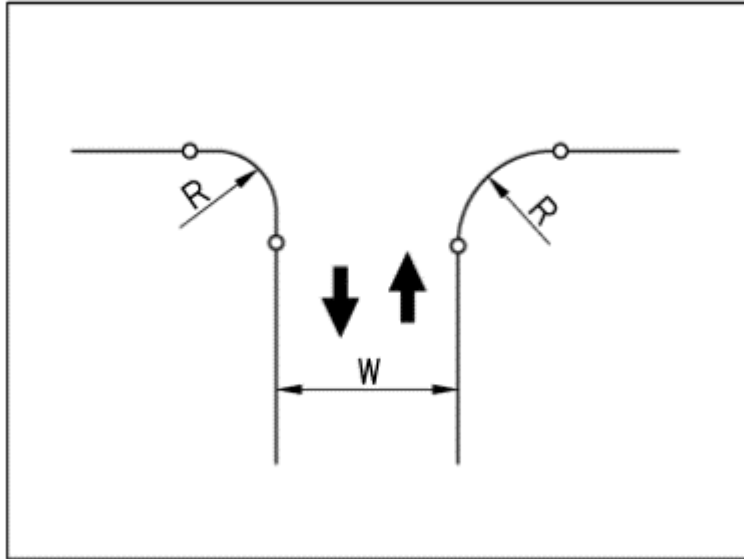


Figure C-3. One Entry Lane/One Exit Lane

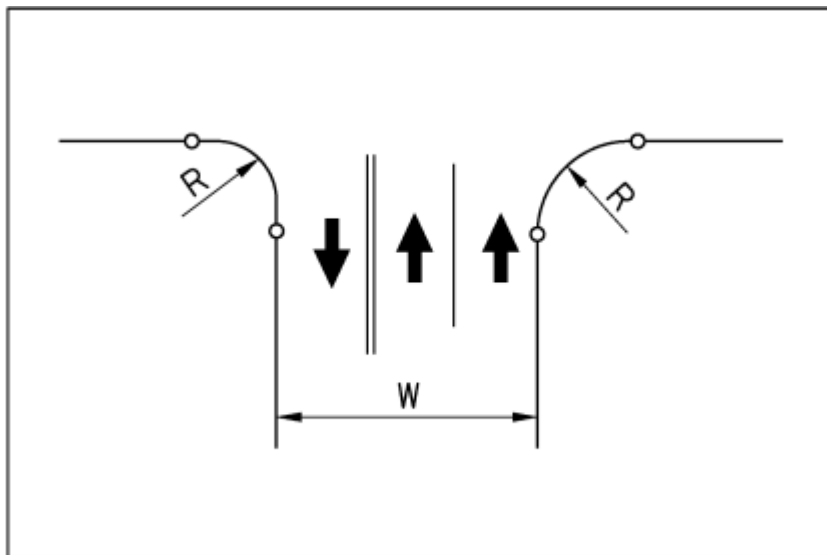


Figure C-4. One Entry Lane/Two Exit Lanes (Without a Divider)

See Table C-2 for Suggested Dimensions Based on Conditions.

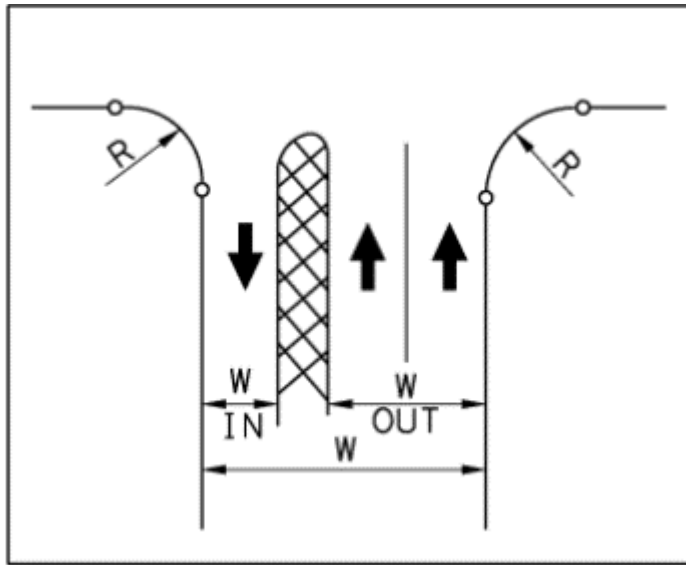


Figure C-5. One Entry Lane/Two Exit Lanes (With a Divider)

