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1360.01 General

The primary purpose of an interchange is to reduce conflicts caused by vehicle crossings and minimize conflicting left-turn movements. Provide interchanges on all Interstate highways and freeways, and at other locations where traffic cannot be controlled efficiently by intersections at grade.

For additional information, see the following:

- Chapter 520 Access control
- Chapter 530 Limited access
- Chapter 550 Access Revision Report
- Chapter 1103 Design controls
- Chapter 1106 Design element dimensions
- Chapter 1240 Turning widths
- Chapter 1250 Cross Slope and Superelevation
- Chapter 1310 Intersections
- Chapter 1410 HOV lanes
- Chapter 1420 HOV direct access connections

1360.02 Interchange Design

1360.02(1) General

All freeway exits and entrances, except HOV direct access connections, are to connect on the right of through traffic. Variations from this will be considered only for special conditions.

HOV direct access connections may be constructed on the left of through traffic when they are designed in accordance with Chapter 1420.

Provide complete ramp facilities for all directions of travel wherever possible. However, give primary consideration to the basic traffic movement function that the interchange is to fulfill.

Complications are rarely encountered in the design and location of rural interchanges that simply provide a means of exchanging traffic between a limited access freeway and a local crossroad. Carefully consider the economic and operational effects of locating traffic interchanges along a freeway through a community, particularly with respect to local access, to provide convenient local service without reducing the capacity of the major route(s).

Where freeway-to-freeway interchanges are involved, do not provide ramps for local access unless they can be added conveniently and without detriment to efficient traffic flow or reduction of capacity, either ramp or freeway main line. When exchange of traffic between freeways is the basic function, and local access is prohibited by access control restrictions or traffic volume, separate interchanges for local service may be needed.

1360.02(2) Interchange Patterns

Basic interchange patterns have been established that can be used under certain general conditions and modified or combined to apply to many more. Consider alternatives in the design of a specific facility; however, the conditions in the area and on the highway involved govern the final design of the interchange.

Selection of the final design is based on a study of projected traffic volumes, site conditions, geometric controls, criteria for intersecting legs and turning roadways, driver expectancy, consistent ramp patterns, continuity, and cost.

The patterns most frequently used for interchange design are those commonly described as directional, semi directional, cloverleaf, partial cloverleaf, diamond, and single point (urban) interchange (see Exhibit 1360-1).

1360.02(2)(a) Directional

A directional interchange is the most effective design for connection of intersecting freeways. The directional pattern has the advantage of reduced travel distance, increased speed of operation, and higher capacity. These designs eliminate weaving and have a further advantage over cloverleaf designs in avoiding the loss of sense of direction drivers experience in traveling a loop. This type of interchange is costly to construct, commonly using a four-level structure.

1360.02(2)(b) Semi directional

A semi directional interchange has ramps that loop around the intersection of the highways. This results in multiple single-level structures and more area than the directional interchange.

1360.02(2)(c) Cloverleaf

The full cloverleaf interchange has four loop ramps for the left-turning traffic. Outer ramps provide for the right turns. A full cloverleaf is the minimum type interchange for a freeway-to-freeway interchange. Cloverleaf designs often incorporate a C-D road to minimize signing difficulties and remove weaving conflicts from the main roadway.

The principal advantage of this design is the elimination of all left-turn conflicts with one single-level structure. Because all movements are merging movements, it is adaptable to any grade line arrangement.

The cloverleaf has some major disadvantages. The left-turn movement has a circuitous route on the loop ramp, the speeds are low on the loop ramp, and there are weaving conflicts between the loop ramps. The cloverleaf also needs a large area. The weaving and the radius of the loop ramps are a capacity constraint on the left-turn movements.

1360.02(2)(d) Partial Cloverleaf

A partial cloverleaf (PARCLO) has loop ramps in one, two, or three quadrants that are used to eliminate the major left-turn conflicts. These loops may also serve right turns for interchanges where ramp cannot be built in one or two quadrants. Outer ramps are provided for the remaining turns. Design the grades to provide sight distance between vehicles approaching these ramps.

1360.02(2)(e) Diamond

A diamond interchange has four ramps that are essentially parallel to the major arterial. Each ramp provides for one right-turn and one left-turn movement. Because left turns are made at grade across conflicting traffic on the crossroad, intersection sight distance is a primary consideration.

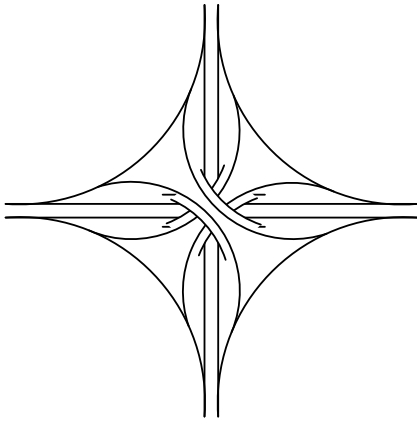
The diamond design is the most generally applicable and serviceable interchange configuration and usually has a smaller footprint than any other type. Consider this design first unless another design is clearly dictated by traffic, topography, or special conditions.

1360.02(2)(f) Single Point Urban

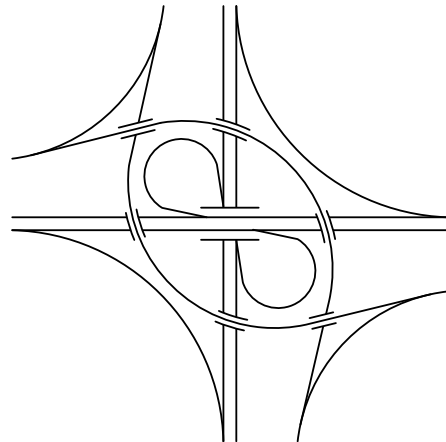
A single point urban interchange (SPUI) is a modified diamond with all of its ramp terminals on the crossroad combined into one signalized at-grade intersection. This single intersection accommodates all interchange and through movements.

A single point urban interchange can improve the traffic operation on the crossroad with less right of way than a typical diamond interchange, but a larger structure.

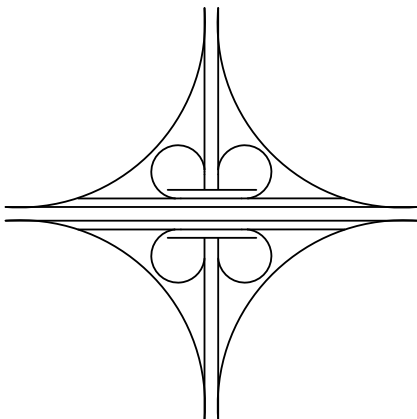
Exhibit 1360-1 Basic Interchange Patterns



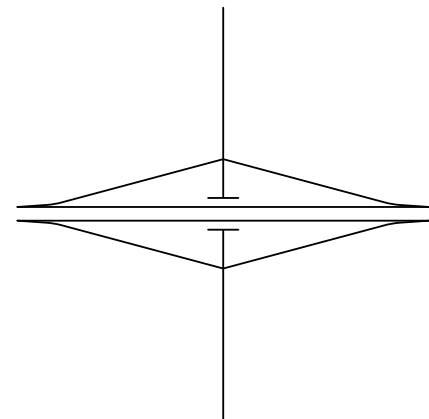
Directional



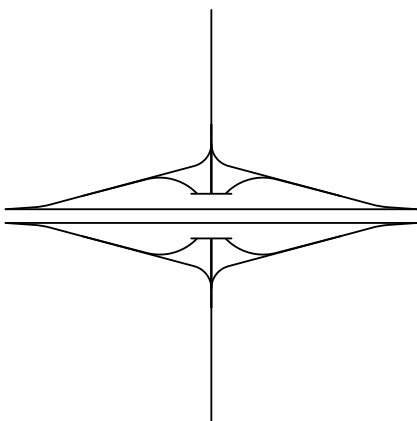
Semidirectional



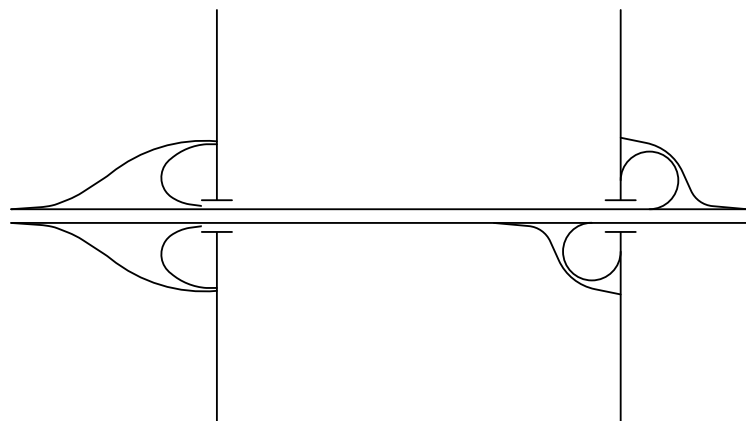
Cloverleaf With C-D Roads



Diamond



Single Point Urban Interchange (SPUI)



Partial Cloverleaf

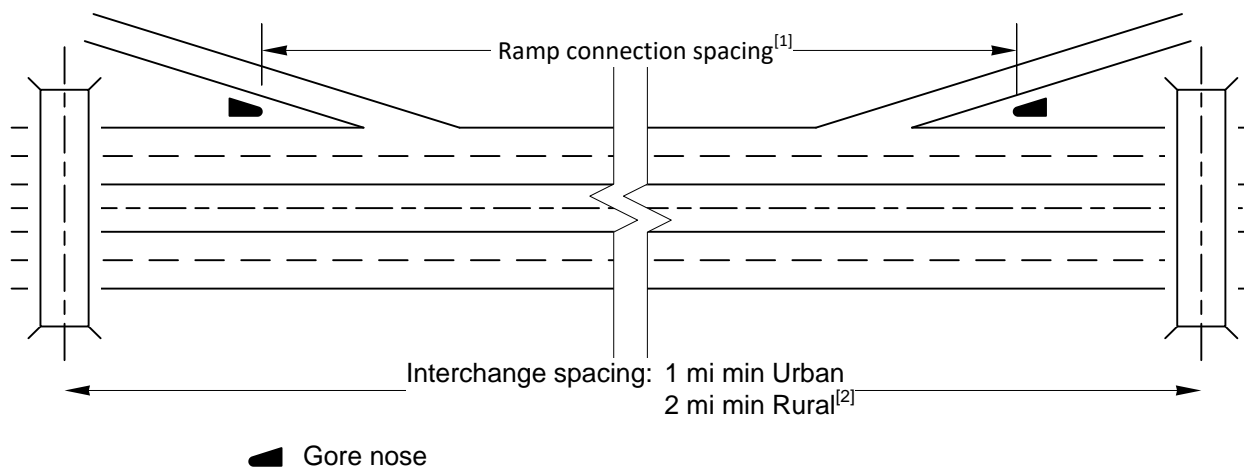
1360.02(3) Spacing

To avoid excessive interruption of main line traffic, consider each proposed facility in conjunction with adjacent interchanges, intersections, and other points of access along the route as a whole.

The minimum spacing between adjacent interchanges is 1 mile in urban areas, 3 miles on the Interstate in rural areas, and 2 miles on non-Interstate in rural areas (see Exhibit 1360-2). In urban areas, spacing less than 1 mile may be used with C-D roads or grade-separated (braided) ramps. Interchange spacing is measured along the freeway centerline between the centerlines of the crossroads.

The spacing between interchanges may also be dependent on the spacing between ramp connections. The minimum spacing between the gore noses of adjacent ramps is given in Exhibit 1360-3.

Exhibit 1360-2 Interchange Spacing



Notes:

- [1] As a minimum, provide length for weaving and signing, but not less than given in Exhibit 1360-3.
- [2] 3 miles on the Interstate System.

Consider either frontage roads or C-D roads to facilitate the operation of near-capacity volumes between closely spaced interchanges or ramp terminals. C-D roads may be needed where cloverleaf loop ramps are involved or where a series of interchange ramps have overlapping speed change lanes. Base the distance between successive ramp terminals on capacity. Check the intervening sections by weaving analyses to determine whether capacity, sight distance, and effective signing can be provided without the use of auxiliary lanes or C-D roads.

Provide justifications for existing interchanges with less-than-desirable spacing or ramp connection spacing to remain in place.

1360.02(4) Route Continuity

Route continuity is providing the driver of a through route a path on which lane changes are minimized and other traffic operations occur to the right. In maintaining route continuity, interchange configuration may not favor the heavy traffic movement, but rather the through route. In this case, design the heavy traffic movements with multilane ramps, flat curves, and reasonably direct alignment.

