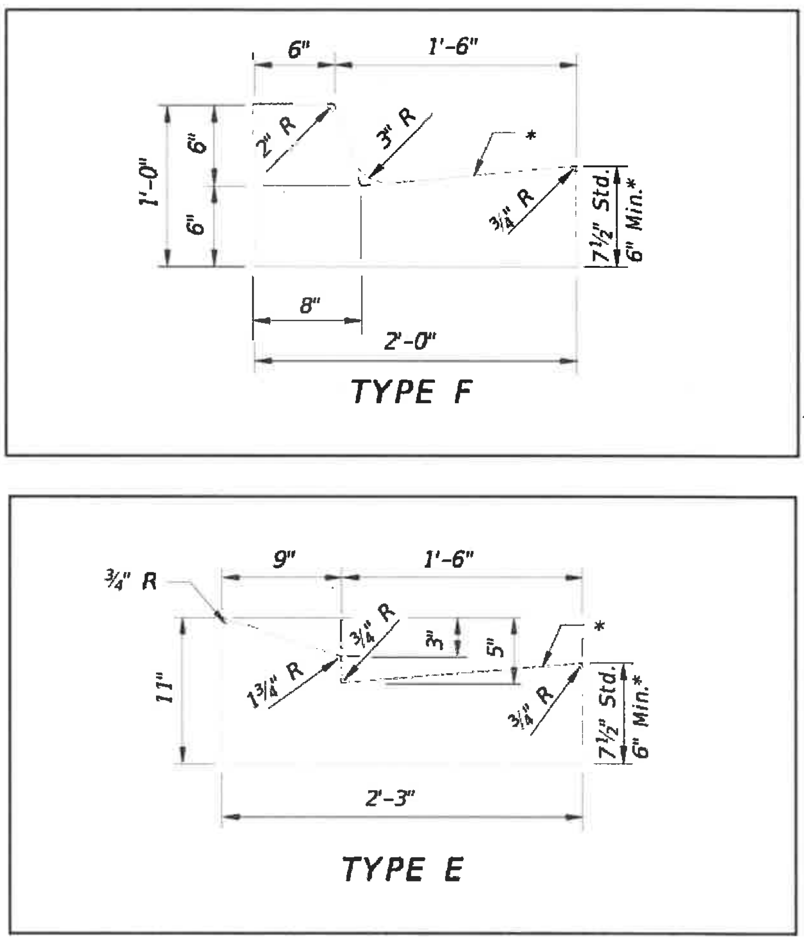
C.7.g Curbs

Curbs may be used to provide drainage control and to improve delineation of the roadway. Curbs are generally designed with a gutter to form a combination curb and gutter section. . In Florida, the standard curb of this type is 6 inches in height. See Figure 3 – 14 Standard Detail for FDOT Type F and E Curbs for examples of sloping curbs. These curbs are not to be used on facilities with design speeds greater than 45 mph. See ***Chapter 4 – Roadside Design*** for additional design criteria on the use of curbs.

Figure 3 – 14 Standard Detail for FDOT Type F and E Curbs



C.7.h Parking

When on-street parking is to be an element of design, parallel parking should be considered. Under certain circumstances, angle parking is an allowable form of street parking. The type of on-street parking selected should depend on the specific function and width of the street, the adjacent land use, traffic volume, as well as existing and anticipated traffic operations. On-street parking is allowed on facilities with posted speeds of 35 mph or less.

It can generally be stated that on-street parking decreases through capacity, impedes traffic flow, and increases crash potential. However, where parking is needed, and adequate off-street parking facilities are not available or feasible, on-street parking may be necessary.

C.7.i Right of Way

The acquisition of sufficient right of way is necessary in order to provide space for a safe street or highway. The width of the right of way required depends on the design of the roadway, the arrangement of bridges, underpasses and other structures, and the need for cuts or fills. The right of way acquired should be sufficient to:

- Allow development of the full cross section, including adequate medians and roadside clear zones. Determination of the necessary width requires that adequate consideration also be given to the accommodation of utility poles beyond the clear zone.
- Allow the layout of safe intersections, interchanges, and other access points.
- Allow adequate sight distance at all points, particularly on horizontal curves, at an intersection, and other access points.
- Allow, where appropriate, additional buffer zones to improve roadside safety, noise attenuation, and the overall aesthetics of the street or highway.
- Allow adequate space for placement of pedestrian and bicycle facilities, including curb ramps, bus bays, and transit shelters, where applicable.

- Allow for future lane additions, increases in cross section, or other improvement. Frontage roads should also be considered in the ultimate development of many high volume facilities.
- Allow treatment of stormwater runoff.
- Allow construction of future grade separations or other intersection improvements at selected crossroads.
- Allow corner cuts for upstream corner crossing drainage systems and placement of poles, boxes, and other visual screens out of the critical sight triangle.
- Allow landscaping and irrigation as required for the project.

The acquisition of wide rights of way is costly, but it may be necessary to allow the construction and future improvement of safe streets and highways. The minimum right of way should be at least 50 feet for all two-lane roads. For pre-existing conditions, when the existing right of way is less than 50 feet, efforts should be made to acquire the necessary right of way.

Local cul-de-sac and dead end streets having an ADT of less than or equal to 400 and a length of 600 feet or less, may utilize a right of way of less than 50 feet, if all elements of the typical section meet the standards included in this Manual.

The right of way for frontage roads may be reduced depending on the typical section requirements and the ability to share right of way with the adjacent street or highway facility.

C.7.j Changes in Typical Section

C.7.j.1 General Criteria

Changes in cross section should be avoided. When changes in widths, slopes, or other elements are necessary, they should be affected in a smooth, gradual fashion.

C.7.j.2 Lane Deletions and Additions

The addition or deletion of traffic or bicycle lanes should be undertaken on tangent sections of roadways. The approach to lane deletions and additions should have ample advance warning and sight distance.

The termination of lanes (including auxiliary lanes) shall meet the general requirements for merging lanes. See Section C.9.c.1 for additional information.

Where additional lanes are intermittently provided on two-lane, two-way highways, median separation should be considered.

C.7.j.3 Preferential Lanes

To increase the efficiency and separation of different vehicle movements, preferential use lanes, such as bike lanes and bus lanes, should be considered. These lanes are often an enhancement to corridor safety and increase the horizontal clearance to roadside aboveground fixed objects. The ***MUTCD, Chapter 3D*** provides further information on preferential lane markings. See ***Chapter 9 – Bicycle Facilities*** for information on marking bicycle lanes.

C.7.j.4 Structures

The pavement, median, and shoulder width, and sidewalks should be carried across structures such as bridges and box culverts. Shoulder widths for multi-lane rural divided highway bridges may be reduced as shown in Table 3 – 20 Minimum Shoulder Widths for Flush Shoulder Rural Highways. The designer should evaluate the economic practicality of utilizing dual versus single bridges for roadway sections incorporating wide medians.

The minimum roadway width for bridges on urban streets with curb and gutter shall be the same as the curb-to-curb width of the approach roadway. Sidewalks on the approaches should be carried across all structures. Curbed sidewalks should not be used adjacent to traffic lanes when design speeds exceed 45 mph. When the bridge rail (barrier wall) is placed between the traffic and sidewalk, it should be offset a minimum distance of $2^1/_2$ feet from the edge of the travel lane, wide curb lane or bicycle lane. For long (500 feet or greater), and/or high level bridges, it is desirable to provide an offset distance that will accommodate a disabled vehicle. The transition from the bridge to the adjacent roadway section may be made by dropping the curb at the first intersection or well in advance of the traffic barrier, or reducing the curb in front of the barrier to a low sloping curb with a gently sloped traffic face. See ***Chapter 17 – Bridges and Other Structures*** for additional requirements.

C.7.j.4.(a) Lateral Offset

Supports for bridges, barriers, or other structures should be placed at or beyond the required shoulder. Where possible, these structures should be located outside of the required clear zone. See ***Chapter 4 – Roadside Design*** for additional information on lateral offsets for structures.

C.7.j.4.(b) Vertical Clearance

Vertical clearance should be adequate for the type of expected traffic. Freeways and arterials shall have a vertical clearance of at least 16 feet-6 inches (includes 6 inch allowance for future resurfacing). Other streets and highways should have a clearance of 16 feet unless the provision of a reduced clearance is fully justified by a specific analysis of the situation (14 feet minimum). The minimum vertical clearance for a pedestrian or shared use bridge over a roadway is 17 feet. The minimum vertical clearance for a bridge over a railroad is 23 feet; however additional clearance may be required by the rail owner.

C.7.j.4.(c) End Treatment

The termini of guardrails, bridge railings, abutments, and other structures should be constructed to protect vehicles and their occupants from serious impact. Requirements for end treatment of structures are given in ***Chapter 4 - Roadside Design***.

C.8 Access Control

All new facilities (and existing when possible) should have some degree of access control, since each point of access produces a traffic conflict. The control of access is one of the most effective, efficient, and economical methods for improving the capacity and safety characteristics of streets and highways. The reduction of the frequency of access points and the restriction of turning and crossing maneuvers, which should be primary objectives, is accomplished more effectively by the design of the roadway geometry than by the use of traffic control devices. Design criteria for access points are presented under the general requirements for intersection design.

Additional information on access management can be found in ***Rule Chapter 1497 State Highway System Access Control Classification System, Florida Administrative Code.*** The ***Department's Driveway Information Guide (2008)*** and ***Median Handbook (2014)*** provide further information on designing roadways and connections to support access management.

C.8.a Justification

The justification for control of access should be based on several factors, including safety, capacity, economics, and aesthetics.

C.8.b General Criteria

C.8.b.1 Location of Access Points

All access locations should have adequate sight distance available for the safe execution of entrance, exit, and crossing maneuvers.

Locations of access points near structures, decision points, or the termination of street or highway lighting should be avoided.

Driveways should not be placed within the influence zone of intersections or other points that would tend to produce traffic conflict.

C.8.b.2 Spacing of Access Points

The spacing of access points should be adequate to prevent conflict or mutual interference of traffic flow.

Separation of entrance and exit ramps should be sufficient to provide adequate distance for required weaving maneuvers.

Adequate spacing between access and decision points is necessary to avoid burdening the driver with the need for rapid decisions or maneuvers.

Frequent median openings should be avoided.

The use of a frontage road or other auxiliary roadways is recommended on arterials and higher classifications where the need for direct driveway or minor road access is frequent.