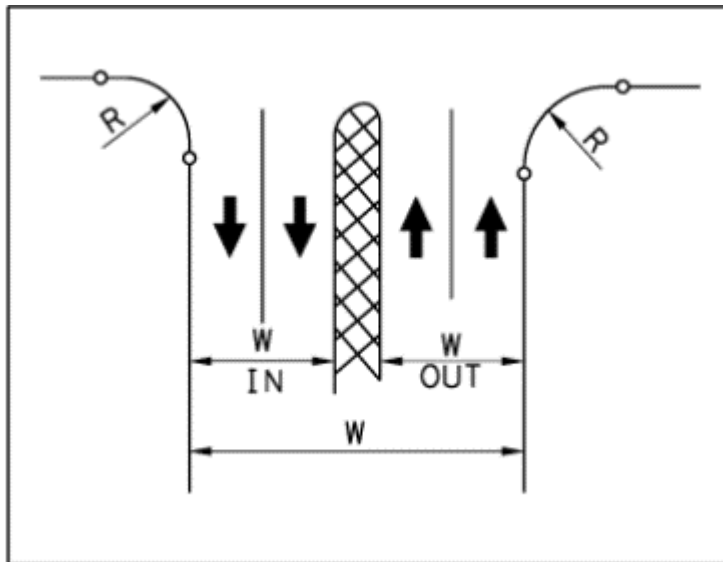


Figure C-6. Two Entry Lanes/Two Exit Lanes (With a Divider)

See Table C-2 for Suggested Dimensions Based on Conditions.

Anchor: #i1007352

Divided Driveways

A raised or depressed separation between the entry and exit sides of a divided driveway needs to be visible to drivers. Suggested treatments and divider sizes are shown in Table C-3:

Anchor: #i1006160Table C-3. Dimensions for Dividers in the Driveway Throat to Separate Entry and Exit Sides of the Driveway		
Treatment	Width	Length
Slightly raised ⁽¹⁾ (4in [100 mm]) with contrasting surface ⁽¹⁾	4 –15 ft [1.2 – 4.5 m]	20 ft [6.0 m]
⁽¹⁾ For Rural - Rounded edges, 30° to 45° slope. (See Figure C-7)		

Figure C-7 illustrates a slightly raised divider (height 4 inches [100 mm]).

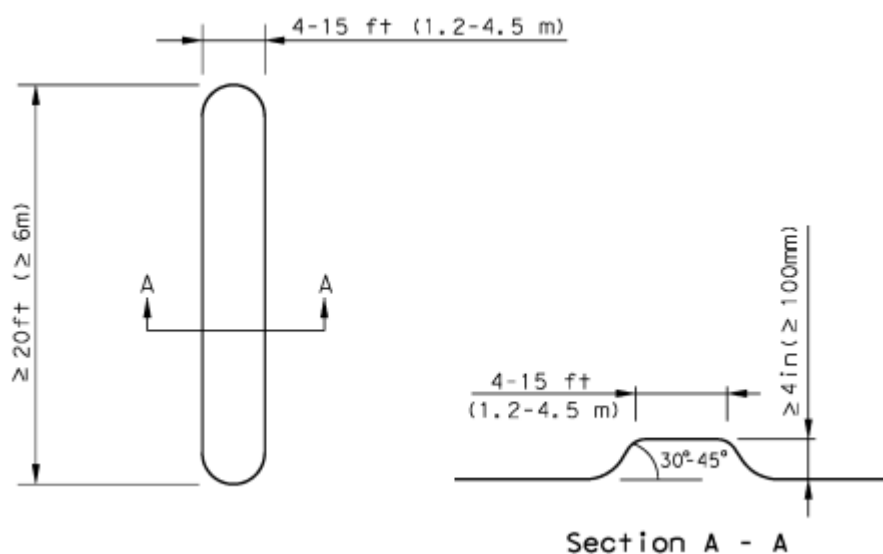


Figure C-7. Illustration of Slightly Raised Divider

A divided driveway is desirable in the following situations:

1. There are a total of four or more entering and exiting lanes.
2. A large number of pedestrians (30 or more in a one-hour interval) routinely cross the driveway.