1360.02(5) Drainage

Avoid interchanges located in proximity to natural drainage courses. These locations often result in complex and unnecessarily costly hydraulic structures. The open areas within an interchange can be used for stormwater detention facilities.

1360.02(6) Uniformity of Exit Pattern

While interchanges are of necessity custom-designed to fit specific conditions, it is desirable that the pattern of exits along a freeway have some degree of uniformity. From the standpoint of driver expectancy, it is desirable that each interchange have only one point of exit, located in advance of the crossroad.

Exhibit 1360-3 Minimum Ramp Connection Spacing

On-On or Off-Off		Off-On		Turning Roadways		On-Off (Weaving)			
Freeway	C-D Road	Freeway	C-D Road	System[2] Interchange	Service[3] Interchange	A	B	C	D
1,000	800	500	400	800	600	200	160	160	100
Gore nose									

L = Minimum distance in feet from gore nose to gore nose.

A = Between two interchanges connected to a freeway: a system interchange[2] and a service interchange.[3]

B = Between two interchanges connected to a C-D road: a system interchange[2] and a service interchange.[3]

C = Between two interchanges connected to a freeway: both service interchanges.[3]

D = Between two interchanges connected to a C-D road: both service interchanges.[3]

Notes:

These values are based on operational experience, need for flexibility, and signing. Check them in accordance with Exhibit 1360-12 and the procedures outlined in the Highway Capacity Manual, and use the larger value.

[1] With justification, these values may be reduced for cloverleaf ramps.

[2] A system interchange is a freeway-to-freeway interchange.

[3] A service interchange is a freeway-to-local road interchange.

1360.03 Ramps

1360.03(1) Ramp Design Speed

The design speed for a ramp is based on the design speed for the freeway main line.

It is desirable that the ramp design speed at the connection to the freeway be equal to the free-flow speed of the freeway. Meet or exceed the upper range values from Exhibit 1360-4 for the design speed at the ramp connection to the freeway. Transition the ramp design speed to provide a smooth acceleration or deceleration between the speeds at the ends of the ramp. However, do not reduce the ramp design speed below the lower-range speed of 25 mph. For loop ramps, use a design speed as high as feasible, but not lower than 25 mph.

These design speed guidelines do not apply to the ramp in the area of the ramp terminal at-grade intersection. In the area of the intersection, use a design speed of 15 mph for turning traffic or 0 mph for a stop condition. Use the allowed skew at the ramp terminal at-grade intersection to minimize ramp curvature.

For freeway-to-freeway ramps and C-D roads, the design speed at the connections to both freeways is the upper range values from Exhibit 1360-4; however, with justification, the midrange values from Exhibit 1360-4 may be used for the remainder of the ramp. When the design speed for the two freeways is different, use the higher design speed.

Existing ramps meet design speed criteria if acceleration or deceleration criteria are met (see Exhibit 1360-10 or Exhibit 1360-11) and superelevation meets the criteria in Chapter 1250.

Exhibit 1360-4 Ramp Design Speed

Main Line Design Speed (mph)		50	55	60	65	70	80
Ramp Design Speed (mph)	Upper Range	45	50	50	55	60	70
	Midrange	30	40	45	45	50	60
	Lower Range	25	25	25	25	25	25

1360.03(2) Sight Distance

Design ramps in accordance with the provisions in Chapter 1260 for stopping sight distances.

1360.03(3) Grade

The maximum grade for ramps for various design speeds is given in Exhibit 1360-5.

Exhibit 1360-5 Maximum Ramp Grade

Ramp Design Speed (mph)		25 – 30	35 – 40	45 and above
Ramp Grade (%)	Desirable	5	4	3
	Maximum *	7	6	5

* On one-way ramps, downgrades may be 2% greater

1360.03(4) Cross Section

Provide the ramp widths given in Exhibit 1360-6. Ramp traveled ways may need additional width when operational needs exist.

Cross slope and superelevation criteria for ramp traveled ways and shoulders are as given in Chapter 1250 for roadways. At ramp terminals, the intersection lane and shoulder width design guidance shown in Chapter 1310 may be used.

Whenever feasible, make the ramp cross slope at the ramp beginning or ending station equal to the cross slope of the through lane pavement. Where space is limited and superelevation runoff is long, or when parallel connections are used, the superelevation transition may be ended beyond (for on-ramps) or begun in advance of (for off-ramps) the ramp beginning or ending station, provided that the algebraic difference in cross slope at the edge of the through lane and the cross slope of the ramp does not exceed 4%. In such cases, provide smooth transitions for the edge of traveled way.

Exhibit 1360-6 Ramp Widths

Number of Lanes		1	2
Ramp Width (ft)	Traveled Way [1]	11-13 [5]	23-25 [3] [5]
	Shoulders	Right	4-8 [2] [5]
		Left	2
	Medians [4]	6	6-8

Notes:

- [1] Evaluate shoulder use to accommodate offtracking, if determined inadequate for operational performance needs, apply turning roadway widths in Chapter 1240.
- [2] Provide width necessary to accommodate offtracking by large vehicles.
- [3] Add 12 ft for each additional lane.
- [4] The minimum two-way ramp median width (including shoulders) is given. Wider medians may be required for signs or other traffic control devices and their respective clearances. When either the on- or off-ramp is single-lane, use the one-lane column. If both directions are two lanes, use the two-lane column.
- [5] Use the mode/function/performance approach described in Chapter 1106 to choose between the range of widths given.

Ramp shoulders may be used by large trucks for offtracking and by smaller vehicles cutting to the inside of curves. Evaluate the need to pave shoulders full depth for larger vehicle offtracking using turn simulation software on one-way ramps to accommodate this type of use. If operational performance needs demonstrate that accommodation of offtracking on shoulders is inadequate apply turning roadway widths in Chapter 1240.

1360.03(5) Two-Way Ramps

Two-way ramps are on- and off-ramps on a single roadway. Design two-way ramps as separate one-way ramps. Provide a raised median to physically separate the on- and off- ramps. Wider medians than given in Exhibit 1330-6 may be required for signing or other traffic control devices and their clearances. (For signs, it is sign width plus 4 feet.) Where wider medians are required, provide a 2-foot clearance between the face of curb and the edge of traveled way. Where additional width is not required, the raised median width may be reduced to a double-faced mountable or extruded curb. Traffic barrier or a depressed median may be provided in place of the raised median.

1360.03(6) Ramp Lane Increases

When off-ramp traffic and left-turn movement volumes at the ramp terminal at-grade intersection cause excessive queue length, it may be desirable to add lanes to the ramp to reduce the queue length caused by congestion and turning conflicts. Make provision for the addition of ramp lanes whenever ramp exit or entrance volumes are expected to result in an undesirable mobility or safety performance. (See Chapter 1210 for width transition design.)

1360.03(7) Ramp Meters

Ramp meters are used to allow a measured or regulated amount of traffic to enter the freeway. When operating in the “measured” mode, they release traffic at a measured rate to keep downstream demand below capacity and improve system travel times. In the “regulated” mode, they break up platoons of vehicles that occur naturally or result from nearby traffic signals. Even when operating at near capacity, a freeway main line can accommodate merging vehicles one or two at a time, while groups of vehicles will cause main line flow to break down.

The location of the ramp meter is a balance between the storage and acceleration criteria. Locate the ramp meter to maximize the available storage and so that the acceleration lane length, from a stop to the freeway main line design speed, is available from the stop bar to the merging point. With justification, the average main line running speed during the hours of meter operation may be used for the highway design speed to determine the minimum acceleration lane length from the ramp meter. (See Section 1360.04(4) for information on the design of on-connection acceleration lanes and Chapter 1050 for additional information on the design of ramp meters.)

Driver compliance with the signal is required for the ramp meter to have the desired results. Consider enforcement areas with metered ramps.

Consider HOV bypass lanes with ramp meters. (See Chapter 1410 for design data for ramp meter bypass lanes.)

1360.04 Interchange Connections

To the extent practicable, provide uniform geometric design and uniform signing for exits and entrances in the design of a continuous freeway. Do not design an exit ramp as an extension of a main line tangent at the beginning of a main line horizontal curve.

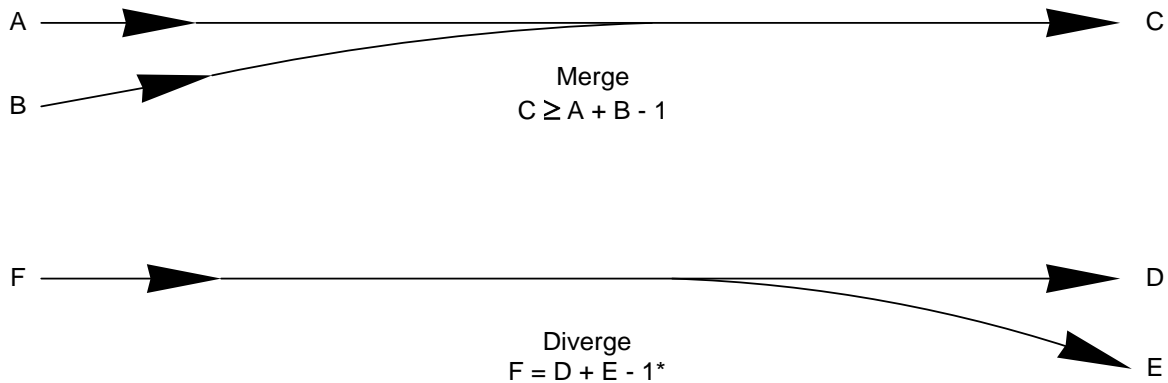
Provide spacing between interchange connections as given in Exhibit 1360-3.

Avoid on-connections on the inside of a main line curve, particularly when the ramp approach angle is accentuated by the main line curve, the ramp approach results in a reverse curve to connect to the main line, or the elevation difference will cause the cross slope to be steep at the nose.

Keep the use of mountable curb at interchange connections to a minimum.

Provide justification when curb is used adjacent to traffic with a design speed of 40 mph or higher.

Exhibit 1360-7 Lane Balance



*Note: Number of lanes (F) may increase by one lane, when the lane is an auxiliary lane between closely spaced entrance and exit ramps.

1360.04(1) Lane Balance

Design interchanges to the following principles of lane balance:

1360.04(1)(a) Entrances

At entrances, make the number of lanes beyond the merging of two traffic streams not less than the sum of all the lanes on the merging roadways less one (see Exhibit 1360-7).

1360.04(1)(b) Exits

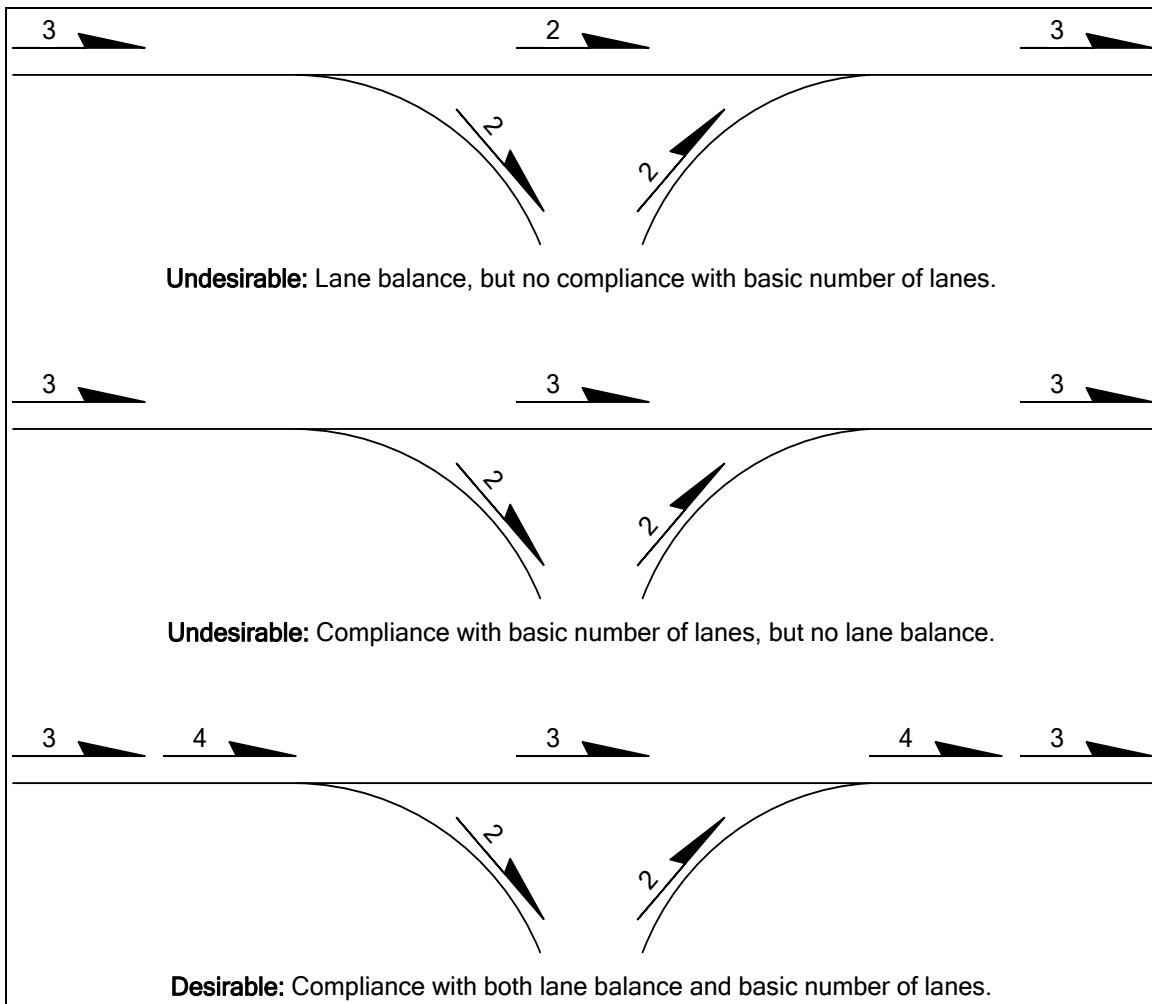
At exits, make the number of approach lanes equal the number of highway lanes beyond the exit plus the number of exit lanes less one (see Exhibit 1360-7). Exceptions to this are:

- At a cloverleaf.
- At closely spaced interchanges with a continuous auxiliary lane between the entrance and exit.

In these cases, the auxiliary lane may be dropped at a single-lane, one-lane reduction off-connection (Exhibit 1360-21), with the number of approach lanes being equal to the sum of the highway lanes beyond the exit and the number of exit lanes. Closely spaced interchanges have a distance of less than 2,100 feet between the end of the acceleration lane and the beginning of the deceleration lane.

Maintain the basic number of lanes, as described in Chapter 1210, through interchanges. When a two-lane exit or entrance is used, maintain lane balance with an auxiliary lane (see Exhibit 1360-8). The exception to this is when the basic number of lanes is changed at an interchange.

Exhibit 1360-8 Lane Balance

**1360.04(2) Main Line Lane Reduction**

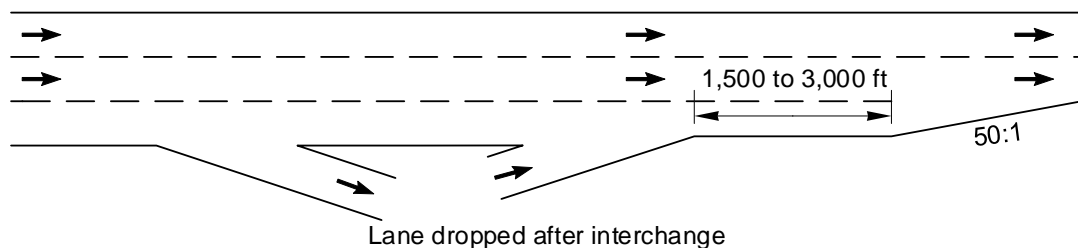
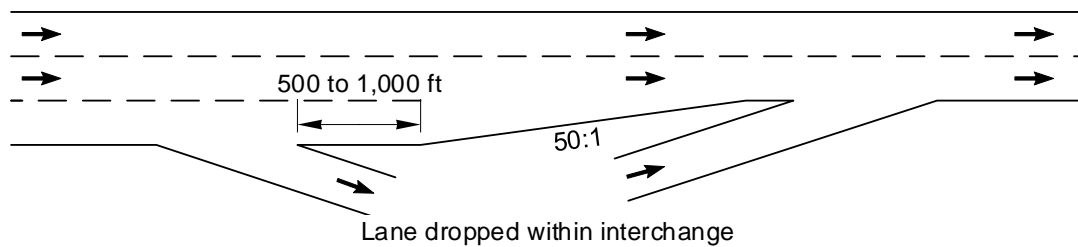
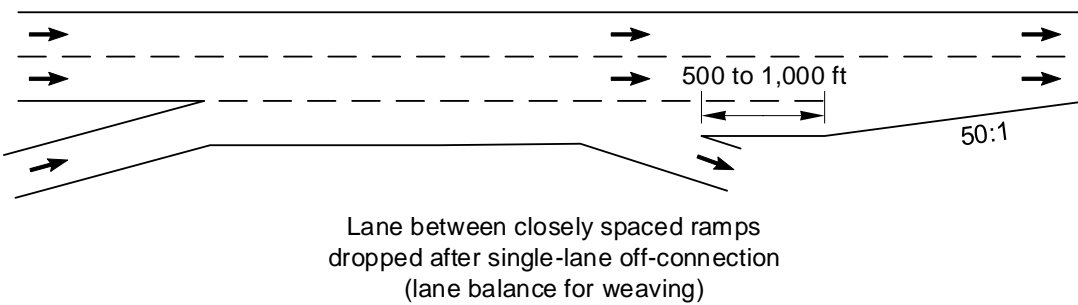
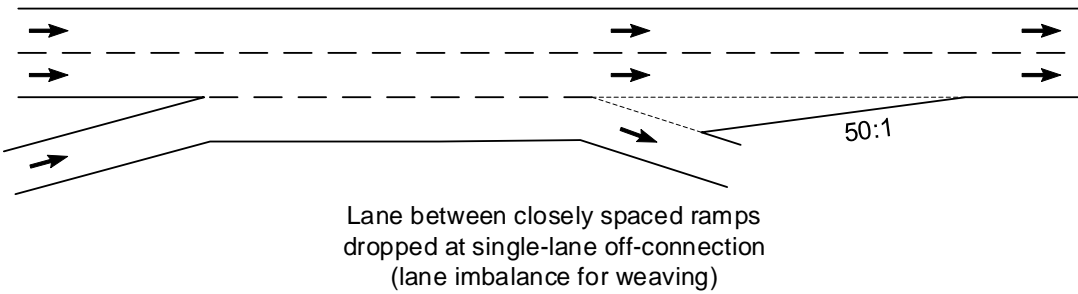
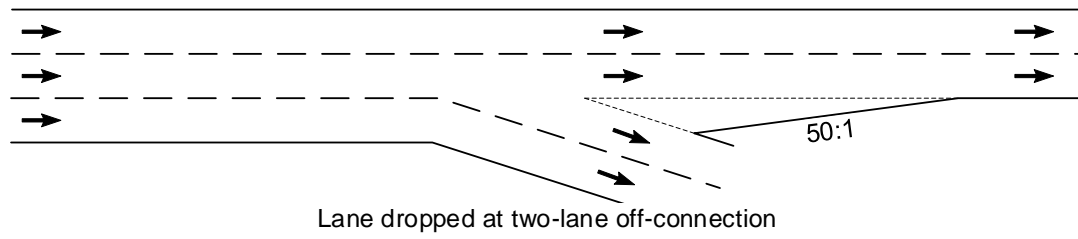
The reduction of a basic lane or an auxiliary lane may be made at a two-lane exit or may be made between interchanges. When a two-lane exit is used, provide a recovery area with a normal acceleration taper. When a lane is dropped between interchanges, drop it 1,500 to 3,000 feet from the end of the acceleration taper of the previous interchange. This allows for signing but will not be so far that the driver becomes accustomed to the number of lanes and will be surprised by the reduction (see Exhibit 1360-9).

Reduce the traveled way width of the freeway by only one lane at a time.

1360.04(3) Sight Distance

Locate off-connections and on-connections on the main line to provide decision sight distance for a speed/path/direction change as described in Chapter 1260.

Exhibit 1360-9 Main Line Lane Reduction Alternatives



1360.04(4) On-Connections

On-connections are the paved areas at the end of on-ramps that connect them to the main lane of a freeway. They have two parts: an acceleration lane and a taper. The acceleration lane allows entering traffic to accelerate to the freeway speed and evaluate gaps in the freeway traffic. The taper is for the entering vehicle to maneuver into the through lane.

On-connections are either tapered or parallel. The tapered on-connection provides direct entry at a flat angle, reducing the steering control needed. The parallel on-connection adds a lane adjacent to the through lane for acceleration with a taper at the end. Vehicles merge with the through traffic with a reverse curve maneuver similar to a lane change. While less steering control is needed for the taper, the parallel is narrower at the end of the ramp and has a shorter taper at the end of the acceleration lane.

1360.04(4)(a) Acceleration Lane

Provide the minimum acceleration lane length, given in Exhibit 1360-10, for each ramp design speed on all on-ramps. When the average grade of the acceleration lane is 3% or greater, multiply the distance from the Minimum Acceleration Lane Length table by the factor from the Adjustment Factor for Grades table.

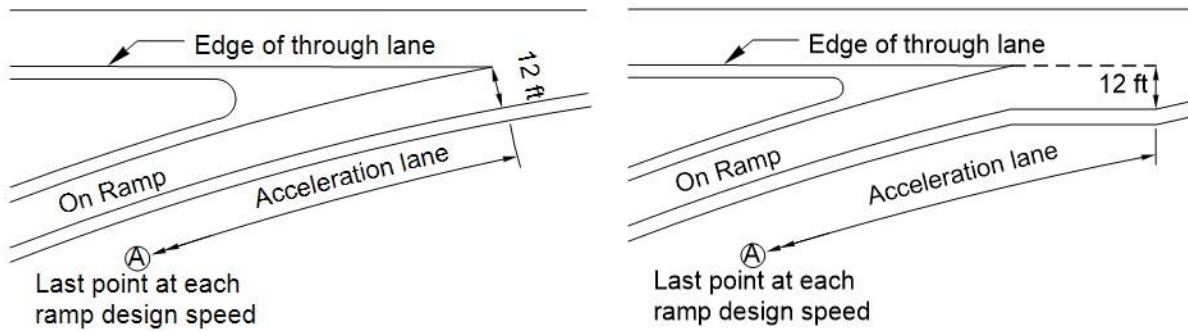
For existing ramps that do not have significant crashes in the area of the connection with the freeway, the freeway posted speed may be used to calculate the acceleration lane length for Preservation projects. If corrective action is indicated, use the freeway design speed to determine the length of the acceleration lane.

The acceleration lane is measured from the last point designed at each ramp design speed (usually the PT of the last curve for each design speed) to the last point of the ramp width. Curves designed at higher design speeds may be included as part of the acceleration lane length.

1360.04(4)(b) Gap Acceptance

For parallel on-connections, provide the minimum gap acceptance length (L_g) to allow entering motorists to evaluate gaps in the freeway traffic and position their vehicles to use the gap. The length is measured beginning at the point that the left edge of traveled way for the ramp intersects the right edge of traveled way of the main line to the ending of the acceleration lane (see Exhibit 1360-16 and Exhibit 1360-17). The gap acceptance length and the acceleration length overlap, with the ending point controlled by the longer of the two.

Exhibit 1360-10 Acceleration Lane Length



Highway Design Speed (mph)	Tapered On-Connection					Parallel On-Connection					
	Ramp Design Speed (mph)										
	0	15	20	25	30	35	40	45	50	60	70
30	180	140									
35	280	220	160								
40	360	300	270	210	120						
45	560	490	440	380	280	160					
50	720	660	610	550	450	350	130				
55	960	900	810	780	670	550	320	150			
60	1200	1140	1100	1020	910	800	550	420	180		
65	1410	1350	1310	1220	1120	1000	770	600	370		
70	1620	1560	1520	1420	1350	1230	1000	820	580	210	
80	2000	1950	1890	1830	1730	1610	1380	1200	970	590	210

Minimum Acceleration Lane Length (ft)

Highway Design Speed (mph)	Grade	Upgrade				Downgrade
		Ramp Design Speed				
		20	30	40	50	All Ramp Design Speeds
40	3% to less than 5%	1.3	1.3			0.70
45		1.3	1.35			0.675
50		1.3	1.4	1.4		0.65
55		1.35	1.45	1.45		0.625
60		1.4	1.5	1.5	1.6	0.60
70		1.5	1.6	1.7	1.8	0.60
40	5% or more	1.5	1.5			0.60
45		1.5	1.6			0.575
50		1.5	1.7	1.9		0.55
55		1.6	1.8	2.05		0.525
60		1.7	1.9	2.2	2.5	0.50
70		2.0	2.2	2.6	3.0	0.50

Adjustment Factors for Grades Greater Than 3%

Note: Lane widths are shown for illustrative purposes. Determine lane widths based on Exhibit 1360-6.