C.8.b.3 Restrictions of Maneuvers

Where feasible, the number and type of permitted maneuvers (crossing, turning slowing, etc.) should be restricted.

The restriction of crossing maneuvers may be accomplished by the use of grade separations and continuous raised medians.

The restriction of left turns is achieved most effectively by continuous medians.

Channelization should be considered for the purposes of guiding traffic flow and reducing vehicle conflicts.

C.8.b.4 Auxiliary Lanes

Deceleration lanes for right turn exits (and left turns, where permitted) should be provided on all high-speed facilities. These turn lanes should not be excessive or continuous, since they complicate pedestrian crossings and bicycle/motor vehicle movements.

Storage (or deceleration lanes) to protect turning vehicles should be provided, particularly where turning volumes are significant.

Special consideration should be given to the provisions for deceleration, acceleration, and storage lanes in commercial or industrial areas with significant truck/bus traffic.

C.8.b.5 Grade Separation

Grade separation interchange design should be considered for junctions of high volume arterial streets and highways.

Grade separation (or an interchange) should be utilized when the expected traffic volume exceeds the intersection capacity.

Grade separation should be considered to eliminate conflict or long waiting periods at potentially hazardous intersections.

C.8.b.6 Roundabouts

Roundabouts have proven safety and operational characteristics and should be evaluated as an alternative to conventional intersections whenever practical. Modern roundabouts, when correctly designed, are a proven safety countermeasure to conventional intersections, both stop controlled and signalized. In addition, when constructed in appropriate locations, drivers will experience less delay with modern roundabouts. *NCHRP Report 672 Roundabouts: An Informational Guide*, is adopted by FHWA and establishes criteria and procedures for the justification, operational and safety analysis of modern roundabouts in the United States. The modern roundabout is characterized by the following:

- A central island of sufficient diameter to accommodate vehicle tracking and to provide sufficient deflection to promote lower speeds
- Entry is by gap acceptance through a yield condition at all legs
- Speeds through the intersection are 20 - 25 mph or less, consider urban, suburban, rural, single vs, multilane.

Roundabouts should be considered under the following conditions:

1. New construction
2. Reconstruction
3. Traffic Operations improvements
4. Resurfacing (3R) with Right of Way acquisition
5. Need to reduce frequency and severity of crashes

C.8.c Control for All Limited Access Highways

Entrances and exits on the right side only are highly desirable for all limited access highways. Acceleration and deceleration lanes are mandatory. Intersections shall be accomplished by grade separation (interchange) and should be restricted to connect with arterials or collector roads.

The control of access on freeways should conform to the requirements given in Table 3 – 24 Access Control for All Limited Access Highways. The spacing of exits and entrances should be increased wherever possible to reduce conflicts. Safety and capacity characteristics are improved by restricting the number and increasing the spacing of access points.

Table 3 – 24 Access Control for All Limited Access Highways

	Urban	Rural
Minimum Spacing		
Interchanges	1 to 3 miles	3 to 25 miles
Maneuver Restrictions		
Crossing Maneuvers	Via Grade Separation Only	
Exit and Entrance	From Right Side Only	
Turn Lane Required	Acceleration Lane at all Entrances Deceleration Lane at all Exits	

C.8.d Control of Urban and Rural Streets and Highways

The design and construction of urban, as well as rural, highways should be governed by the general criteria for access control previously outlined. In addition, the design of urban streets should be in accordance with the criteria listed below:

- The general layout of local and collector streets should follow a branching network, rather than a highly interconnected grid pattern.
- The street network should be designed to reduce, consistent with origin/destination requirements, the number of crossing and left turn maneuvers.
- The design of the street layout should be predicated upon reducing the need for traffic signals.
- The use of a public street or highway as an integral part of the internal circulation pattern for commercial property should be discouraged.
- The number of driveway access points should be restricted as much as possible through areas of strip development.

- Special consideration should be given to providing turn lanes (auxiliary lane for turning maneuvers) where the total volume or truck/bus volume is high.
- Major traffic generators may be exempt from the restrictions on driveway access if the access point is designed as a normal intersection adequate to handle the expected traffic volume.

These are minimum requirements only; it is generally desirable to use more stringent criteria for control of access.

The design of rural highways should be in accordance with the general criteria for access control for urban streets. The use of acceleration and deceleration lanes on all high-speed highways, particularly if truck and bus traffic is significant, is strongly recommended.

C.8.e Land Development

It should be the policy of each agency with responsibility for street and highway design, construction, or maintenance to promote close liaison with utility, lawmaking, zoning, building, and planning agencies. Cooperation should be solicited in the formulation of laws, regulations, and master plans for land use, zoning, and road construction. Further requirements and criteria for access control and land use relationships are given in ***Chapter 2 - Land Development***.

C.9 Intersection Design

Intersections increase traffic conflicts and the demands on the driver, and are inherently hazardous locations. The design of an intersection should be predicated on reducing motor vehicle, bicycle, and pedestrian conflicts, minimizing the confusion and demands on the driver for rapid and/or complex decisions, and providing for smooth traffic flow. The location and spacing of intersections should follow the requirements presented in Section C.8 Access Control, this chapter. Intersections should be designed to minimize time and distance of all who pass through or turn at an intersection.

The additional effort and expense required to provide a high quality intersection is justified by the corresponding safety benefits. The overall reduction in crash potential derived from a given expenditure for intersection improvements is generally much greater than the same expenditure for improvements along an open roadway. Properly designed intersections increase capacity, reduce delays, and improve safety.

One of the most common deficiencies that may be easy to correct is lack of adequate left turn storage.

The requirements and design criteria contained in this section are applicable to all driveways, intersections, and interchanges. All entrances to, exits from, or interconnections between streets and highways are subject to these design standards.

C.9.a General Criteria

The layout of a given intersection may be influenced by constraints unique to a particular location or situation. The design shall conform to sound principles and criteria for safe intersections. The general criteria include the following:

- The layout of the intersection should be as simple as is practicable. Complex intersections, which tend to confuse and distract the driver, produce inefficient and hazardous operations.
- The intersection arrangement should not require the driver to make rapid or complex decisions.

- The layout of the intersection should be clear and understandable so a proliferation of signs, signals, or markings is not required to adequately inform and direct the driver.
- The design of intersections, particularly along a given street or highway, should be as consistent as possible.
- The approach roadways should be free from steep grades and sharp horizontal or vertical curves.
- Intersections with driveways or other roadways should be as close to right angle as possible.
- Adequate sight distance should be provided to present the driver a clear view of the intersection and to allow for safe execution of crossing and turning maneuvers.
- The design of all intersection elements should be consistent with the design speeds of the approach roadways.
- The intersection layout and channelization should encourage smooth flow and discourage wrong way movements.
- Special attention should be directed toward the provision of safe roadside clear zones.
- The provision of auxiliary lanes should be in conformance with the criteria set forth in Section C.8 Access Control, this chapter.
- The requirements for bicycle and pedestrian movements should receive special consideration.

C.9.b Sight Distance

Inadequate sight distance is a contributing factor in the cause of a large percentage of intersection crashes. The provision of adequate sight distance at intersections is absolutely essential and should receive a high priority in the design process.

C.9.b.1 General Criteria

General criteria to be followed in the provision of sight distance include the following:

- Sight distance exceeding the minimum stopping sight distance should be provided on the approach to all intersections (entrances, exits, stop signs, traffic signals, and intersecting roadways). The use of proper approach geometry free from sharp horizontal and vertical curvature will normally allow for adequate sight distance.
- The approaches to exits or intersections (including turn, storage, and deceleration lanes) should have adequate sight distance for the design speed and also to accommodate any allowed lane change maneuvers.
- Adequate sight distance should be provided on the through roadway approach to entrances (from acceleration or merge lanes, stop or yield signs, driveways or traffic signals) to provide capabilities for defensive driving. This lateral sight distance should include as much length of the entering lane or intersecting roadway as is feasible. A clear view of entering vehicles is necessary to allow through traffic to aid merging maneuvers and to avoid vehicles that have "run" or appear to have the intention of running stop signs or traffic signals.
- Approaches to school or pedestrian crossings and crosswalks should have sight distances exceeding the minimum values. This should also include a clear view of the adjacent pedestrian pathways or shared use paths.
- Sight distance in both directions should be provided for all entering roadways (intersecting roadways and driveways) to allow entering vehicles to avoid through traffic. See Section C.9.B.4 for further information.
- Safe stopping sight distances shall be provided throughout all intersections, including turn lanes, speed change lanes, and turning roadways.
- The use of lighting (***Chapter 6 – Lighting***) should be considered to improve intersection sight distance for night driving.

C.9.b.2 Obstructions to Sight Distance

The provisions for sight distance are limited by the street or highway geometry and the nature and development of the area adjacent to the roadway. Where line of sight is limited by vertical curvature or obstructions, stopping sight distance shall be based on the eye height of 3.50 feet and an object height of 2.0 feet. At exits or other locations where the driver may be uncertain as to the roadway alignment, a clear view of the pavement surface should be provided. At locations requiring a clear view of other vehicles or pedestrians for the safe execution of crossing or entrance maneuvers, the sight distance should be based on a driver's eye height of 3.50 feet and an object height of 3.00 feet (preferably 1.50 feet). The height of eye for truck traffic may be increased for determination of line of sight obstructions for intersection maneuvers. Obstructions to sight distance at intersections include the following:

- Any property not under the highway agency's jurisdiction, through direct ownership or other regulations, should be considered as an area of potential sight distance obstruction. Based on the degree of obstruction, the property should be considered for acquisition by deed or easement.
- Areas which contain vegetation (trees, shrubbery, grass, etc.) that cannot easily be trimmed or removed by regular maintenance activity should be considered as sight obstructions.
- Parking lanes shall be considered as obstructions to line of sight. Parking shall be prohibited within clear areas required for sight distance at intersections.
- Large (or numerous) poles or support structures for lighting, signs, signals, or other purposes that significantly reduce the field of vision within the limits of clear sight shown in Figure 3 – 16 Departure Sight Triangle in Section C.9.b.4. may constitute sight obstructions. Potential sight obstructions created by poles, supports, and signs near intersections should be carefully investigated.

In order to ensure the provision for adequate intersection sight distance, on-site inspections should be conducted before and after construction, including placement of signs, lighting, guardrails, or other objects and how they impact intersection sight distance.

C.9.b.3 Stopping Sight Distance

The provision for safe stopping sight distance at intersections and on turning roadways is even more critical than on open roadways. Vehicles are more likely to be traveling in excess of the design or posted speed and drivers are frequently distracted from maintaining a continuous view of the upcoming roadway.