Locating signing and lighting within a divider may assist approaching drivers in determining the driveway's location and geometrics.

An excessively wide divider may confuse drivers and cause them to think there are two closely spaced, two-way driveways. To avoid this problem, the recommended maximum width of a divider is 15 feet [4.5 m]. On the other hand, a divider that is too small may not be adequately visible to the motorist. Therefore the recommended minimum width of a slightly raised divider (height > 4 inches) is 4 feet [1.2 m].

Section 4: Profiles

Public driveways and commercial driveways should be constructed with a vertical curve between the pavement cross-slope and the driveway approach and between changes in grade within the driveway throat length. A private residential driveway may be constructed without vertical curves provided that a change in grade does not adversely affect vehicle operations. Typically a change in grade of three percent (3%) or less and a distance between changes in grade of at least eleven feet [3.3 m] accommodates most vehicles. However, literature suggests that a six percent (6%) to eight percent (8%) change in grade may operate effectively. Individual site conditions should be evaluated to accommodate the vehicle fleet using the driveway.

Anchor: #i1007405

Driveway Grades

To achieve satisfactory driveway profiles, some of the significant factors to be considered are:

1. Abrupt grade changes, which cause vehicles entering and exiting driveways to move at extremely slow speeds, can create:
 - The possibility of rear end collisions for vehicles entering the driveway.
 - The need for large traffic gaps that may be unavailable or infrequent, causing drivers to accept inadequate gaps.
2. Where sidewalks are present, or in developing areas where pedestrians may be expected now or in the future, slower turning speeds may be beneficial and special design requirements apply. See Section 6 for more information.
3. The comfort of vehicle occupants and potential vehicle damage, (i.e., prevent the dragging of center or overhanging portion of passenger vehicles).
4. Grades must be compatible with the site requirements for sight distance and drainage, to prevent excessive drainage runoff from entering the roadway or adjacent property.

Because a large combination of slopes, tangent lengths, and vertical curves will provide satisfactory driveway profiles, some generalizations should be considered relative.

On curb and gutter sections, placement of vertical curves should be at the extended gutter line and not closer to the travel lanes unless curb and gutter returns and proper drainage are provided. On curb and gutter sections, the entire curb and gutter for the length of the curb cut should be removed and the gutter pan recast as an integral part of the driveway apron.

As shown in Table C-4, the suggested changes in driveway grades with a vertical curve (between the pavement cross slope and the driveway apron slope) are approximately 10 percent for private residential driveways and approximately 8 percent for all other driveways.

Anchor: #i1006176Table C-4. Suggested Change in Grade with a Vertical Curve	
Driveway	Change in Grade (A) ⁽¹⁾
Private Residential Driveways	10%
All Other Driveways	8%
(1)Change in grade between the pavement cross-slope and the driveway apron slope	

Construction practice can provide a suitable sag vertical curve between the pavement cross-slope and the driveway apron when the apron length L_a (see Figure C-8) is equal to or greater than 20 feet [7 m].