1360.04(4)(c) Single-Lane On-Connections

Single-lane on-connections may be either tapered or parallel. Design single-lane tapered on-connections as shown in Exhibit 1360-15 and single-lane parallel on-connections as shown in Exhibit 1360-16.

1360.04(4)(d) Two-Lane On-Connections

For two-lane on-connections, the parallel is desirable. Design two-lane parallel on-connections as shown in Exhibit 1360-17. A capacity analysis will normally be the basis for determining whether a freeway lane or an auxiliary lane is to be provided.

Justify the use of a two-lane tapered on-connection. Design two-lane tapered on connections in accordance with Exhibit 1360-18.

1360.04(5) Off-Connections

Off-connections are the paved areas at the beginning of an off-ramp, connecting it to a main lane of a freeway. They have two parts: a taper for maneuvering out of the through traffic and a deceleration lane to slow to the speed of the first curve on the ramp. Deceleration is not assumed to take place in the taper.

Off-connections are either tapered or parallel. The tapered is desirable because it fits the normal path for most drivers. When a parallel connection is used, drivers tend to drive directly for the ramp and not use the parallel lane. However, when a ramp is on the outside of a curve, the parallel off-connection is desirable. An advantage of the parallel connection is that it is narrower at the beginning of the ramp.

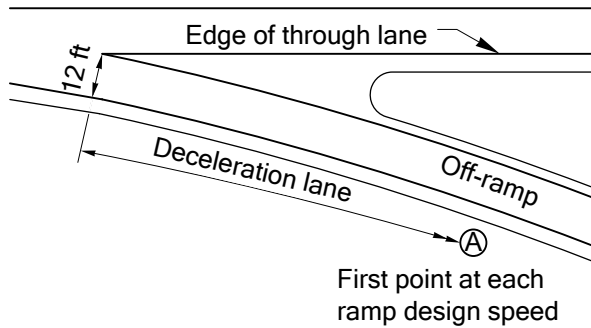
1360.04(5)(a) Deceleration Lane

Provide the minimum deceleration lane length given in Exhibit 1360-11 for each design speed for all off-ramps. Also, provide deceleration lane length to the end of the anticipated queue at the ramp terminal. When the average grade of the deceleration lane is 3% or greater, multiply the distance from the Minimum Deceleration Lane Length table by the factor from the Adjustment Factor for Grades table.

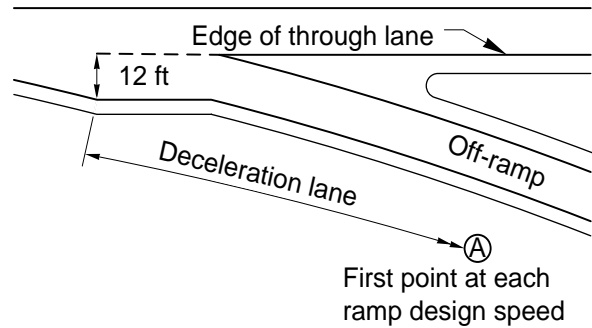
For existing ramps that do not have significant crashes in the area of the connection with the freeway, the freeway posted speed may be used to calculate the deceleration lane length for Preservation projects. If corrective action is indicated, use the freeway design speed to determine the length of the deceleration lane.

The deceleration lane is measured from the point where the taper reaches the selected ramp lane width to the first point designed at each ramp design speed (usually the PC of the first curve for each design speed). Curves designed at higher design speeds may be included as part of the deceleration lane length.

Exhibit 1360-11 Deceleration Lane Length



Tapered Off-Connection



Parallel Off-Connection

Highway Design Speed (mph)	Ramp Design Speed (mph)										
	0	15	20	25	30	35	40	45	50	60	70
30	235	200	170	140							
35	280	250	210	185	150						
40	320	295	265	235	185	155					
45	385	350	325	295	250	220	155				
50	435	405	385	355	315	285	225	175			
55	480	455	440	410	380	350	285	235	180		
60	530	500	480	460	430	405	350	300	240		
65	570	540	520	500	470	440	390	340	280	185	
70	615	590	570	550	520	490	440	390	340	240	
80	735	710	690	670	640	610	555	510	465	360	265

Minimum Deceleration Lane Length (ft)

Grade	Upgrade	Downgrade
3% to less than 5%	0.9	1.2
5% or more	0.8	1.35

Adjustment Factors for Grades Greater Than 3%

Note: Lane widths are shown for illustrative purposes. Determine lane widths based on Exhibit 1360-6.

1360.04(5)(b) Gores

Gores (see Exhibit 1360-12 and Exhibit 1360-13) are decision points. Design them to be clearly seen and understood by approaching drivers. In a series of interchanges along a freeway, it is desirable that the gores be uniform in size, shape, and appearance.

The paved area between the physical nose and the gore nose is the reserve area. It is reserved for the installation of an impact attenuator. The minimum length of the reserve area is controlled by the design speed of the main line (see Exhibit 1360-12 and Exhibit 1360-13).

In addition to striping, raised pavement marker rumble strips may be placed for additional warning and delineation at gores. (See the *Standard Plans* for striping and rumble strip details.)

Keep the unpaved area beyond the gore nose as free of obstructions as possible to provide a clear recovery area. Grade this unpaved area as nearly level with the roadways as possible. Avoid placing obstructions such as heavy sign supports, luminaire poles, and structure supports in the gore area.

When an obstruction is placed in a gore area, provide an impact attenuator (see Chapter 1620) and barrier (see Chapter 1610). Place the beginning of the attenuator as far back in the reserve area as possible, desirably after the gore nose.

1360.04(5)(c) Single-Lane Off-Connections

For single-lane off-connections, the tapered is desirable. Use the design shown in Exhibit 1360-19 for tapered single-lane off-connections. Justify the use of a parallel single-lane off-connection, as shown in Exhibit 1360-20.

1360.04(5)(d) Single-Lane Off-Connection With One Lane Reduction

The single-lane off-connection with one lane reduction, shown in Exhibit 1360-21, is used when the conditions from lane balance for a single-lane exit, one-lane reduction, are met.

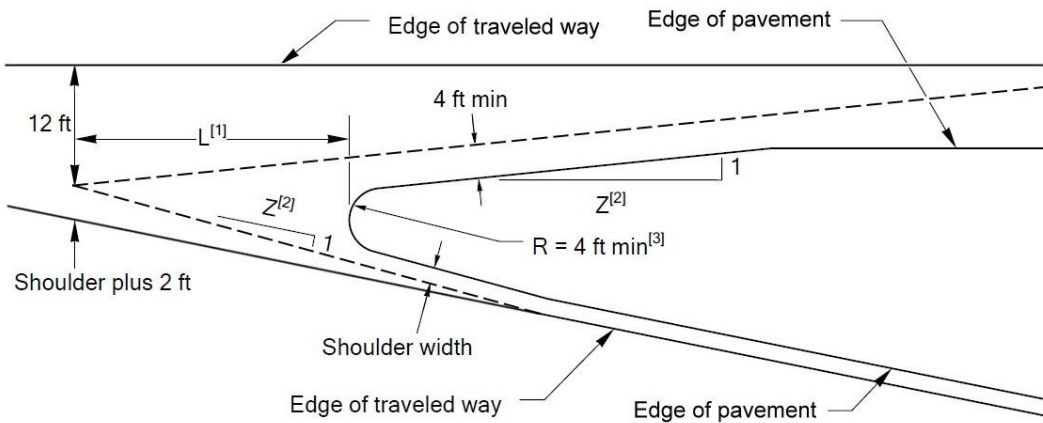
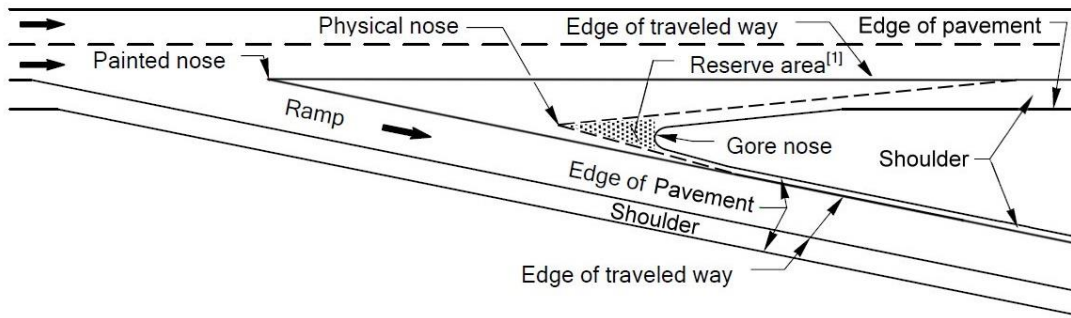
1360.04(5)(e) Tapered Two-Lane Off-Connection

The tapered two-lane off-connection design, shown in Exhibit 1360-22, is desirable where the number of freeway lanes is reduced or where high-volume traffic operations will be improved by the provision of a parallel auxiliary lane and the number of freeway lanes is unchanged.

1360.04(5)(f) Parallel Two-Lane Off-Connection

The parallel two-lane off-connection, shown in Exhibit 1360-23, allows less operational flexibility than the taper, requiring more lane changes. Justify the use of a parallel two-lane off-connection.

Exhibit 1360-12 Gore Area Characteristics



Single-Lane Off-Connections: No Lane Reduction

Notes:

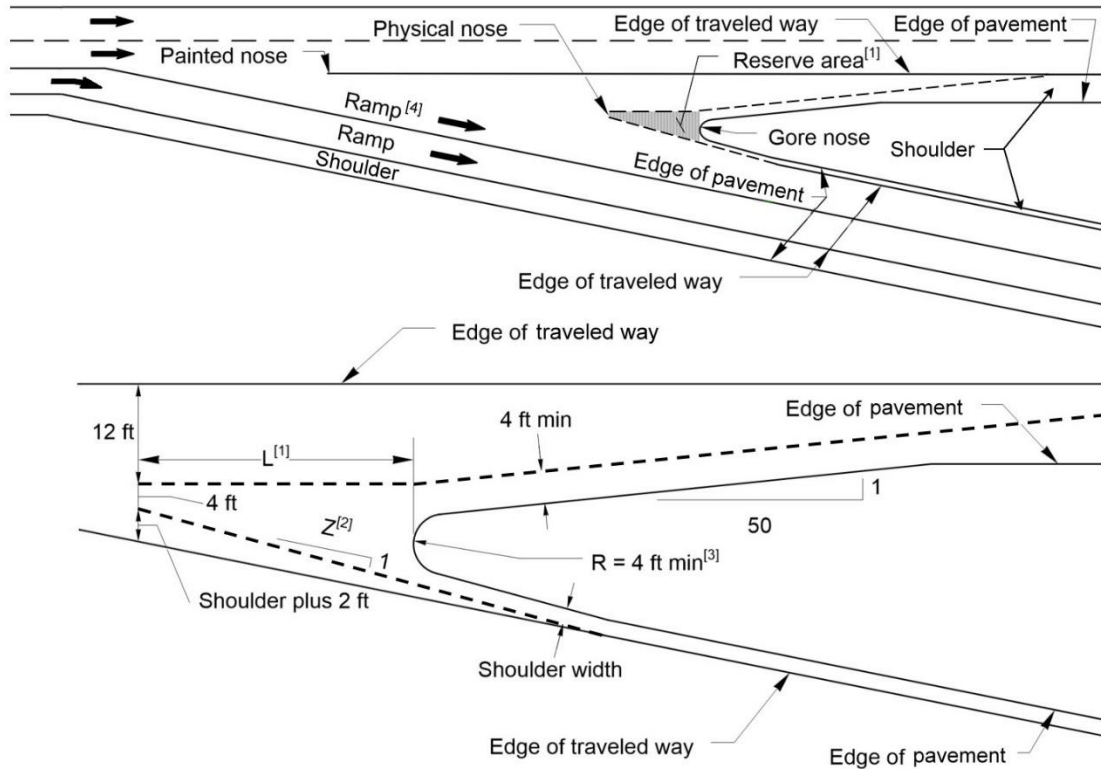
[1] The reserve area length (L) is not less than:

Main Line Design Speed (mph)	40	45	50	55	60	65	70	80
L (ft)	25	30	35	40	45	50	55	70

[2] $Z = \frac{\text{Design Speed}}{2}$, design speed is for the main line.