C.9.b.3.(a) Approach to Stops

The approach to stop signs, yield signs, or traffic signals should be provided with a sight distance no less than values given in Table 3 – 25 Minimum Stopping Sight Distance (Rounded Values). These values are applicable for any street, highway, or turning roadway. The driver should, at this required distance, have a clear view of the intersecting roadway, as well as the sign or traffic signal.

Where the approach roadway is on a grade or vertical curve, the sight distance should be no less than the values shown in Figure 3 – 15 Sight Distances for Approach to Stop on Grades. In any situation where it is feasible, sight distances exceeding those should be provided. This is desirable to allow for more gradual stopping maneuvers and to reduce the likelihood of vehicles running through stop signs or signals. Advance warnings for stop signs are desirable.

Table 3 – 25 Minimum Stopping Sight Distance (Rounded Values)

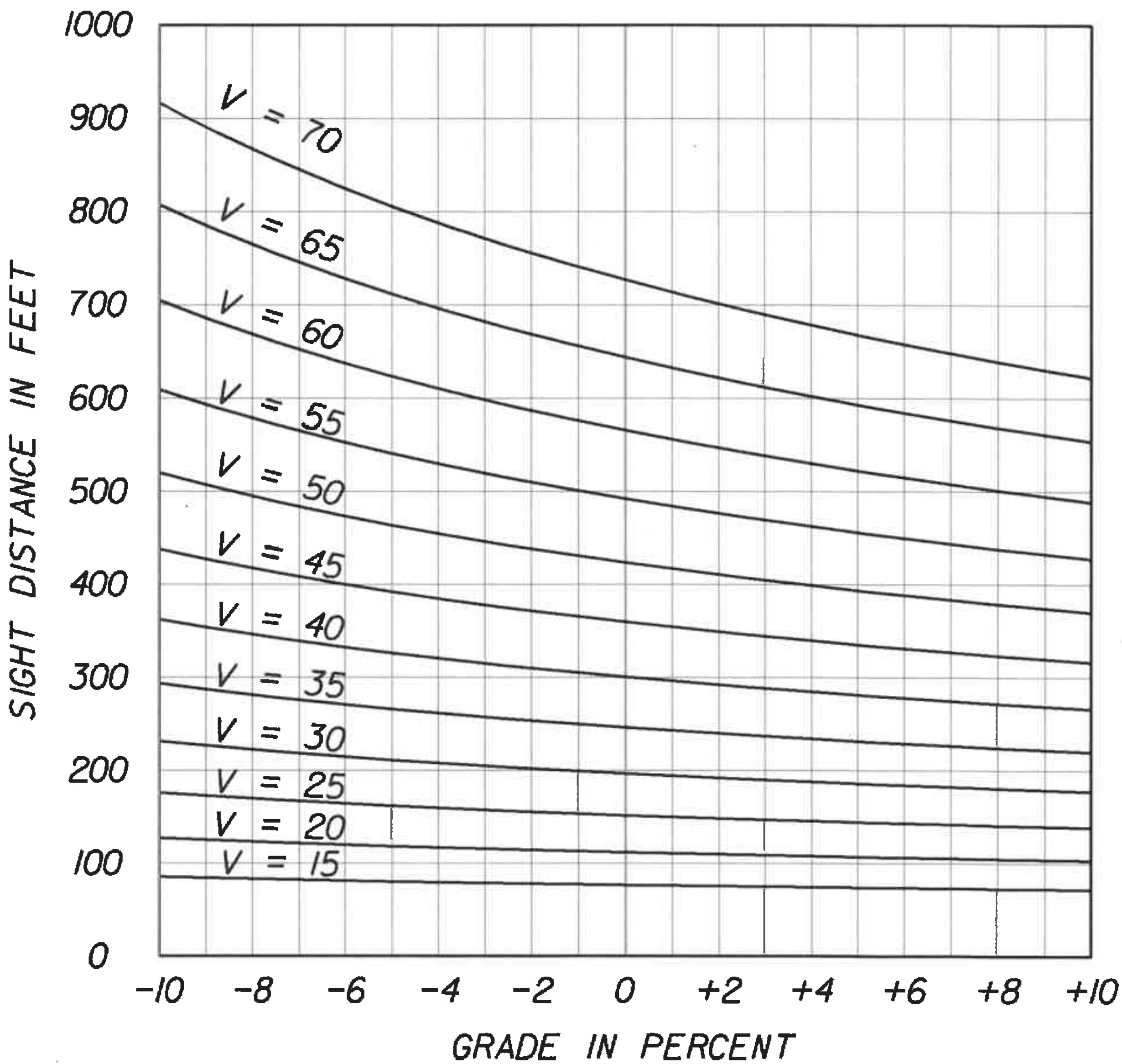
Design Speed (mph)	20	25	30	35	40	45	50	55	60	65	70
Stopping Sight Distance (feet)	115	155	200	250	305	360	425	495	570	645	730

C.9.b.3.(b) On Turning Roads

The required stopping sight distance at any location on a turning roadway (loop, exit, etc.) shall be based on the design speed at that point. Ample sight distance should be provided since the driver is burdened with negotiating a curved travel path and the available friction factor for stopping has been reduced by the roadway curvature. The minimum sight distance values are given in Table 3 – 25 Minimum Stopping

Sight Distance (Rounded Values) or Figure 3 – 15 Sight Distances for Approach to Stop on Grades. Due to the inability of vehicle headlights to adequately illuminate a sharply curved travel path, roadway lighting should be considered for turning roadways.

Figure 3 – 15 Sight Distances for Approach to Stop on Grades



$$S = 3.675 + V \quad \frac{V^{2}}{30(0.3478 \pm G)}$$

S = Sight Distance
V = Design Speed
G = Grade

C.9.b.4 Sight Distance for Intersection Maneuvers

Sight distance is also provided at intersections to allow the drivers of stopped vehicles a sufficient view of the intersecting street or highway to decide when to enter or cross the intersecting street or highway. Sight triangles, which are specified areas along intersection approach legs and across their included corners, shall, where practical, be clear of obstructions that would prohibit a driver's view of potentially conflicting vehicles. Departure sight triangles shall be provided in each quadrant of each intersection approach controlled by stop signs.

Figures 3 – 16 Departure Sight Triangle (Traffic Approaching from Left or Right) and 3 – 17 Intersection Sight Distance show typical departure sight triangles to the left and to the right of the location of a stopped vehicle on a minor road (stop controlled) and the intersection sight distances for the various movements.

Distance "a" is the length of leg of the sight triangle along the minor road. This distance is measured from the driver's eye in the stopped vehicle to the center of the nearest lane on the major road (through road) for vehicles approaching from the left, and to the center of the nearest lane for vehicles approaching from the right.

Distance "b" is the length of the leg of the sight triangle along the major road measured from the center of the minor road entrance lane. This distance is a function of the design speed and the time gap in major road traffic needed for minor road drivers turning onto or crossing the major road. This distance is calculated as follows:

$$ISD = 1.47 V_{major} t_g$$

Where:

ISD=Intersection Sight Distance (ft.) – length of leg of sight triangle along the major road.

V_{major}= Design Speed (mph) of the Major Road

t_g= Time gap (sec.) for minor road vehicle to enter the major road.

Time gap values, t_g, to be used in determination of ISD are based on studies and observations of the time gaps in major road traffic actually accepted by drivers turning onto or across the major road. Design time gaps will vary and depend on the design vehicle, the type of the maneuver, the crossing distance involved in the maneuver, and the minor road approach grade.

For intersections with stop control on the minor road, there are three maneuvers or cases that must be considered. ISD is calculated for each maneuver case that may occur at the intersection. The case requiring the greatest ISD will control. Cases that must be considered are as follows (Case numbers correspond to cases identified in the AASHTO – "A Policy on Geometric Design of Highways and Streets" - 2011):

Case B1 – Left Turns from the Minor (stop controlled) Road

Case B2 – Right Turns from the Minor (stop controlled) Road

Case B3 – Crossing the Major Road from the Minor (stop controlled) Road

See Sections C.9.b.4.(c) and (d) for design time gaps for Case B.

For Intersections with Traffic Signal Control see Section C.9.b.4.(e) (AASHTO Case D).

For intersections with all way stop control see Section C.9.b.4.(f) (AASHTO Case E).

For left turns from the major road see Section C.9.b.4.(g) (AASHTO Case F).

Figure 3 – 16 Departure Sight Triangle (Traffic Approaching from Left or Right)