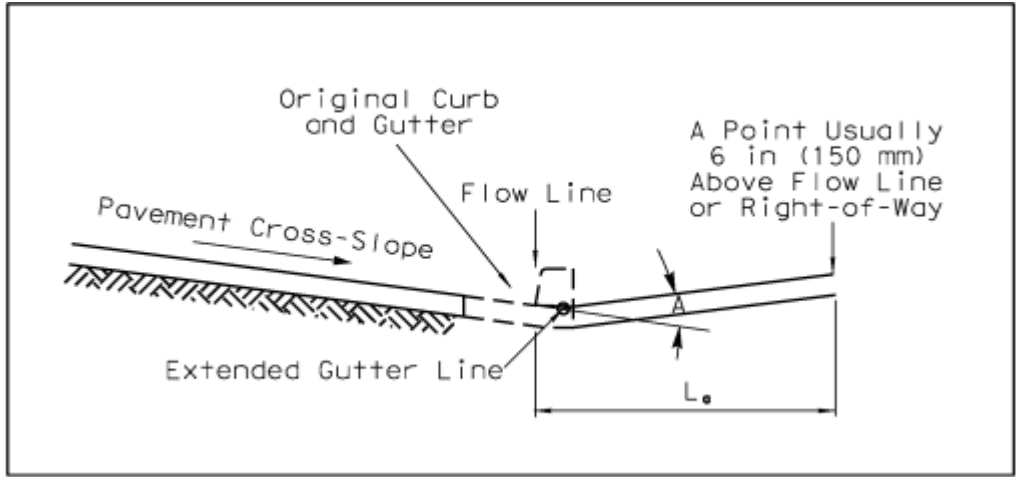


Figure C-8. Suggested Dimensions to Achieve an Appropriate Vertical Curve

Maximum driveway grades should be limited to 12 percent for private residential driveways and to 8 percent for other driveways. Where possible, the driveway grade should be limited to 6 percent or less within the roadway right-of-way.

A construction easement is required for construction beyond the right-of-way line. For construction beyond the right-of-way, it is necessary for the property owner to furnish the construction easement or right of entry required.

Also, within the limits of curb return radii, no drop curb should be allowed except as required for curb ramps.

The length of the vertical curve between the pavement cross-slope and the driveway apron is a function of the algebraic difference in the grades. Table C-5 provides the desirable and minimum lengths for these vertical curves.

Anchor: #i1006192Table C-5. Length of Vertical Curve L (feet) For a Change in

Grade Between the Pavement Cross-Slope and the Driveway Apron Slope					
Change in Grade, A					
	Crests			Sags	
	Des.	Min.		Des.	Min.
	ft (m)	ft (m)		ft (m)	ft (m)
4-5%	5 (1.5)	3 (0.9)		7 (2.1)	4 (1.2)
6-7%	6 (1.8)	4 (1.2)		8 (2.4)	5 (1.5)
8-10%	8 (2.4)	5 (1.5)		10 (3.0)	7 (2.1)
Rounded: Parabolic curvature. The plans may specify a particular type of curvature. Des.: Desirable Minimum Length Min.: Minimum Length Where practical, greater lengths should be provided to achieve a flatter and smoother profile. C-9 through C-11 illustrate typical driveway profiles.					

The length of the vertical curve at other points of driveway grade change is also a function of the algebraic difference in the grades. Table C-6 provides the typical lengths for these vertical curves.

Figures C-9 through C-11 illustrate typical driveway profiles.

Anchor: #i1006238Table C-6. Typical Length of Vertical Curve, L, For Change in Grade in Driveway Profile					
		Crest		Sag	
Change in Grade A		Private Residential Driveways	Other Driveways	Private Residential Driveways	Other Driveways
		ft (m)	ft (m)	ft (m)	ft (m)

4-5%	2 (0.6)	5 (1.5)	3 (0.9)	6 (1.8)
6-7%	3 (0.9)	5 (1.5)	5 (1.5)	7 (2.1)
8-10%	4 (1.2)	6 (1.8)	6 (1.8)	8 (2.4)