[3] Radius may be reduced, when protected by an impact attenuator.

Exhibit 1360-13 Gore Area Characteristics



**Single-Lane, One-Lane Reduction Off-Connections
or Two-Lane Off-Connections**

Notes:

[1] The reserve area length (L) is not less than:

Main Line Design Speed (mph)	40	45	50	55	60	65	70	80
L (ft)	25	30	35	40	45	50	55	70

[2] $Z = \frac{\text{Design Speed}}{2}$, design speed is for the main line.

[3] Radius may be reduced, when protected by an impact attenuator.

[4] This lane is omitted for a single-lane, one-lane reduction off-connection

1360.04(6) Collector-Distributor Roads

A Collector-Distributor (C-D) road can be within a single interchange, through two closely spaced interchanges, or continuous through several interchanges. Design C-D roads that connect three or more interchanges to be two lanes wide. Other C-D roads may be one or two lanes in width, depending on capacity. Consider intermediate connections to the main line for long C-D roads.

- a. Exhibit 1360-24 shows the designs for collector-distributor outer separations. Use Design A, with concrete barrier, when adjacent traffic in either roadway is expected to exceed 40 mph. Design B, with mountable curb, may be used when adjacent posted speed does not exceed 40 mph.
- b. The details shown in Exhibit 1360-25 apply to single-lane C-D road off-connections. Design a two-lane C-D road off-connection, with the reduction of a freeway lane or an auxiliary lane, as a normal two-lane off-connection in accordance with Section 1360.04(5).
- c. Design C-D road on-connections in accordance with Exhibit 1360-26.

1360.04(7) Loop Ramp Connections

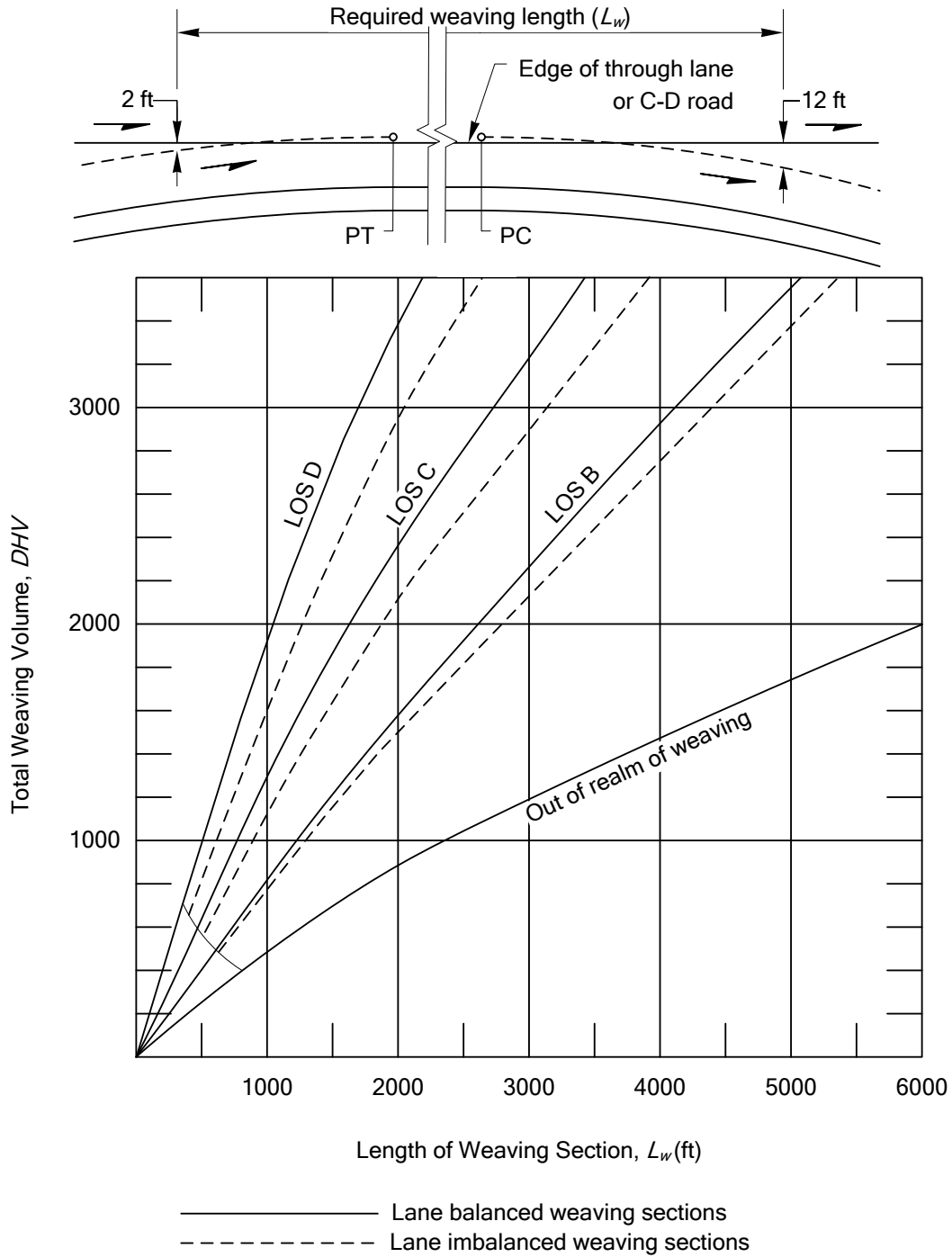
Loop ramp connections at cloverleaf interchanges are distinguished from other ramp connections by a low-speed ramp on-connection, followed closely by an off-connection for another low-speed ramp. The loop ramp connection design is shown in Exhibit 1360-27. The minimum distance between the ramp connections is dependent on a weaving analysis. When the connections are spaced far enough apart that weaving is not a consideration, design the on-connection in accordance with Section 1360.04(4) and the off-connection in accordance with Section 1360.04(5).

1360.04(8) Weaving Sections

Weaving sections may occur within an interchange, between closely spaced interchanges, or on segments of overlapping routes. Exhibit 1360-14 gives the length of the weaving section for preliminary design. The total weaving traffic is the sum of the traffic entering from the ramp to the main line and the traffic leaving the main line to the exit ramp in equivalent passenger cars. For trucks, a passenger car equivalent of two may be estimated. Use the Highway Capacity Manual for the final design of weaving sections.

Because weaving sections cause considerable turbulence, interchange designs that eliminate weaving or remove it from the main roadway are desirable. Use C-D roads for weaving between closely spaced ramps when adjacent to high-speed highways. C-D roads are not needed for weaving on low-speed roads.

Exhibit 1360-14 Length of Weaving Sections



Note:

To determine whether or not lane balance for weaving exists, see Exhibit 1360-9.

1360.05 Ramp Terminal Intersections at Crossroads

Design ramp terminal intersections at grade with crossroads as intersections at grade (see Chapter 1300). Whenever possible, design ramp terminals to discourage wrong-way movements. Locate ramp terminal intersections at grade with crossroads to provide signal progression if the intersection becomes signalized in the future. Provide intersection sight distance as described in Chapter 1310 or Chapter 1320.

1360.06 Interchanges on Two-Lane Highways

Occasionally, the first stage of a conventional interchange will be built with only one direction of the main roadway and operated as a two-lane two-way roadway until the ultimate roadway is constructed.

The design of interchanges on two-lane two-way highways may vary considerably from traditional concepts due to the following conditions:

- The potential for cross-centerline crashes due to merge conflicts or motorist confusion.
- The potential for wrong-way or U-turn movements.
- Future construction considerations.
- Traffic type and volume.
- The proximity to multilane highway sections that might influence a driver's impression that these roads are also multilane.

Provide the deceleration taper for all interchange exit ramps on two-lane highways. Design the entering connection with either the normal acceleration taper or a "button hook" configuration with a stop condition before entering the main line. Consider the following items:

- Design the stop condition connection in accordance with a tee (T) intersection as shown in Chapter 1310. Use this type of connection when an acceleration lane is not possible. Provide decision sight distance as described in Chapter 1260.
- Since designs may vary from project to project, analyze each project for the most efficient signing placement, such as one-way, two-way, no passing, do not enter, directional arrows, guideposts, and traffic buttons.
- Prohibit passing through the interchange area on two-lane highways by means of signing, pavement marking, or a combination of both. The desirable treatment is a 4 foot median island, highlighted with raised pavement markers and diagonal stripes. When using a 4-foot median system, extend the island 500 feet beyond any merging ramp traffic acceleration taper. The width for the median can be provided by reducing each shoulder 2 feet through the interchange (see Exhibit 1360-28).
- Include signing and pavement markings to inform both the entering and through motorists of the two-lane two-way characteristic of the main line.
- Use as much of the ultimate roadway as possible. Where this is not possible, leave the area for future lanes and roadway ungraded.
- Design and construct temporary ramps as if they were permanent unless second-stage construction is planned to rapidly follow the first stage. Design the connection to meet the needs of the traffic.

1360.07 Interchange Plans for Approval

Exhibit 1360-29 is a sample showing the general format and data for interchange design plans.

Compass directions (W-S Ramp) or crossroad names (E-C Street) may be used for ramp designations.

Include the following, as applicable:

- Design speeds (see Chapter 1103) for main line and crossroads.
- Curve data on main line, ramps, and crossroads.
- Numbers of lanes and widths of lanes and shoulders on main line, crossroads, and ramps.
- Superelevation diagrams for the main line, the crossroad, and all ramps; these may be submitted on separate sheets.
- Channelization.
- Stationing of ramp connections and channelization.
- Proposed right of way and access control treatment (see Chapter 510, Chapter 520, and Chapter 530).
- Delineation of all crossroads, existing and realigned.
- Traffic data for the proposed design; include all movements.
- For HOV direct access connections on the left, include the statement that the connection will be used solely by HOVs or will be closed.

Prepare a preliminary contour grading plan for each completed interchange. Show the desired contours of the completed interchange, including details of basic land formation, slopes, graded areas, or other special features. Coordinate the contour grading with the drainage design and the roadside development plan.

1360.08 Documentation

Refer to Chapter 300 for design documentation requirements.

1360.09 References

1360.09(1) Design Guidance

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC “Manual on uniform traffic control devices for streets and highways” (MUTCD)

Plans Preparation Manual, M 22-31, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21 01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

1360.09(2) Supporting Information

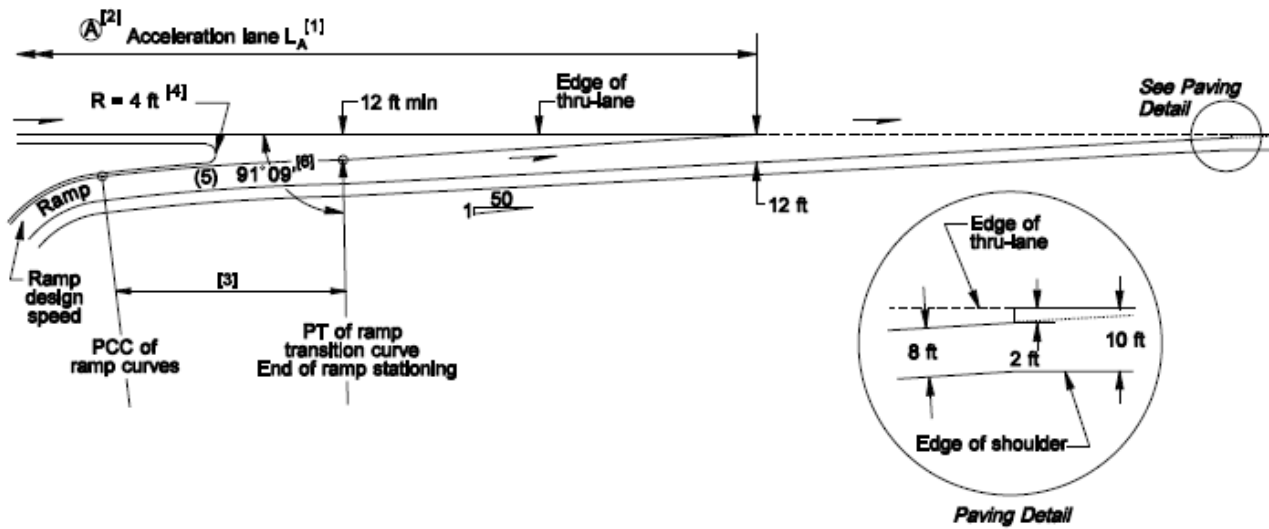
A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition

A Policy on Design Standards – Interstate System, AASHTO, 2005

Highway Capacity Manual (Special Report 209), Transportation Research Board

Procedure for Analysis and Design of Weaving Sections: A User’s Guide, Jack E. Leisch, October 1985

Exhibit 1360-15 On-Connection: Single-Lane, Tapered



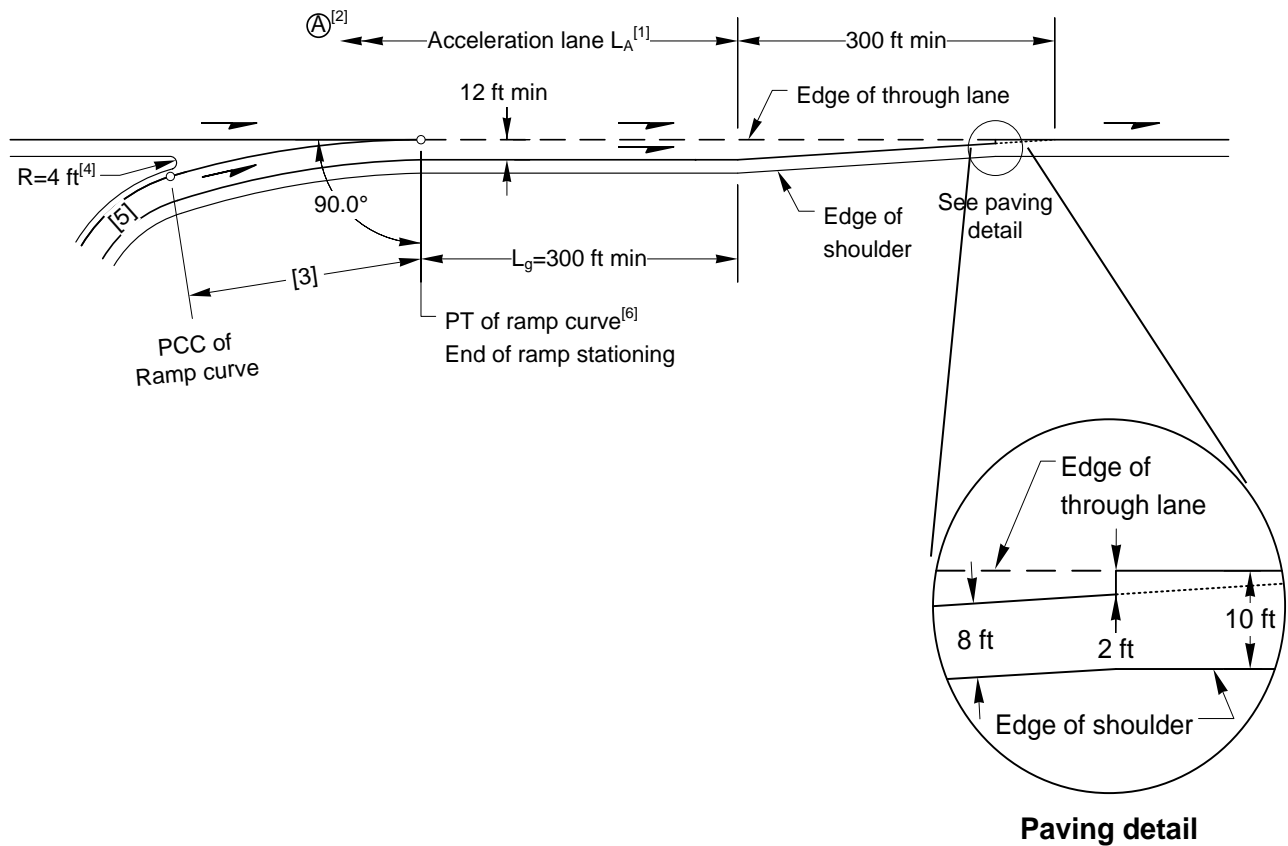
Notes:

- [1] For acceleration lane length L_A , see Exhibit 1360-10.
- [2] Point \textcircled{A} is the point controlling the ramp design speed.
- [3] A transition curve with a minimum radius of 3000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3000-ft radius to tangent to the main line.
- [4] Radius may be reduced when concrete barrier is placed between the ramp and main line.
- [5] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.
- [6] Approximate angle to establish ramp alignment.

General:

For striping, see the [Standard Plans](#).

Exhibit 1360-16 On-Connection: Single-Lane, Parallel



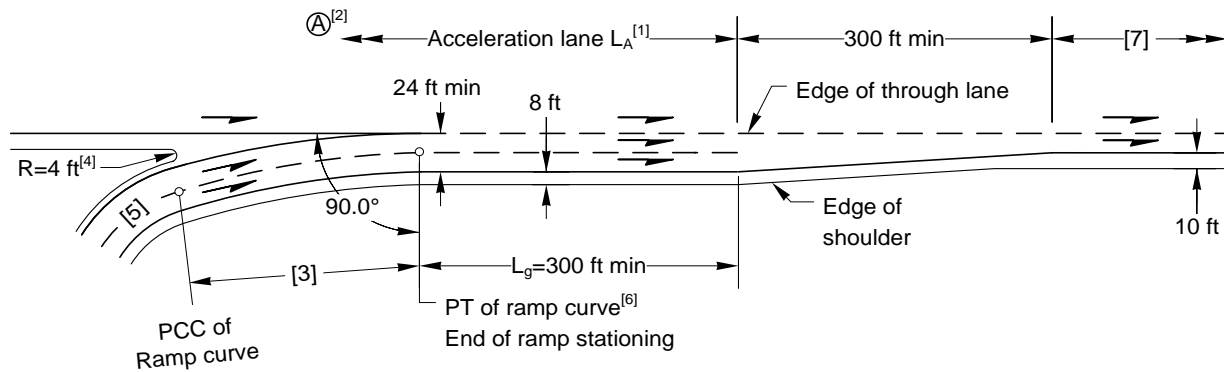
Notes:

- [1] For acceleration lane length L_A , see Exhibit 1360-10.
- [2] Point \textcircled{A} is the point controlling the ramp design speed.
- [3] A transition curve with a minimum radius of 3000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3000-ft radius to tangent to the main line. The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.
- [4] Radius may be reduced when concrete barrier is placed between the ramp and main line.
- [5] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.
- [6] Ramp stationing may be extended to accommodate superelevation transition.

General:

For striping, see the [Standard Plans](#).

Exhibit 1360-17 On-Connection: Two-Lane, Parallel



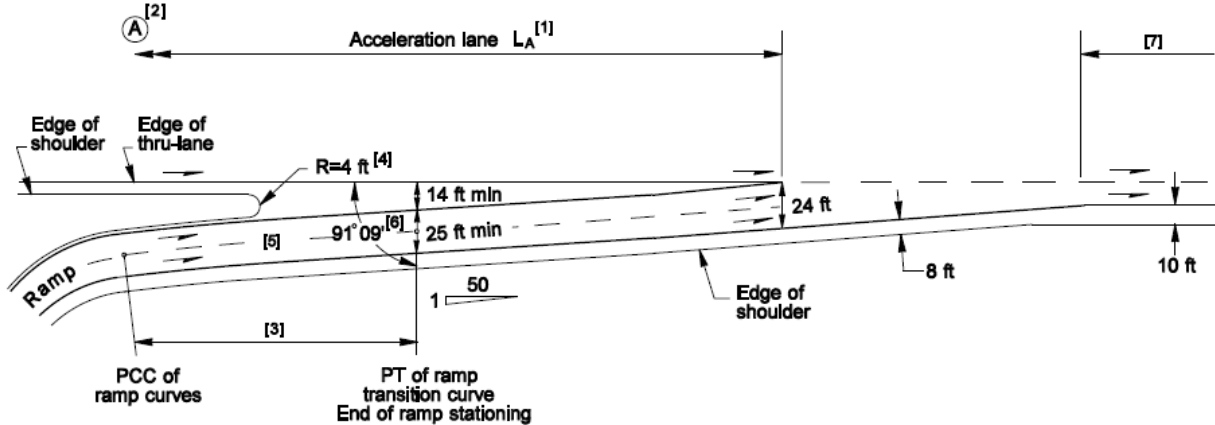
Notes:

- [1] For acceleration lane length L_A , see Exhibit 1360-10.
- [2] Point \textcircled{A} is the point controlling the ramp design speed.
- [3] A transition curve with a minimum radius of 3000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3000-ft radius to tangent to the main line. The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.
- [4] Radius may be reduced when concrete barrier is placed between the ramp and main line.
- [5] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.
- [6] Ramp stationing may be extended to accommodate superelevation transition.
- [7] Added lane or 1,500-ft auxiliary lane plus 600-ft taper.

General:

For striping, see the [Standard Plans](#).

Exhibit 1360-18 On-Connection: Two-Lane, Tapered



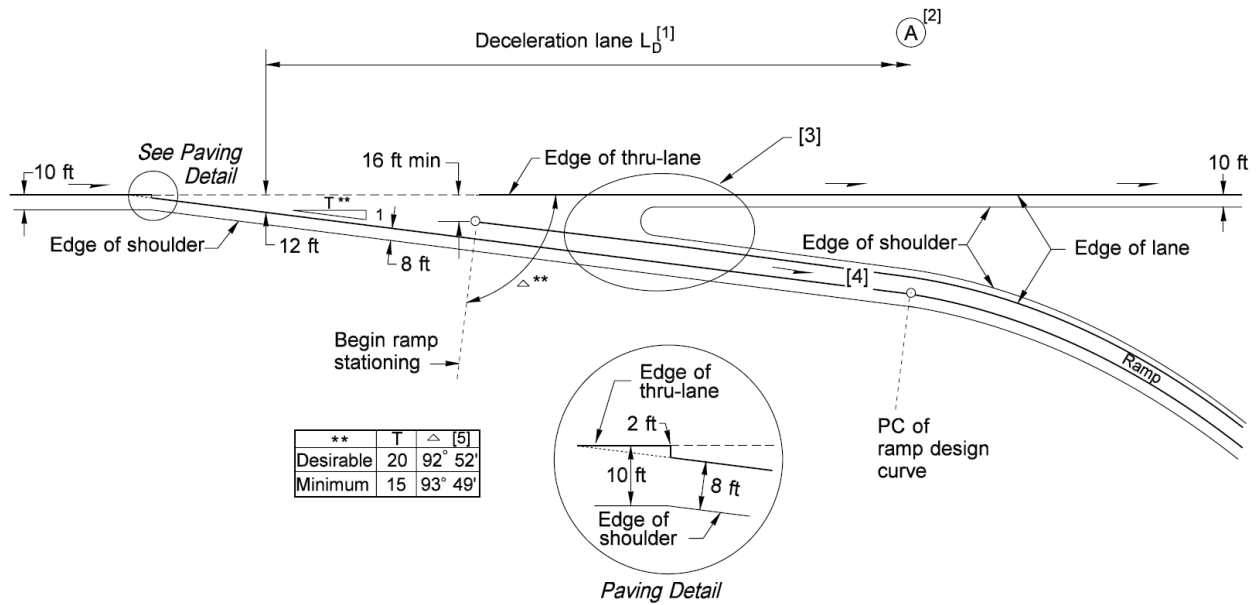
Notes:

- [1] For acceleration lane length L_A , see Exhibit 1360-10.
- [2] Point $\text{\textcircled{A}}$ is the point controlling the ramp design speed.
- [3] A transition curve with a minimum radius of 3000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3000-ft radius to tangent to the main line.
- [4] Radius may be reduced when concrete barrier is placed between the ramp and main line.
- [5] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.
- [6] Approximate angle to establish ramp alignment.
- [7] Added lane or 1,500-ft auxiliary lane plus 600-ft taper.