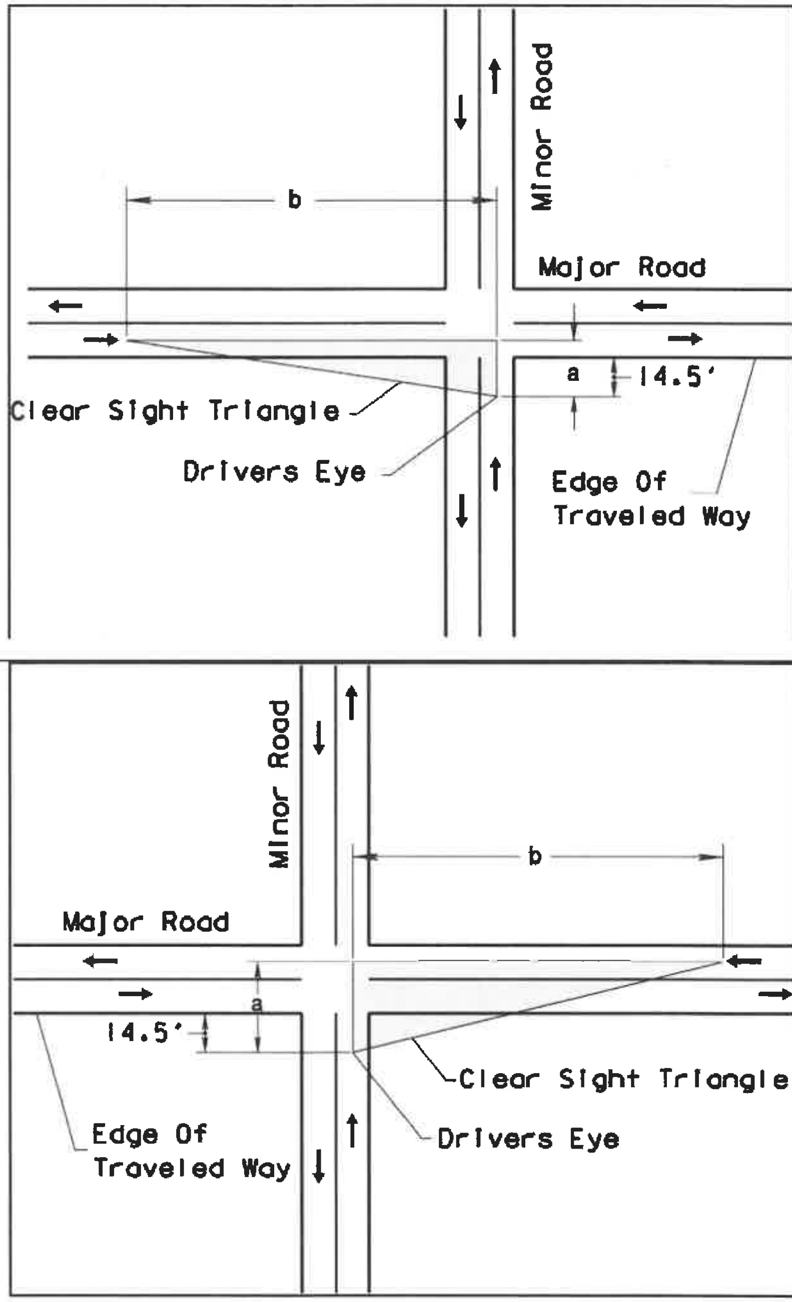
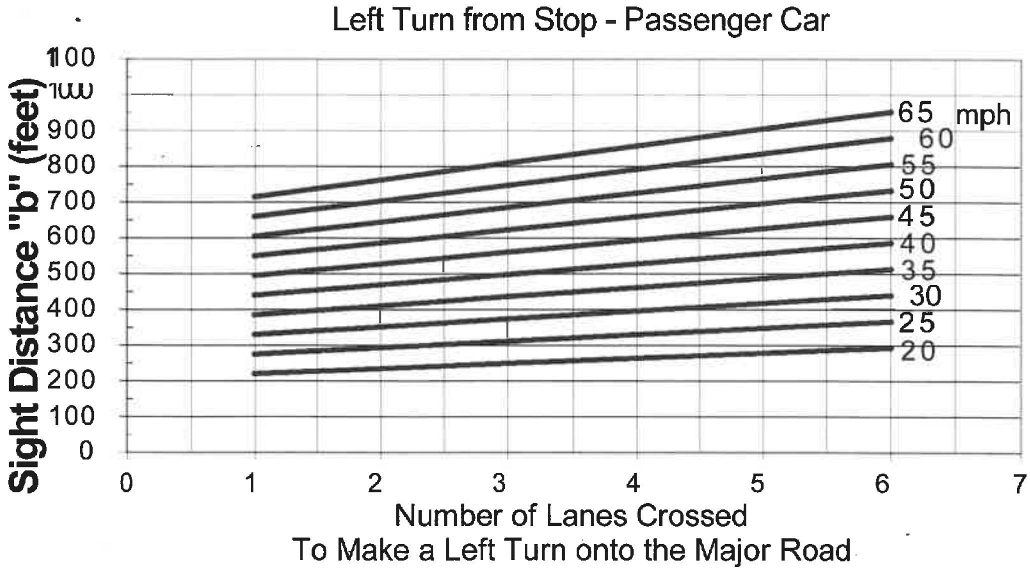
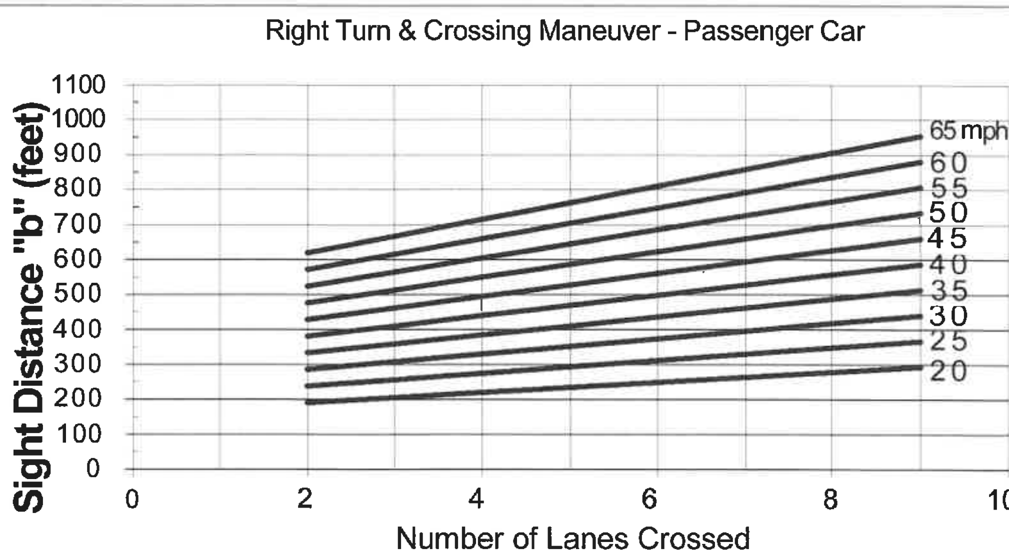


Figure 3 – 17 Intersection Sight Distance



A vehicle crosses one lane to make a left turn onto a two lane-two way road; crosses two lanes on a four lane undivided road; and so forth. For divided highways, convert median widths to equivalent number of lanes. For medians 25' and greater a two step maneuver may be considered - see text.



For right turn maneuver use distance based on 2 lanes crossed.
For crossing divided highways, convert median widths to equivalent number of lanes. For medians 25' and greater a two step maneuver may be considered - see text.

C.9.b.4.(a) Driver's Eye Position and Vehicle Stopping Position

The vertex (decision point or driver's eye position) of the departure sight triangle on the minor road shall be a minimum of 14.5 feet from the edge of the major road traveled way. This is based on observed measurements of vehicle stopping position and the distance from the front of the vehicle to the driver's eye. Field observations of vehicle stopping positions found that, where necessary, drivers will stop with the front of their vehicle 6.5 feet or less from the edge of the major road traveled way. Measurements of passenger cars indicate that the distance from the front of the vehicle to driver's eye for the current U.S. passenger car fleet is almost always 8 feet or less.

When executing a crossing or turning maneuver after stopping at a stop sign, stop bar, or crosswalk as required in ***Section 316.123, Florida Statutes***, it is assumed that the vehicle will move slowly forward to obtain sight distance (without intruding into the crossing travel lane) stopping a second time as necessary.

C.9.b.4.(b) Design Vehicle

Dimensions of clear sight triangles are provided for passenger cars, single unit trucks, and combination trucks stopped on the minor road. It can usually be assumed that the minor road vehicle is a passenger car. However, where substantial volumes of heavy vehicles enter the major road, such as from a ramp terminal, the use of tabulated values for single unit or combination trucks should be considered.

C.9.b.4.(c) Case B1 - Left Turns from the Minor Road

Design time gap values for left turns from the minor road onto two lane two way major highway are as follows:

Design Vehicle	Time Gap (t_g) in Seconds
Passenger Car	7.5
Single Unit Truck	9.5
Combination Truck	11.5

If the minor road approach grade is an upgrade that exceeds 3 percent, add 0.2 seconds for each percent grade for left turns.

For multilane streets and highways without medians wide enough to store the design vehicle with a clearance of 3 feet on both ends of the vehicle, add 0.5 seconds for passenger cars or 0.7 seconds for trucks for each additional lane from the left, in excess of one, to be crossed by the turning vehicle. The median width should be included in the width of additional lanes. This is done by converting the median width to an equivalent number of 12 foot lanes.

For multilane streets and highways with medians wide enough to store the design vehicle with a clearance of 3 feet on both ends of the vehicle a two-step maneuver may be assumed. Use case B2 for crossing to the median.

C.9.b.4.(d) Case B2 - Right Turns From the Minor Road and Case B3 – Crossing Maneuver From the Minor Road

Design time gap values for a stopped vehicle on a minor road to turn right onto or cross a two lane highway are as follows:

Design Vehicle	Time Gap (t_g) in Seconds
Passenger Car	6.5
Single Unit Truck	8.5
Combination Truck	10.5

If the approach grade is an upgrade that exceeds 3 percent, add 0.1 seconds for each percent grade.

For crossing streets and highways with more than 2 lanes, add 0.5 seconds for passenger cars or 0.7 seconds for trucks for each additional lane to be crossed. Medians not wide enough to store the design vehicle with a clearance of 3 feet on both ends of the vehicle should be included in the width of additional lanes. This is done by converting the median width to an equivalent number of 12 foot lanes.

For crossing divided streets and highways with medians wide enough to store the design vehicle with a clearance of 3 feet on both ends of the vehicle, a two-step maneuver may be assumed. Only the number of lanes to be crossed in each step are considered.

C.9.b.4.(e) Intersections with Traffic Signal Control (AASHTO Case D)

At signalized intersections, the first vehicle stopped on one approach should be visible to the driver of the first vehicle stopped on each of the other approaches. Left turning vehicles should have sufficient sight distance to select gaps in oncoming traffic and complete left turns. Apart from these sight conditions, no other sight triangles are needed for signalized intersections. However, if the traffic signal is to be placed on two-way flashing operation in off peak or nighttime conditions, then the appropriate departure sight triangles for Cases B1, B2, or B3, both to the left and to the right, should be provided. In addition, if right turns on red are to be permitted, then the appropriate departure sight triangle to the left for Case B2 should be provided to accommodate right turns.

C.9.b.4.(f) Intersections with All-Way Stop Control (AASHTO Case E)

At intersections with all-way stop control, the first stopped vehicle on one approach should be visible to the drivers of the first stopped vehicles on each of the other approaches. There are no other sight distance criteria applicable to intersections with all-way stop control.

C.9.b.4.(g) Left Turns from the Major Road (AASHTO Case F)

All locations along a major road from which vehicles are permitted to turn left across opposing traffic shall have sufficient sight distance to accommodate the left turn maneuver. In this case, the ISD is measured from the stopped position of the left turning vehicle (see Figure 3 – 18 Sight Distance for Vehicle Turning Left from Major Road).