Anchor: #i1007509

Profiles on Curb and Gutter Sections

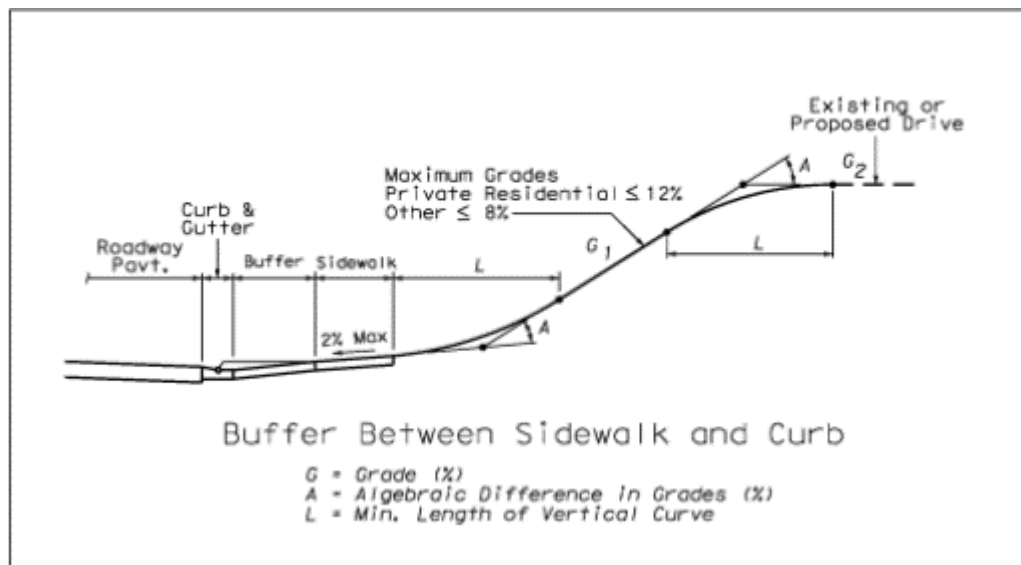


Figure C-9. Roadway with Curb and Gutter, Driveway Profiles on an Upgrade

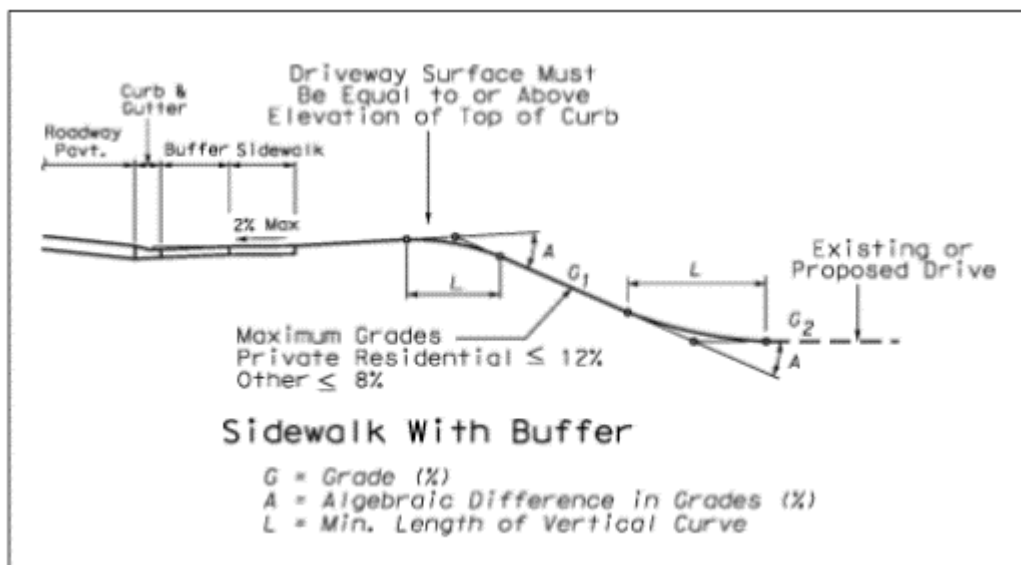


Figure C-10. Roadway with Curb and Gutter, Driveway Profiles on a Downgrade

See Tables C-5 and C-6 for lengths of vertical curves.