General:

For striping, see the [Standard Plans](#)

Exhibit 1360-19 Off-Connection: Single-Lane, Tapered



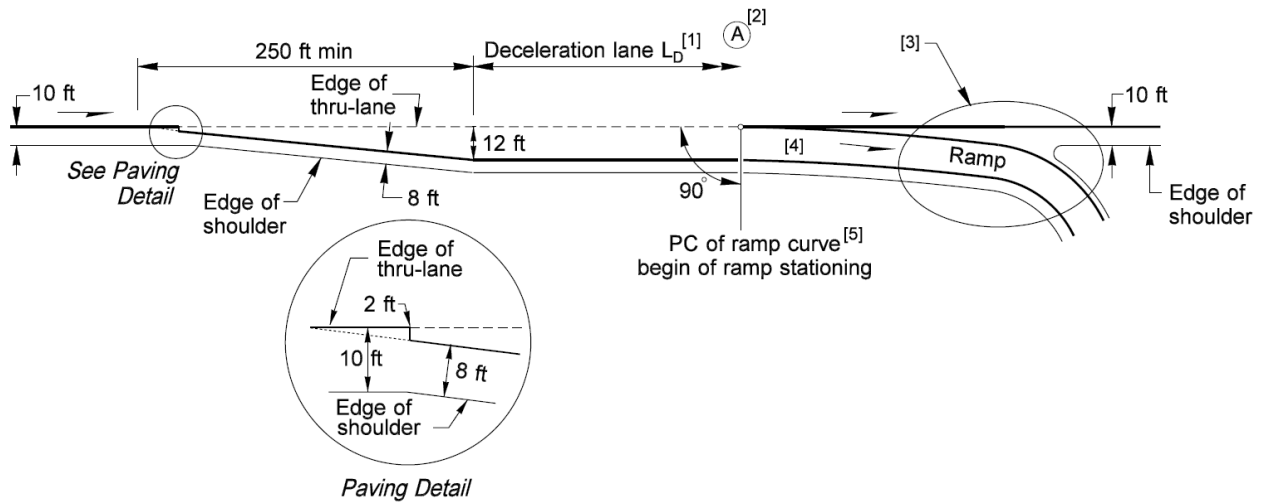
Notes:

- [1] For deceleration lane length L_D , see Exhibit 1360-11.
- [2] Point **A** is the point controlling the ramp design speed.
- [3] For gore details, see Exhibit 1360-12.
- [4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.
- [5] Approximate angle to establish ramp alignment.

General:

For striping, see the [Standard Plans](#).

Exhibit 1360-20 Off-Connection: Single-Lane, Parallel



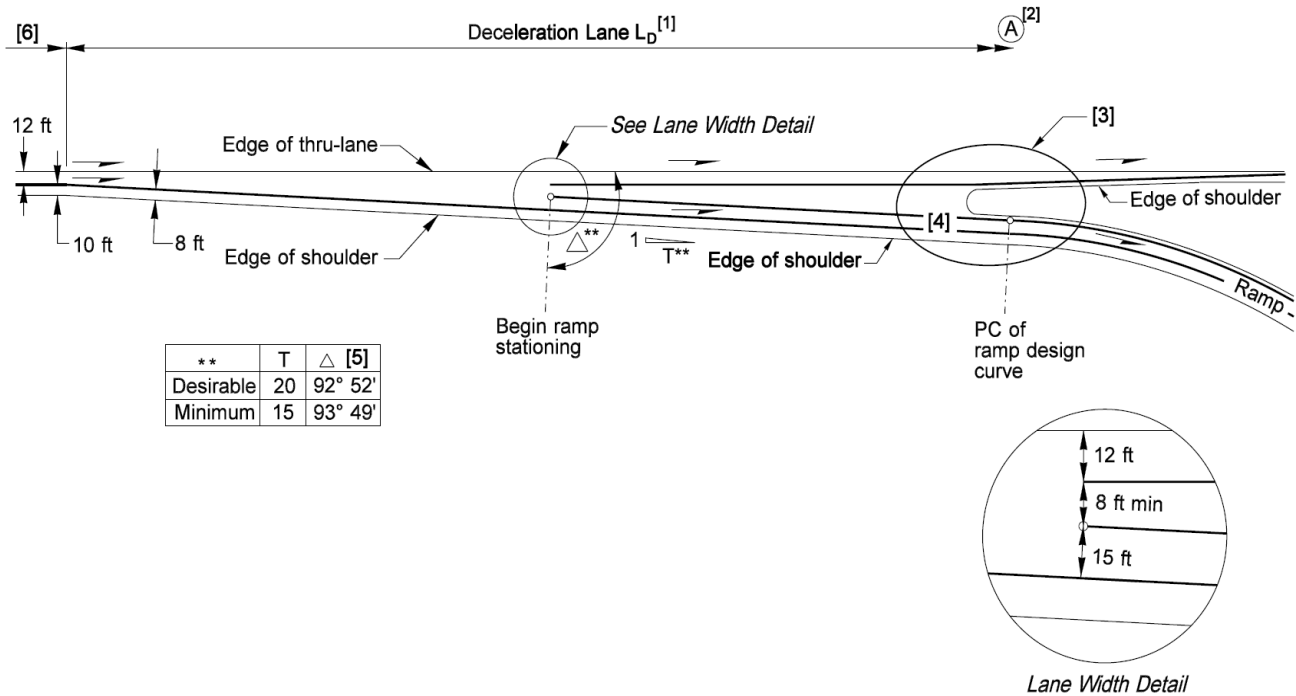
Notes:

- [1] For deceleration lane length L_D , see Exhibit 1360-11.
- [2] Point A is the point controlling the ramp design speed.
- [3] For gore details, see Exhibit 1360-12.
- [4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.
- [5] Ramp stationing may be extended to accommodate superelevation transition.

General:

For striping, see the [Standard Plans](#).

Exhibit 1360-21 Off-Connection: Single-Lane, One-Lane Reduction



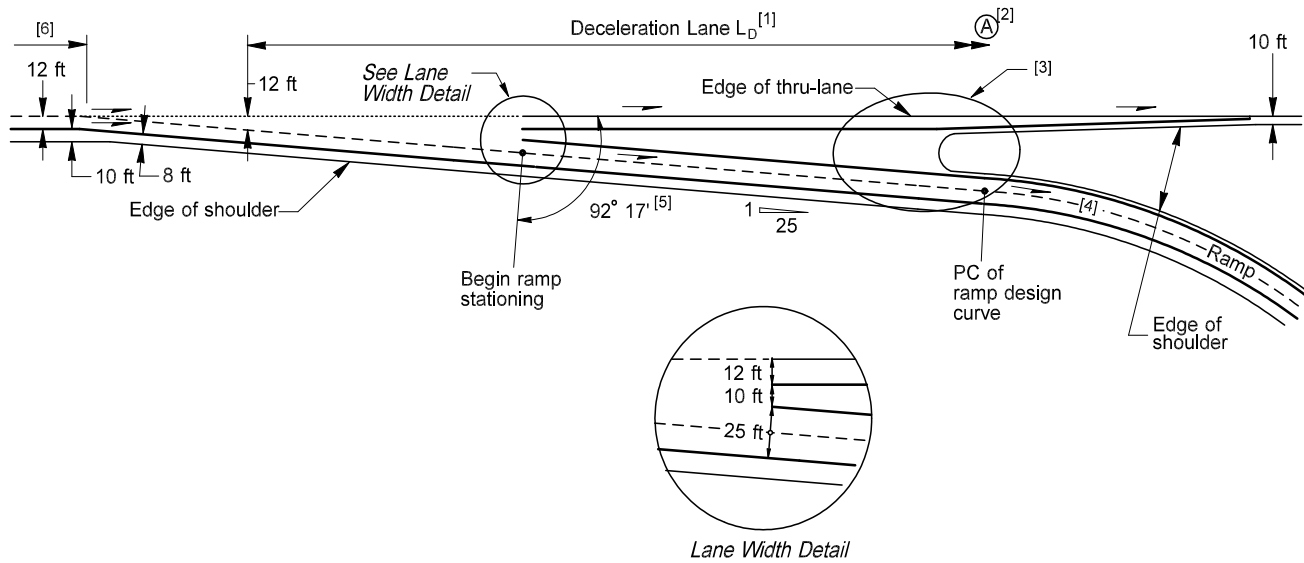
Notes:

- [1] For deceleration lane length L_D , see Exhibit 1360-10.
- [2] Point A is the point controlling the ramp design speed.
- [3] For gore details, see Exhibit 1360-13.
- [4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.
- [5] Approximate angle to establish ramp alignment.
- [6] Auxiliary lane between closely spaced interchanges to be dropped.

General:

For striping, see the [Standard Plans](#).

Exhibit 1360-22 Off-Connection: Two-Lane, Tapered



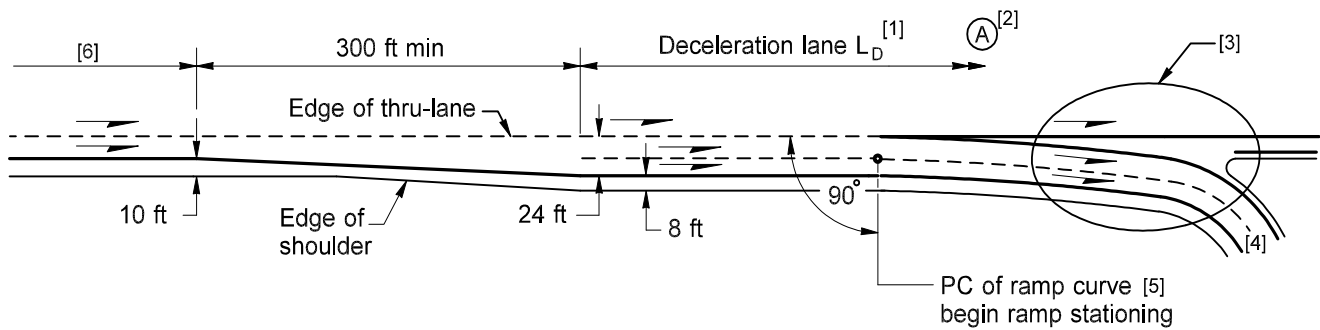
Notes:

- [1] For deceleration lane length L_D , see Exhibit 1360-11.
- [2] Point A is the point controlling the ramp design speed.
- [3] For gore details, see Exhibit 1360-13.
- [4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.
- [5] Approximate angle to establish ramp alignment.
- [6] Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300-ft taper.

General:

For striping, see the [Standard Plans](#).

Exhibit 1360-23 Off-Connection: Two-Lane, Parallel



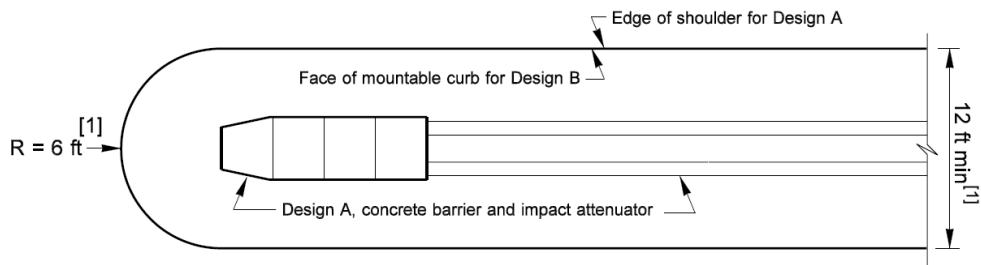
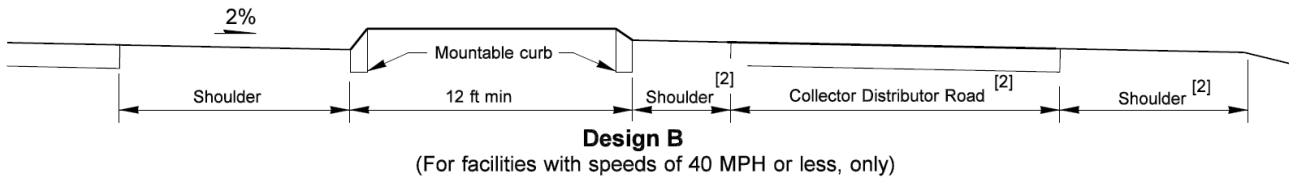
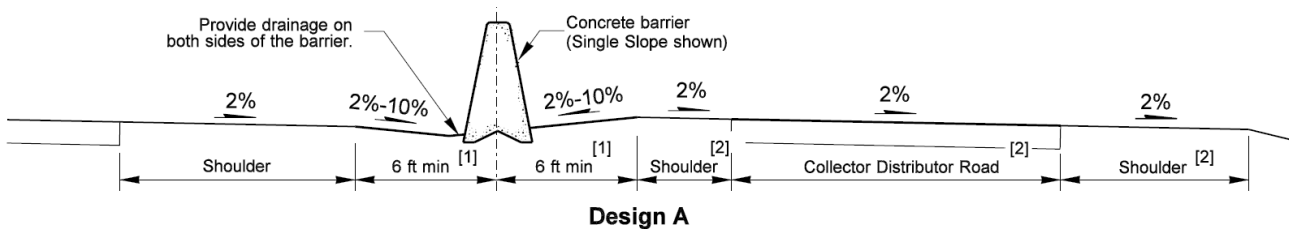
Notes:

- [1] For deceleration lane length L_D , see Exhibit 1360-11.
- [2] Point \textcircled{A} is the point controlling the ramp design speed.
- [3] For gore details, see Exhibit 1360-13.
- [4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.
- [5] Ramp stationing may be extended to accommodate superelevation transition.
- [6] Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300-ft taper.