Design time gap values for left turns from the major road are as follows:

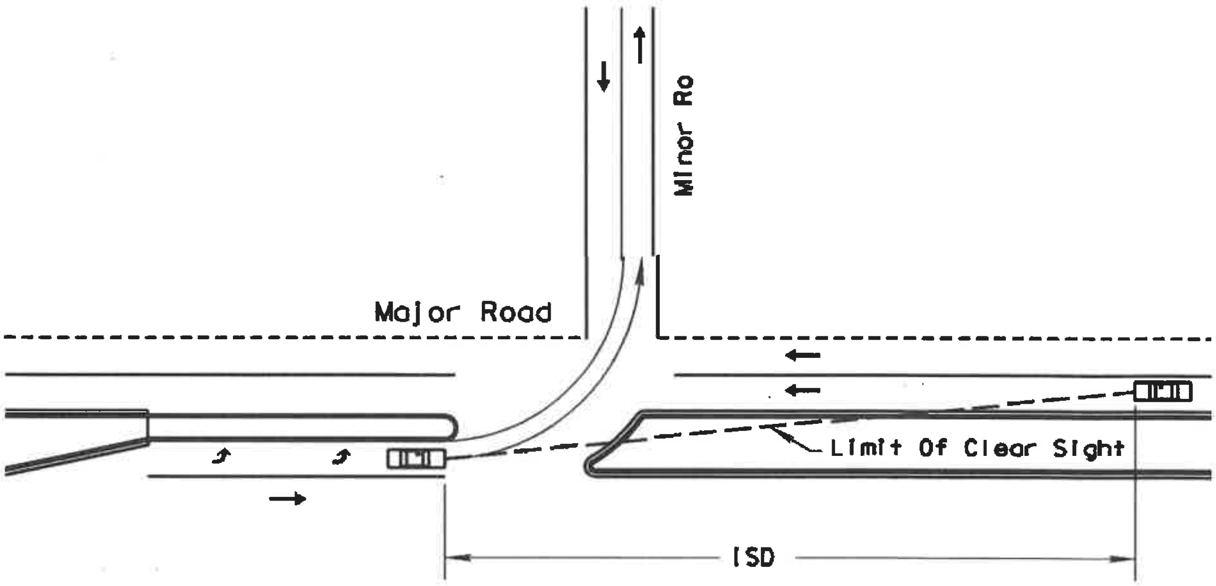
Design Vehicle	Time Gap (t_g) in Seconds
Passenger Car	5.5
Single Unit Truck	6.5
Combination Truck	7.5

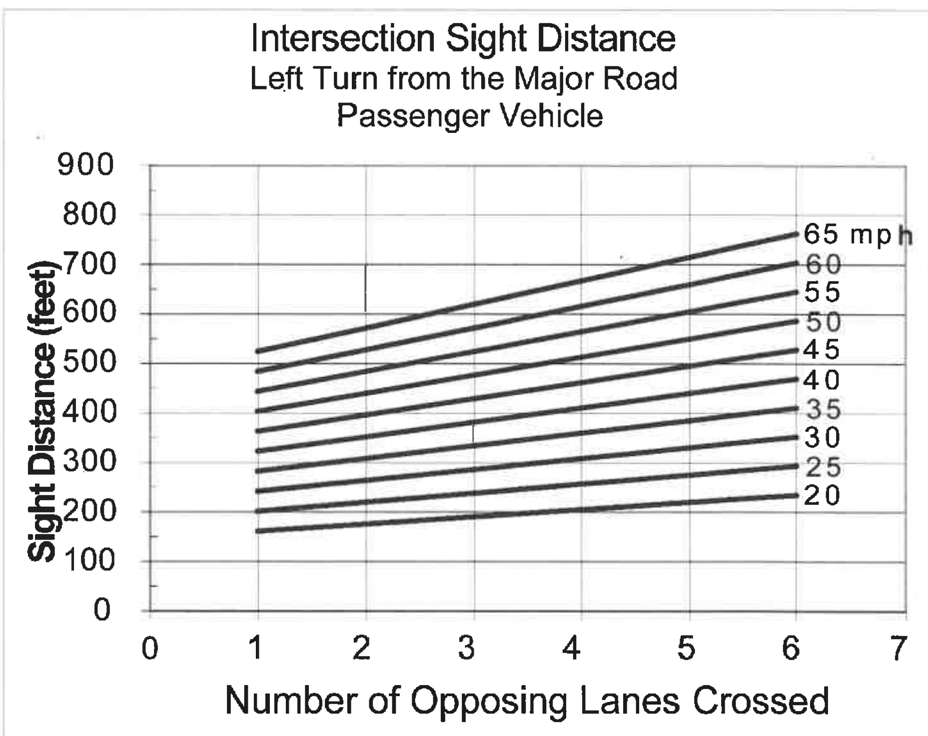
For left turning vehicles that cross more than one opposing lane, add 0.5 seconds for passenger cars and 0.7 seconds for trucks for each additional lane to be crossed.

C.9.b.4.(h) Intersection Sight Distance References

The Department's *Design Manual, Chapter 212 Intersections* , provides ISD values for several basic intersection configurations based on Cases B1, B2, B3, and D, and may be used when applicable. For additional guidance on Intersection Sight Distance, see the *AASHTO Green Book (2011).*

Figure 3 – 18 Sight Distance for Vehicle Turning Left from Major Road





C.9.c Auxiliary Lanes

Auxiliary lanes are desirable for the safe execution of speed change maneuvers (acceleration and deceleration) and for the storage and protection of turning vehicles. Auxiliary lanes for exit or entrance turning maneuvers shall be provided in accordance with the requirements set forth in C.8 Access Control, this chapter. The pavement width and cross slopes of auxiliary lanes should meet the minimum requirements shown in Table 3-19 Minimum Lane Widths.

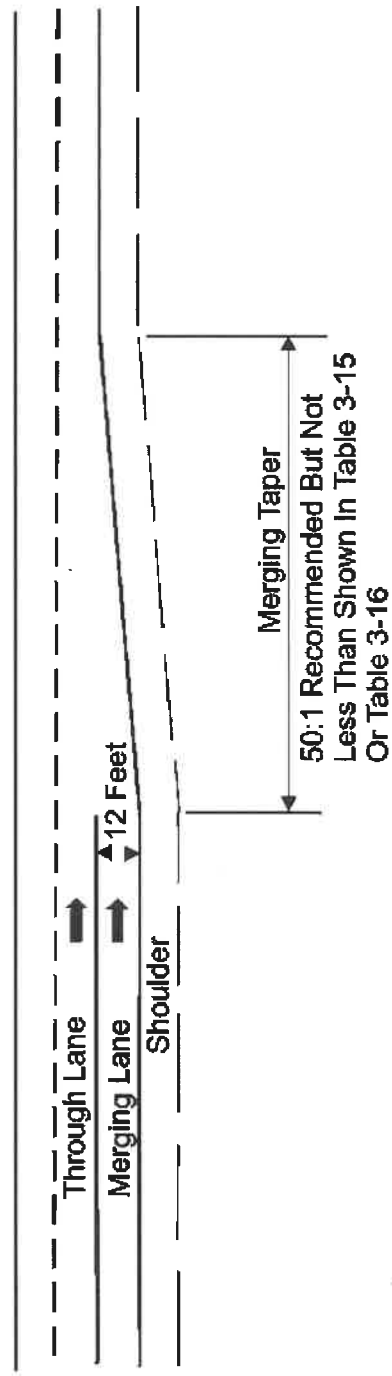
C.9.c.1 Merging Maneuvers

Merging maneuvers occur at the termination of climbing lanes, lane drops, entrance acceleration, and turning lanes. The location provided for this merging maneuver should, where possible, be on a tangent section of the roadway and should be of sufficient length to allow for a smooth, safe transition. The provision of ample distance for merging is essential to allow the driver time to find an acceptable gap in the through traffic and then execute a safe merging maneuver. It is recommended that a merging taper be on a 1:50 transition, but in no case, shall the length be less than set forth in Table 3 – 26 Length of Taper for Use in Conditions with Full Width Speed Change Lanes. The termination of this lane should be clearly visible from both the merging and through lane and should correspond to the general configuration shown in Figure 3 – 19 Termination of Merging Lanes. Advance warning of the merging lane termination should be provided. Lane drops shall be marked in accordance with ***Section 14-15.010, F.A.C. Manual on Uniform Traffic Control Devices (MUTCD).***

Table 3 – 26 Length of Taper for Use in Conditions with Full Width Speed Change Lanes

Design Speed (mph)	20	25	30	35	40	45	50	55	60	65	70
Length of Deceleration Taper (feet)	110	130	150	170	190	210	230	250	270	290	300
Length of Acceleration Taper (feet)	80	100	120	140	160	180	210	230	250	260	280

Figure 3 – 19 Termination of Merging Lanes



C.9.c.2 Acceleration Lanes

Acceleration lanes are required for all entrances to expressway and freeway ramps. Acceleration lanes may be desirable at access points to any street or highway with a large percentage of entering truck traffic.

The distance required for an acceleration maneuver is dependent on the vehicle acceleration capabilities, the grade, the initial entrance speed, and the final speed at the termination of the maneuver. The distances required for acceleration on level roadways for passenger cars are given in Table 3 – 27 Design Lengths of Speed Change Lanes Flat Grades. Where acceleration occurs on a grade, the required distance is obtained by using Table 3 – 28 Ratio of Length of Speed Change Lane on Grade to Length on Level and Table 3 – 29 Minimum Acceleration Lengths for Entrance Terminals.

The final speed at the end of the acceleration lane, should, desirably, be assumed as the design speed of the through roadway. The length of acceleration lane provided should be at least as long as the distance required for acceleration between the initial and final speeds. Due to the uncertainties regarding vehicle capabilities and driver behavior, additional length is desirable. The acceleration lane should be followed by a merging taper (similar to Figure 3 – 19 Termination of Merging Lanes), not less than that length set forth in Table 3 – 26 Length of Taper for Use in Conditions with Full Width Speed Change Lanes. The termination of acceleration lanes should conform to the general configuration shown for merging lanes in Figure 3 – 19 Termination of Merging Lanes. Recommended acceleration lanes for freeway entrance terminals are given in Table 3 – 29 Minimum Acceleration Lengths for Entrance Terminals.