Anchor: #i1007531

Profiles with Drainage Ditch

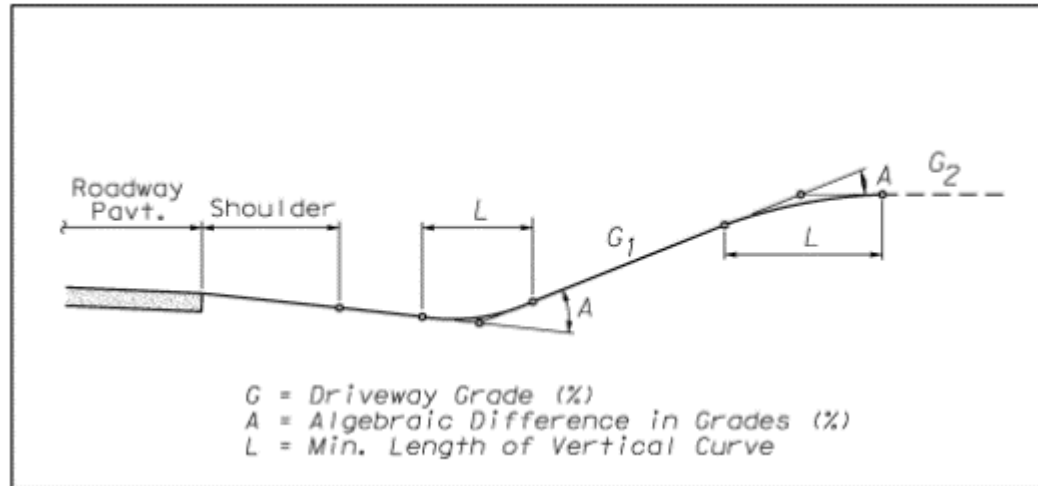


Figure C-11. Driveway Profiles on Roadway with Drainage Ditch

See Tables C-5 and C-6 for lengths of vertical curves

Design Equations

To determine needed length of guard fence for a given obstacle, design equations have been formulated for low volume (ADT 750 or less) and higher volume (ADT more than 750) conditions. A horizontal clearance width of 16 ft [4.9 m] and length of roadside travel of 200 ft [61 m] are incorporated in the low volume design equation (for use on roadways when the present ADT volume is 750 or less). Also, if the horizontal clearance required is less than 16 ft [4.9 m] and the present ADT is 750 or less, use Equation A-1 for calculating the guardrail length of need.

US Customary:

$$L = 200 - \frac{200}{D} \times G$$

Where:

- L = Length of guardrail needed, ft
- D = Distance from edge of travel lane to far side of area of concern or to outside edge of horizontal clearance, whichever is least, ft

- G = Guardrail offset from edge of travel lane, ft

Metric:

$$[L = 61 - \frac{61}{D} \times G]$$

Where:

- L = Length of guardrail needed, m
- D = Distance from edge of travel lane to far side of area of concern or to outside edge of horizontal clearance, whichever is least, m
- G = Guardrail offset from edge of travel lane, m

Equation A-1

For low volume conditions, if the horizontal clearance width (16 ft [4.9 m]) is met or exceeded, $L=0$.

For higher volumes, a horizontal clearance width of 30 ft [9 m] and length of roadside travel of 250 ft [76 m] are incorporated into the design equation (for use on roadways when the present ADT volume is more than 750 or the recommended horizontal clearance is greater than 16 ft [4.9 m]):

(US Customary):

$$L = 250 - \frac{250}{D} \times G$$

(Metric):

$$[L = 76 - \frac{76}{D} \times G]$$

Equation A-2

For high volume conditions, if the horizontal clearance width (30 ft [9 m]) is met or exceeded, $L=0$.

Anchor: #i1005640

Using Design Equations to Determine Length of Guardrail

Before determining length of guard fence, the designer should assemble the following pertinent data:

- present ADT volume
- clear zone (horizontal clearance)
- traffic operations (one-way or two-way)
- lateral and longitudinal dimension of the area of concern
- shoulder width
- offset distance of the area of concern from the edge of travel lane (including from the centerline markings for two-way traffic operations)
- design slope conditions, (i.e. will slopes be 1V:10H or flatter?)
- placement location (alongside shoulder vs. near object, flared, etc.)
- presence of other nearby areas of concern which should be considered simultaneously.

Once this design data has been assembled, the appropriate equation can be used.

The [Example Problems](#) section provides example problems and solutions using the design equations. The guardrail lengths produced by the equations should be rounded up to an even length of guardrail.