General:

For striping, see the [Standard Plans](#).

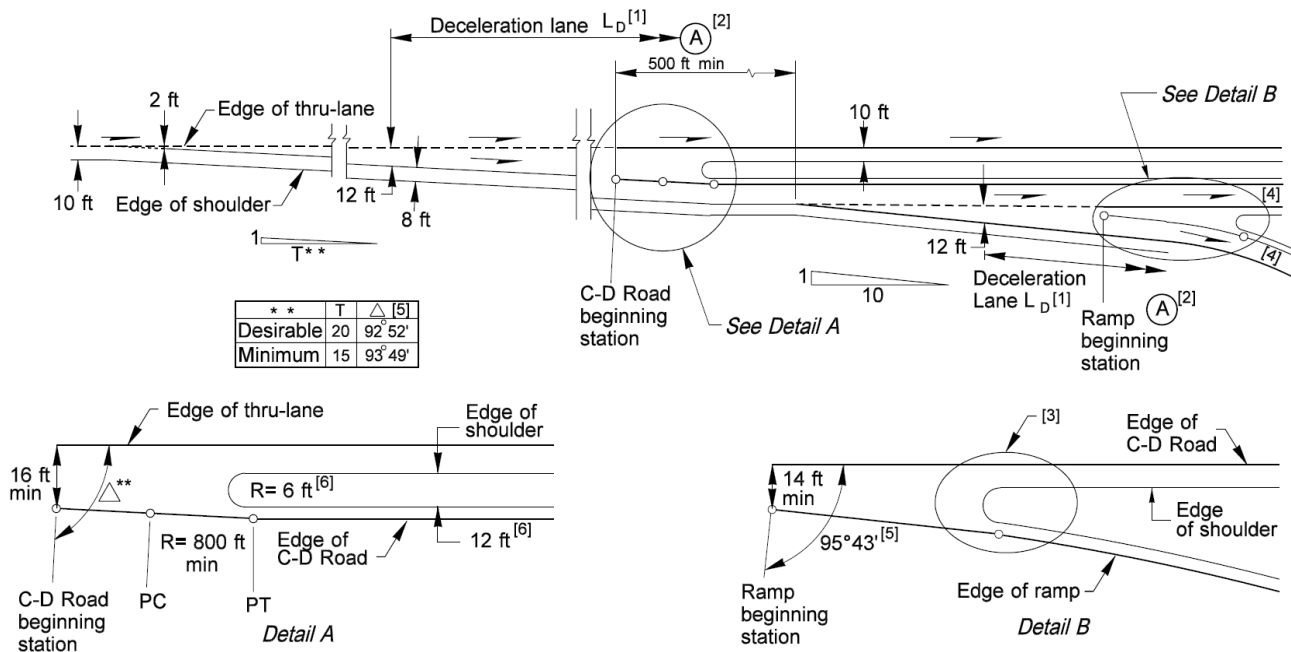
Exhibit 1360-24 Collector-Distributor: Outer Separations



Notes:

- [1] With justification, the concrete barrier may be placed with 2 ft between the edge of either shoulder and the face of barrier. This reduces the width between the edge of through-lane shoulder and the edge of C-D road shoulder to 6 ft and the radius at the nose to 3 ft.
- [2] For collector-distributor road lane and shoulder widths, see ramp lane and shoulder widths, Exhibit 1360-6.

Exhibit 1360-25 Collector Distributor: Off-Connections



Notes:

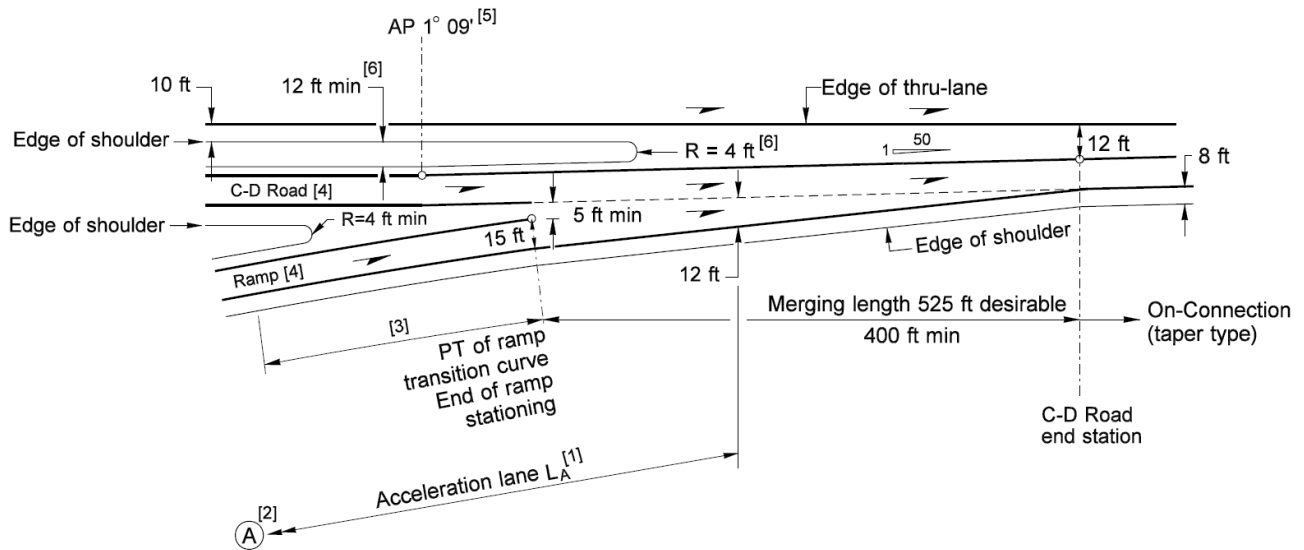
- [1] For deceleration lane length L_D , see Exhibit 1360-11.
- [2] Point \textcircled{A} is the point controlling the C-D road or ramp design speed.
- [3] For gore details, see Exhibit 1360-12.
- [4] For C-D road and ramp lane and shoulder widths, see Exhibit 1360-6.
- [5] Approximate angle to establish alignment.
- [6] May be reduced with justification (see Exhibit 1360-24).

General:

For striping, see the Standard Plans.

Lane and shoulder widths are shown for illustrative purposes. Determine lane and shoulder widths based on Exhibit 1360-6.

Exhibit 1360-26 Collector Distributor: On-Connections



Notes:

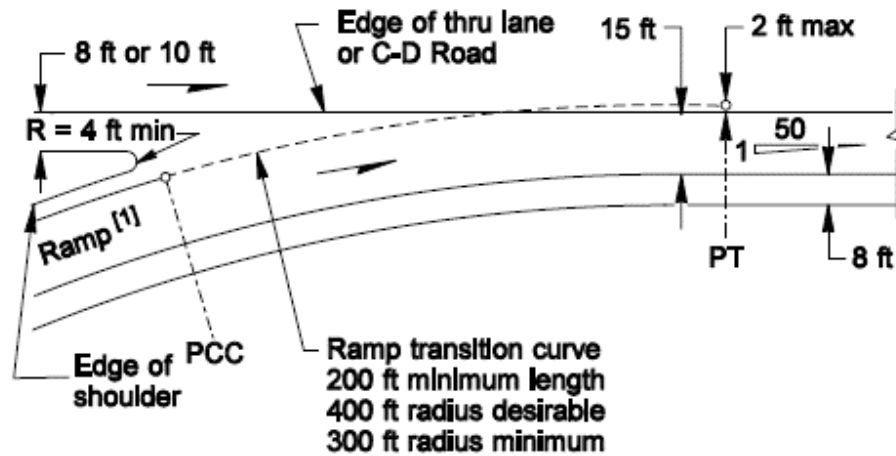
- [1] For acceleration lane length L_A , see Exhibit 1360-10.
- [2] Point \textcircled{A} is the point controlling the ramp design speed.
- [3] A transition curve with a minimum radius of 3000 ft is desirable. The desirable length is 300 ft. When the C-D road is on a curve to the left, the transition may vary from a 3000-ft radius to tangent to the C-D road.
- [4] For C-D road and ramp lane and shoulder widths, see Exhibit 1360-6.
- [5] Approximate angle to establish alignment.
- [6] May be reduced with justification (see Exhibit 1360-24).

General:

For striping, see the Standard Plans.

Lane and shoulder widths are shown for illustrative purposes. Determine lane and shoulder widths based on Exhibit 1360-6.

Exhibit 1360-27 Loop Ramp Connections



Notes:

- [1] For minimum weaving length, see Exhibit 1360-14.
- [2] Lane and shoulder widths are shown for illustrative purposes. For minimum ramp lane and shoulder widths, see Exhibit 1360-6.
- [3] For gore details, see Exhibit 1360-13.

General:

For gore details, see Exhibit 1360-13.

Exhibit 1360-28 Temporary Ramps

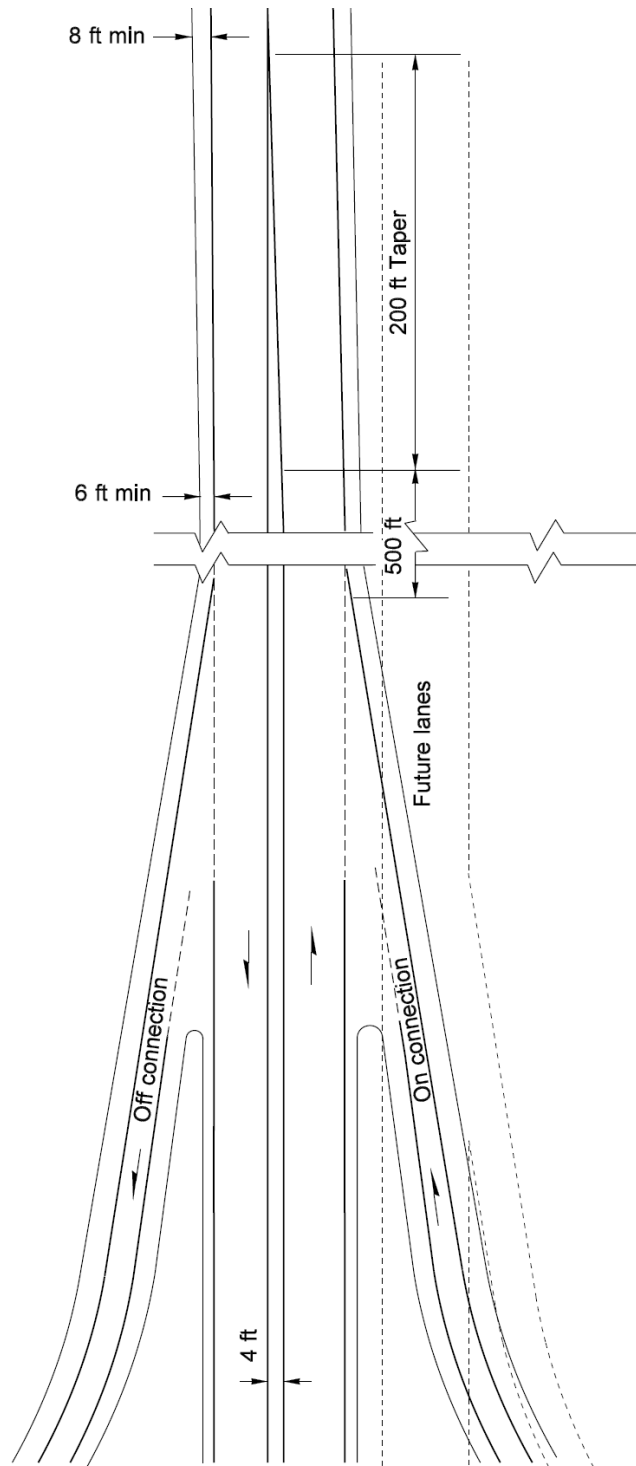


Exhibit 1360-29 Interchange Plan