Table 3 – 27 Design Lengths of Speed Change Lanes
Flat Grades - 2 Percent or Less

Design Speed of turning roadway curve (mph)		Stop Condition	15	20	25	30	35	40	45	50
Minimum curve radius (feet)		---	55	100	160	230	320	430	555	695
Design Speed of Highway (mph)	Lengt h of Taper (feet)*	Total length of DECELERATION LANE, including taper, (feet)								
30	150	385	350	320	290	---	---	---	---	---
35	170	450	420	380	355	320	---	---	---	---
40	190	510	485	455	425	375	345	---	---	---
45	210	595	560	535	505	460	430	---	---	---
50	230	665	635	615	585	545	515	455	405	---
55	250	730	705	690	660	630	600	535	485	---
60	270	800	770	750	730	700	675	620	570	510
65	290	860	830	810	790	760	730	680	630	570
70	300	915	890	870	850	820	790	740	690	640
Design Speed of Highway (mph)	Lengt h of Taper (feet)*	Total length of ACCELERATION LANE, including taper (feet)								
30	120	300	260	---	---	---	---	---	---	---
35	140	420	360	300	---	---	---	---	---	---
40	160	520	460	430	370	280	---	---	---	---
45	180	740	670	620	560	460	340	---	---	---
50	210	930	870	820	760	660	560	340	---	---
55	230	1190	1130	1040	1010	900	780	550	380	---
60	250	1450	1390	1350	1270	1160	1050	800	670	430
65	260	1670	1610	1570	1480	1380	1260	1030	860	630
70	280	1900	1840	1800	1700	1630	1510	1280	1100	860

* For urban street auxiliary lanes, shorter tapers may be used due to lower operating speeds. Refer to Figure 3-16 for allowable taper rates.

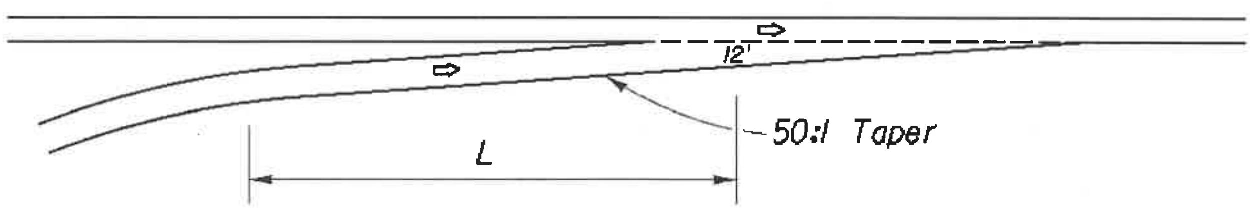
Table 3 – 28 Ratio of Length of Speed Change Lane on Grade to Length on Level

Deceleration Lane			Acceleration Lane					
	Design Speed of Turning Roadway (mph)			Design Speed of Turning Roadway (mph)				
Design Speed of Highway (mph)	All Speeds	All Speeds	Design Speed of Highway (mph)	20	30	40	50	All Speeds
	3% -4% Upgrade	3%-4% Downgrade		3% - 4% Upgrade				3% - 4% Downgrad
All Speeds	0.9	1.2	40	1.3	1.3	---	---	0.7
			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	0.6
			65	1.45	1.55	1.6	1.7	0.6
			70	1.5	1.6	1.7	1.8	0.6
	5% - 6% Upgrade	5% - 6% Downgrade		5% - 6% Upgrade				5% - 6% Downgrad
All Speeds	0.8	1.35	40	1.5	1.5	---	---	0.6
			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	0.5
			65	1.85	2.05	2.4	2.75	0.5
			70	2.0	2.2	2.6	3.0	0.5
Ratios in this table multiplied by the values in Table 3 – 26 give the length of speed change lane for the respective grade.								

Table 3 – 29 Minimum Acceleration Lengths for Entrance Terminals

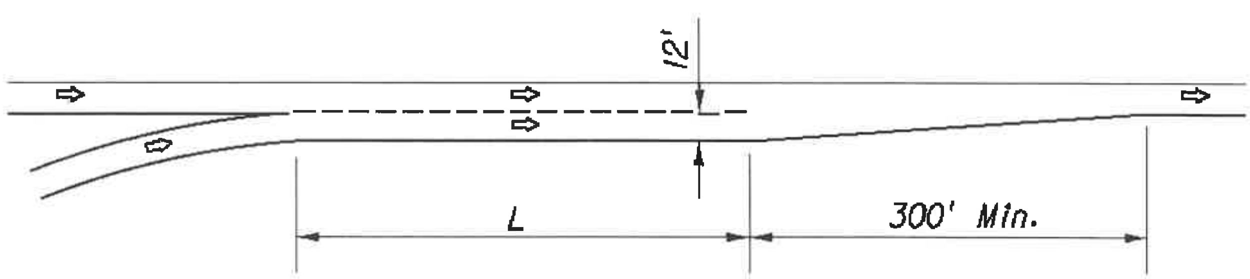
Highway Design Speed (mph)	L = Acceleration Length (feet)								
	For Entrance Curve Design Speed (mph)								
	Stop Condition	15	20	25	30	35	40	45	50
30	180	140	---	---	---	---	---	---	---
35	280	220	160	---	---	---	---	---	---
40	360	300	270	210	120	---	---	---	---
45	560	490	440	380	280	160	---	---	---
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	1,230	1000	820	580

Expressway and Freeway Entrance Terminals



TAPER TYPE

Recommended when design speed at entrance curve is 50 mph or greater.



PARALLEL TYPE

Recommended when design speed at entrance curve is less than 50 mph.

C.9.c.3 Exit Lanes

Auxiliary lanes for exiting maneuvers provide space outside the through lanes for protection and storage of decelerating vehicles exiting the facility.

- Deceleration Lanes - The primary function of deceleration lanes is to provide a safe travel path for vehicles decelerating from the operating speed on the through lanes. Deceleration lanes are required for all freeway exits and are desirable on high-speed (design speed greater than 50 mph) streets and highways.

The distance required for deceleration of passenger cars is given in Table 3 – 30 Minimum Deceleration Lengths for Exit Terminals.

The required distance for deceleration on grades is given in Tables 3 – 27 Design Lengths of Speed Change Lanes Flat Grades - 2 Percent or Less and 3 – 28 Ratio of Length of Speed Change Lane on Grade to Length on Level.

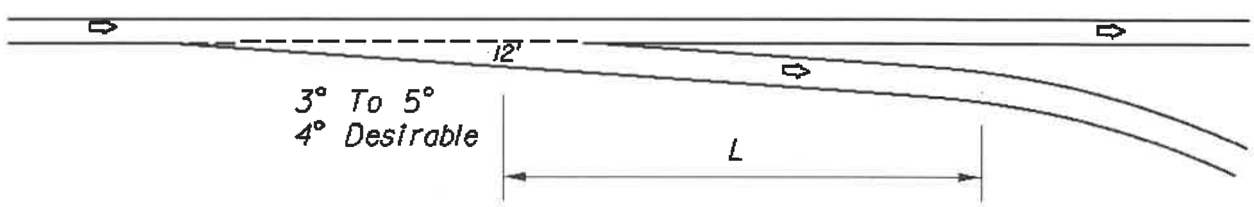
The length of deceleration lanes shall be no less than the values obtained from Tables 3 – 27 and 3 – 28 and should be increased wherever feasible. The initial speed should, desirably, be taken as the design speed of the highway. The final speed should be the design speed at the exit (e.g., a turning roadway) or zero, if the deceleration lane terminates at a stop or traffic signal. A reduction in the final speed to be used is particularly important if the exit traffic volume is high, since the speed of these vehicles may be significantly reduced.

The entrance to deceleration (and climbing) lanes should conform to the general configuration shown in Figure 3 – 20 Entrance for Deceleration Lane. The initial length of straight taper, shown in Table 3 – 29 Minimum Acceleration Lengths for Entrance Terminals, may be utilized as a portion of the total required deceleration distance. The pavement surface of the deceleration lane should be clearly visible to approaching traffic, so drivers are aware of the maneuvers required. Recommended deceleration lanes for exit terminals are given in Table 3 – 30 Minimum Deceleration Lengths for Exit Terminals.

Table 3 – 30 Minimum Deceleration Lengths for Exit Terminals

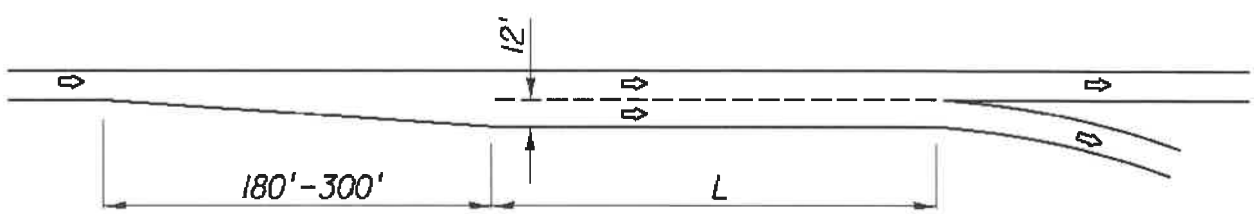
Highway Design Speed (mph)	L = Deceleration Length (feet) For Design Speed of Exit Curve (mph)								
	Stop Condition	15	20	25	30	35	40	45	50
30	235	200	170	140	---	---	---	---	---
35	280	250	210	185	150	---	---	---	---
40	320	295	265	235	185	155	---	---	---
45	385	350	325	295	250	220	---	---	---
50	435	405	385	355	315	285	225	175	---
55	480	455	440	410	380	350	285	235	---
60	530	500	480	460	430	405	350	300	240
65	570	540	520	500	470	440	390	340	280
70	615	590	570	550	520	490	440	390	340

Expressway and Freeway Exit Terminals



TAPER TYPE

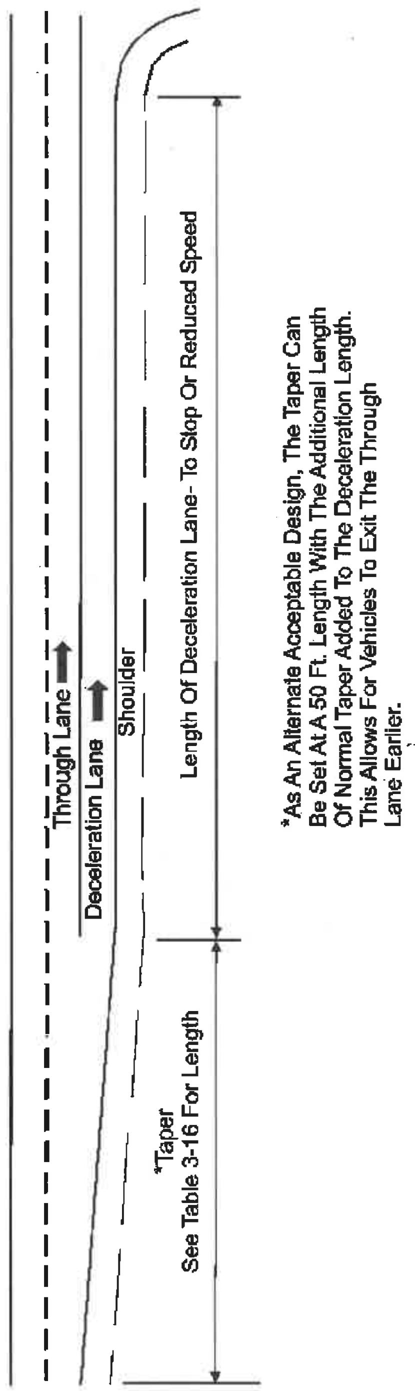
Recommended when design speed at exit curve is 50 mph or greater and when approach visibility is good.



PARALLEL TYPE

Recommended when design speed at exit curve is less than 50 mph or when approach visibility is <u>not</u> good.

Figure 3 – 20 Entrance for Deceleration Lane



C.9.c.4 Auxiliary Lanes at Intersections

The primary function of auxiliary lanes at intersections is to accommodate speed changes and maneuvering of turning traffic. They are typically added to increase capacity and/or reduce crashes at an intersection. Auxiliary lanes for deceleration and storage of queuing vehicles are used preceding intersections and median openings for left-turning and right-turning movements. In some cases, auxiliary lanes for acceleration are used following right-turning movements.

C.9.c.4.(a) Widths of Auxiliary Lanes

The minimum widths for auxiliary lanes are given in Table 3 – 20 Minimum Lane Widths.

C.9.c.4.(b) Lengths of Auxiliary Lanes for Deceleration

Recommended lengths for auxiliary lanes for deceleration (turn lanes) at intersections are provided in Figure 3 – 21 Auxiliary Lanes for Deceleration at Intersections (Turn Lanes) and Table 3 – 31 Turn Lanes – Curbed and Uncurbed Medians. These lengths are based on the Department's criteria. As shown in Figure 3 – 21, the total length of turn lanes consists of three components, (1) Deceleration Length, (2) Storage or Queue Length and (3) Entering Taper. It is common practice to accept a moderate amount of deceleration within the through lanes and to consider the taper as part of the deceleration length. The length criteria for each of the auxiliary lane components are explained as follows:

Deceleration Length

The required total deceleration length is that needed for a safe and comfortable stop from the design speed of the highway. Minimum deceleration lengths (including taper) for auxiliary lanes are provided in Figure 3 – 21 and are based on minimum stopping sight distance.

Storage (Queue) Length

The auxiliary lane should be sufficiently long to store the number of vehicles likely to accumulate during a critical period. The storage length should be sufficient to avoid the possibilities of turning vehicles stopping in the through lanes or the entrance to the auxiliary lane being blocked by vehicles queuing in the through lanes.

At unsignalized intersections the storage length, exclusive of taper, may be based on the number of turning vehicles likely to arrive in an average two-minute period within the peak hour. For low volume intersections where a traffic study is not justified, a minimum 50-foot queue length (2 vehicles) should be provided on rural highways. A minimum 100-foot queue length (4 vehicles) should be provided in urban areas. Locations with over 10% truck traffic should accommodate at least one car and one truck.

At signalized intersections, the required storage length is determined by traffic study and depends on the signal cycle length, the signal phasing arrangement and the rate of arrivals and departures of turning vehicles. The storage length is a function of the probability of occurrence of events and should be based on 1.5 to 2 times the average number of vehicles that would store per cycle that is predicted in the design volume.

Where dual turning lanes are used, the required storage length is reduced to approximately one-half of that required for single-lane operation.

Approach End Taper

The Department's criteria for approach end taper lengths for turn lanes are 50 feet for a single turn lane and 100 feet for a double turn lane, as shown in Figure 3 - 21 Auxiliary Lanes for Deceleration at Intersections (Turn Lanes) and Table 3 – 31 Turn Lanes – Curbed and Uncurbed Medians. These taper lengths apply to all design speeds and are recommended for use on turn lanes on all roads. Short taper lengths are intended to provide approaching road users with positive identification of an added auxiliary lane and results in a longer full width auxiliary lane than use of longer taper lengths based on the path that road users actually follow. The clearance distances L_1 and L_3 account for the full transition lengths a road user will use to enter the auxiliary lane for various speed conditions assumed for design.

It is acceptable to lengthen the taper up to L_1 for single left turns and L_3 for double left turns where traffic study can establish that left turn queue vehicles are adequately provided for within the design queue length and through vehicle queues will not block access to the left turn lane(s).

Figure 3 – 21 Auxiliary Lanes for Deceleration at Intersections (Turn Lanes)

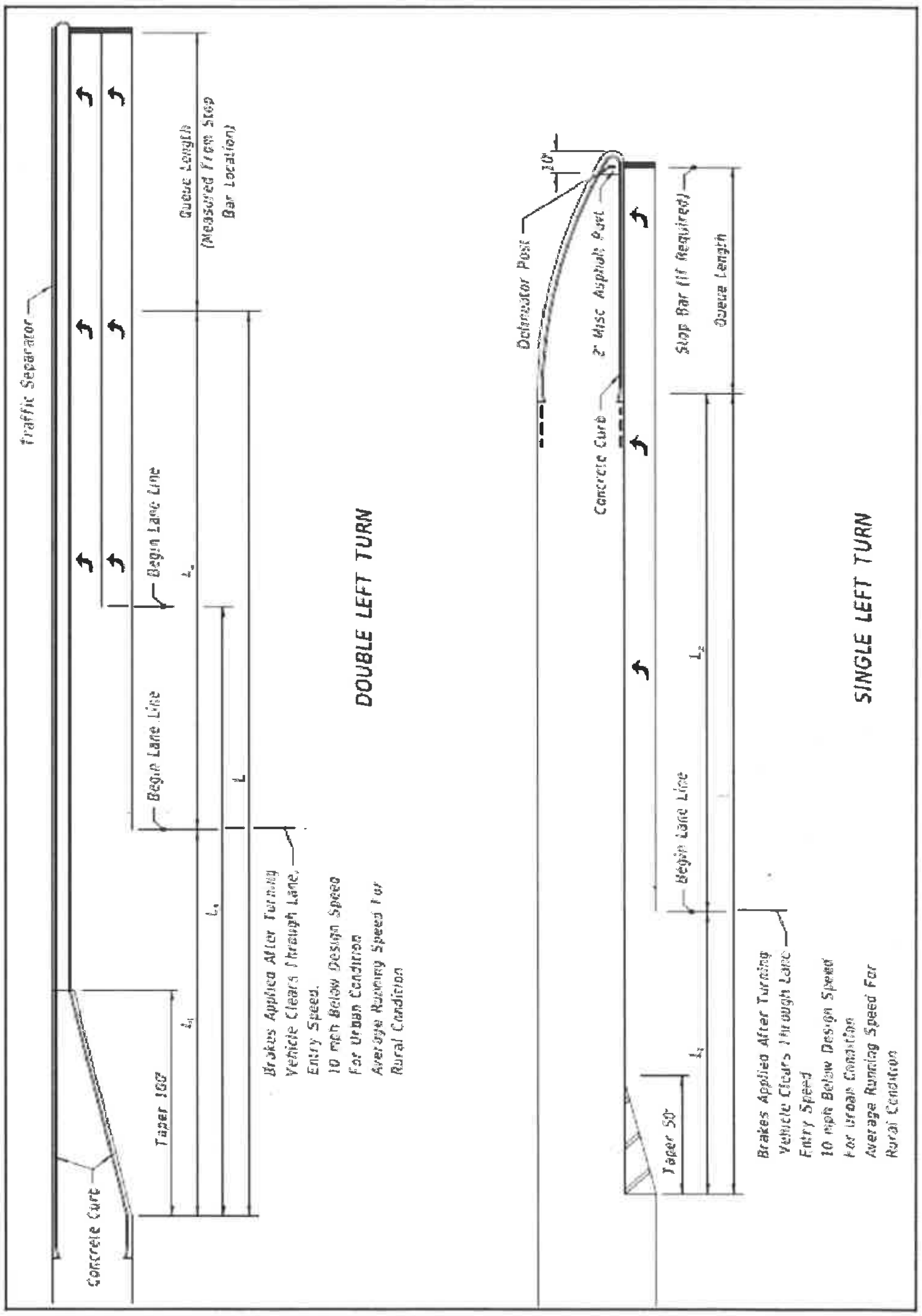


Table 3 – 31 Turn Lanes – Curbed and Uncurbed Medians

Design Speed (mph)	Entry Speed (mph)	Clearance Distance L_1 (feet)	Urban Conditions			Rural Conditions		
			Brake to Stop Distance L_2 (feet)	Total Decel. Distance L (feet)	Clearance Distance L_3 (feet)	Brake to Stop Distance L_2 (feet)	Total Decel. Distance L (feet)	Clearance Distance L_3 (feet)
≤ 30	≤ 25	60	75	135	100			
35	25	70	75	145	110	----	----	----
40	30	80	75	155	120	----	----	----
45	35	85	100	185	135	----	----	----
50	40/44	105	135	240	160	185	290	160
55	48	125	----	----	----	225	350	195
60	52	145	----	----	----	260	405	230
65	55	170	----	----	----	290	460	270

Note: Right turn lane tapers and distances are identical to left turn lanes under stop control conditions. For free flow or yield control conditions, taper lengths and distances are site specific.

C.9.c.4.(c) Lengths of Auxiliary Lanes for Acceleration

Acceleration lanes similar to those used for freeways and expressways are sometimes used at intersections. They are not always desirable at stop-controlled intersections where entering drivers can wait for an opportunity to merge without disrupting through traffic. Acceleration lanes are advantageous on roads without stop control and on all high-volume roads even with stop control where openings between vehicles in the peak-hour traffic streams are infrequent and short. When used, acceleration lanes at intersections should be designed using the criteria provided in Section C.9.c.2 Acceleration Lanes.

C.9.d Turning Roadways at Intersections

The design and construction of turning roadways shall meet the same general requirements for through roadways, except for the specific requirements given in the subsequent sections.

C.9.d.1 Design Speed

Lanes for turning movements at grade intersections may, where justified, be based on a design speed as low as 10 mph. Turning roadways with design speeds in excess of 40 mph shall be designed in accordance with the requirements for through roadways.

A variable design speed may be used to establish cross section and alignment criteria for turning roadways that will experience acceleration and deceleration maneuvers.

C.9.d.2 Horizontal Alignment

- Curvature - The minimum permitted radii (maximum degree) of curvature for various values of superelevation are given in Table 3 – 32 Superelevation Rates for Curves at Intersections. These should be considered as minimum values only and the radius of curvature should be increased wherever feasible. Further information contained in ***AASHTO – "A Policy on Geometric Design of Highways and Streets" - 2011***, should also be considered.

Table 3 – 32 Superelevation Rates for Curves at Intersections

	Design Speed (mph)					
	20	25	30	35	40	45
Minimum Superelevation Rate	0.02	0.04	0.06	0.08	0.09	0.10
Minimum Radius (feet)	90	150	230	310	430	540

The rate of 0.02 is considered the practical minimum for effective drainage across the surface.
Note: Preferably use superelevation rates greater than these minimum values.

- Superelevation Transition - Minimum superelevation transition (runoff) rates (maximum relative gradients) are given in Tables 3 – 33 Maximum Rate of Change in Pavement Edge Elevation for Curves at Intersections and 3 – 34 Maximum Algebraic Difference in Pavement Cross Slope at Turning Roadway Terminals. Other information given in ***AASHTO – "A Policy on Geometric Design of Highways and Streets" - 2011***, should also be considered.

Table 3 – 33 Maximum Rate of Change in Pavement Edge Elevation for Curves at Intersections

Design Speed (mph)	20	25	30	35	40	45	50	55	60	65	70
Maximum relative gradients for profiles between the edge of two lane pavement and the centerline (percent)	0.74	0.70	0.66	0.62	0.58	0.54	0.50	0.47	0.45	0.43	0.40

Table 3 – 34 Maximum Algebraic Difference in Pavement Cross Slope at Turning Roadway Terminals

Design Speed of Exit or Entrance Curve (mph)	Maximum Algebraic Difference in Cross Slope at Crossover Line (percent)
20 and under	5.0 to 8.0
25 and 30	5.0 to 6.0
35 and over	4.0 to 5.0

C.9.d.3 Vertical Alignment

Grades on turning roadways should be as flat as practical and long vertical curves should be used wherever feasible. The length of vertical curves shall be no less than necessary to provide minimum stopping sight distance. Minimum stopping sight distance values are given in Table 3 – 4 Minimum Stopping Sight Distances. For additional guidance on vertical alignment for turning roadways, see ***AASHTO – "A Policy on Geometric Design of Highways and Streets" - 2011***.

C.9.d.4 Cross Section Elements

- Number of Lanes - One-way turning roadways are often limited to a single traffic lane. In this case, the total width of the roadway shall be sufficient to allow traffic to pass a disabled vehicle. Two-way, undivided turning roadways should be avoided. Medians or barriers should be utilized to separate opposing traffic on turning roadways.
- Lane Width - The width of all traffic lanes should be sufficient to accommodate (with adequate clearances) the turning movements of the expected types of vehicles. The minimum required lane widths for turning roadways are given in Table 3 - 35 Derived Pavement Widths for Turning Roadways for Different Design Vehicles. Changes in lane widths should be gradual and should be accomplished in coordination with adequate transitions in horizontal curvature.
- Shoulders - On one-lane turning roadways, serving expressways and other arterials (e.g., loops, ramps), the right hand shoulder should be at least 6 feet wide. The left hand shoulder should be at least 6 feet wide in all cases. On two-lane, one-way roadways, both shoulders should be at least 6 feet wide. Where guardrails or other barriers are used, they should be placed at least 8 feet from edge of travel lane. Guardrails should be placed 2 feet outside the normal shoulder width.

- Clear Zones - Turning roadways should, as a minimum, meet all open highway criteria for clear zones on both sides of the roadway. The areas on the outside of curves should be wider and more gently sloped than the minimum values for open highways. Guardrails or similar barriers shall be used if the minimum width and slope requirements cannot be obtained.

Further criteria and requirements for roadway design are given in ***Chapter 4 - Roadside Design***.

Table 3 – 35 Derived Pavement Widths for Turning Roadways for Different Design Vehicles

Radius on Inner Edge of Pavement, R (feet)	Case 1, One-Lane Operation, No Provision for Passing a Stalled Vehicle												
	P	SU-30	Su-40	City Bus	S-Bus-36	A-Bus	WB-40	WB-62	WB-67	WB-67D	MH	P/T	P/B
50	13	18	21	21	18	22	23	44	57	29	18	19	18
75	13	17	18	19	17	19	20	30	33	23	17	17	17
100	13	16	17	18	16	18	18	25	28	21	16	16	16
150	12	15	16	17	16	17	17	22	23	19	15	16	15
200	12	15	16	16	15	16	16	20	21	18	15	15	15
300	12	15	15	16	15	16	15	18	19	17	15	15	15
400	12	15	15	15	15	15	15	17	18	16	15	15	14
500	12	14	15	15	14	15	15	17	17	16	14	14	14
Target	12	14	14	15	14	15	14	15	15	15	14	14	14

Radius on Inner Edge of Pavement, R (feet)	Case II, One-Lane, One-Way Operation, with Provision for Passing a Stalled Vehicle by Another of the Same Type												
	P	SU-30	40	SU-City Bus	S-Bus-36	A-Bus	WB-40	WB-62	WB-67	WB-MH 67D		P/T	P/B
50	20	30	36	38	31	40	39	81	109	50	30	30	28
75	19	27	30	32	27	34	32	53	59	39	27	27	26
100	18	25	27	30	25	30	29	44	48	34	25	25	24
150	18	23	25	27	23	27	26	36	38	29	23	23	23
200	17	22	24	25	23	26	24	32	34	27	22	22	22
300	17	22	22	24	22	24	23	28	30	25	22	22	21
400	17	21	22	23	21	23	22	26	27	24	21	21	21
500	17	21	21	23	21	23	22	25	26	23	21	21	21
Target	17	20	20	21	20	21	20	21	21	21	20	20	20

Table Continued on Next Page

Radius on Inner Edge of Pavement, R (feet)	Case III, Two-Lane Operation, Either One- or Two-Way (Same Type Vehicle in Both Lanes)												
	P	SU-30	40	SU-City Bus	S-Bus-36	A-Bus	WB-40	WB-62	WB-67	WB-MH 67D		P/T	P/B
50	26	36	42	44	37	46	45	87	115	56	36	36	34
75	25	33	36	38	33	40	38	59	65	45	33	33	32
100	24	31	33	35	31	36	35	50	54	40	31	31	30
150	24	29	31	33	29	33	32	42	44	35	29	29	29
200	23	28	30	31	29	32	30	38	40	33	28	28	28
300	23	28	28	30	28	30	29	34	36	31	28	28	27
400	23	27	28	29	27	29	28	32	33	30	27	27	27
500	23	27	27	29	27	29	28	31	32	29	27	27	27
Target	23	26	26	27	26	27	28	27	27	27	26	26	26

Source – 2011 AASHTO Greenbook, Table 3-28b Derived Pavement Widths for Turning Roadways for Different Design Vehicle

C.9.e At Grade Intersections

C.9.e.1 Turning Radii

Where right turns from through or turn lanes will be negotiated at low speeds (less than 10 mph), the minimum turning capabilities of the vehicle may govern the design. It is desirable that the turning radius and the required lane width be provided in accordance with the criteria for turning roadways. The radius of the inside edge of traveled way should be sufficient to allow the expected vehicles to negotiate the turn without encroaching the shoulder or adjacent traffic lanes.

Where turning roadway criteria are not used, the radius of the inside edge of traveled way should be no less than 25 feet. The use of three-centered compound curves is also a reasonable practice to allow for transition into and out of the curve. The recommended radii and arrangement of compound curves instead of a single simple curve is given in ***AASHTO – "A Policy on Geometric Design of Highways and Streets" - 2011***.

C.9.e.2 Cross Section Correlation

The correlation of the cross section of two intersecting roadways is frequently difficult. A careful analysis should be conducted to ensure changes in slope are not excessive and adequate drainage is provided. At stop-controlled intersections, the through roadway cross section should be carried through the intersection without interruption. Minor roadways should approach the intersection at a slightly reduced elevation so the through roadway cross section is not disturbed. At signalized intersections, it is sometimes necessary to remove part of the crown in order to avoid an undesirable hump in one roadway.

Intersections of grade or cross slope should be gently rounded to improve vehicle operation. Pavement generally should be sloped toward the intersection corners to provide superelevation for turning maneuvers and to promote proper drainage.

Where islands are used for channelization, the width of traffic lanes for turning movements shall be no less than the widths recommended by AASHTO.

C.9.e.3 Median Openings

Median openings should be restricted in accordance with the requirements presented in C.8 Access Control, this chapter. Where a median opening is required, the length of the opening shall be no less than 40 feet. Median curbs should be terminated gradually without the exposure of abrupt curb ends. The termination requirements are given in ***Chapter 4 - Roadside Design***.

C.9.e.4 Channelization

Channelization of at grade intersections is the regulation or separation of conflicting movements into definite travel paths by islands, markings, or other means, to promote safe, orderly traffic flow. The major objective of channelization is to clearly define the appropriate paths of travel and thus assist in the prevention of vehicles deviating excessively or making wrong maneuvers.

Channelization may be used effectively to define the proper path for exits, entrances, and intersection turning movements. The methods used for channelization should be as simple as possible and consistent in nature. The channelized intersection should appear open and natural to the approaching driver. Channelization should be informative rather than restrictive in nature.

The use of low sloping curbs and flush medians and islands can provide adequate delineation in most cases. Islands should be clearly visible and, in general, should not be smaller than 100 square feet in area. The use of small and/or numerous islands should be avoided.

Pavement markings are a useful and effective tool for providing delineation and channelization in an informative rather than restrictive fashion. The layout of all traffic control devices should be closely coordinated with the design of all channelization.

C.9.f Driveways

Direct driveway access within the area of influence of the intersection should be discouraged.

Driveways from major traffic generators (greater than 400 vpd), or those with significant truck/bus traffic, should be designed as normal intersections.

C.9.g Interchanges

The design of interchanges for the intersection of a freeway with a major street or highway, collector/distributor road, or other freeway is a complex problem. The location and spacing of intersections should follow the requirements presented in C.8 Access Control, this chapter. The design of interchanges shall follow the general intersection requirements for deceleration, acceleration, merging maneuvers, turning roadways, and sight distance.