CHAPTER 3

GEOMETRIC DESIGN

TABLES

FIGURES

CHAPTER 3

GEOMETRIC DESIGN

A INTRODUCTION

{General Comments:

1. *Chapter could be reorganized.*
   a. *Could break out (or group) Design Controls into a separate section (or chapter?)*
   b. *Move figures and tables into appropriate sections.*
   c. *Grouping of similar topics (i.e., sidewalk criteria, horizontal clearance criteria…)*
2. *Address minimum standards/criteria for RRR type projects.*
3. *Update Horizontal Clearance / Clear Zone.*
4. *.}*

Geometric design is defined as the design or proportioning of the visible elements of the street or highway. The geometry of the roadway is of central importance since it provides the framework for the design of other highway elements. In addition, the geometric design establishes the basic nature and quality of the vehicle path, which has a primary effect upon the overall safety characteristics of the street or highway.

The design of roadway geometry must be conducted in close coordination with other design elements. These other elements include: pavement design, roadway lighting, traffic control devices, transit, drainage, and structural design. The design should consider safe roadside clear zones, bicycle and pedestrian safetyaccommodation, emergency response, and maintenance capabilities.

The safety characteristics of the design should be given primary consideration. The initial establishment of sufficient right of way and adequate horizontal and vertical alignment is not only essential from a safety standpoint, but also necessary to allow future upgrading and expansion without exorbitant expenditure of highway funds.

The design elements selected should be reasonably uniform but should not be inflexible. More relaxed minimum standard may apply for Traditional Neighborhood Designs. – see Chapter 19. Chapter 19 is intended for use for conditions that encourage pedestrians and bicycles for mixed use development. For this type development, truck traffic should be limited to deliveries within the development with no through truck traffic. Some lane encroachment will be expected during those required deliveries. Transit service will be provided on the perimeter of the development and not penetrate the development.

The minimum standards presented in this chapter should not automatically become the standards for geometric design. The designer should consider use of a higher level, when practical, and consider cost-benefits as well as consistency with adjacent facilities. Reconstruction and maintenance of facilities should, where practical, include upgrading to these minimum standards.[RQ1]

In restricted or unusual conditions, it may not be possible to meet the minimum standards. In such cases, the designer must obtain an exception in accordance with CHAPTER 14 – DESIGN EXCEPTIONS from the reviewing or permitting organization. However, every effort should be made to obtain the best possible alignment, grade, sight distance, and proper drainage consistent with the terrain, the development, safety, and fund availability. ~~The concept of highway users has expanded in recent years creating additional concerns for the designer.~~

In making decisions on the standards to be applied to a particular project, the designer must ~~also now~~ address the needs of pedestrians, transit, bicyclists, elder road users[RQ2], the disabled, and other users. ~~This is true for both urban and rural facilities.~~

The design features of urban local streets are governed by practical limitations to a greater extent than those of similar roads in rural areas. The two dominant design controls are: (1) the type and extent of urban development and its limitations on rights of way and (2) zoning or regulatory restrictions. Some streets primarily are land service streets in residential areas. In such cases, the overriding consideration is to foster a safe and pleasing environment. Other streets are land service only in part, and features of traffic and public transit service may be predominant.

The selection of the type and exact design details of a particular roadway or highway requires considerable study and thought. When reference is made to guidelines and design details given by current American Association of State Highway and Transportation Officials (AASHTO) publications, these guidelines and standards should generally be considered as minimum criteria. For the design of recreational roads, local service roads, and alleys, see AASHTO publications.

Right of way and pavement width requirements[RQ3] for new construction may be reduced for the paving of certain existing unpaved subdivision streets and low volume rural roads provided all of the conditions listed below are satisfied:

- The road is functionally classified as a local road.
- The 20-year projected ADT is less than 750 vehicles per day and the design year projected peak hourly volume is 100 vehicles per hour or less. Note: The design year may be any time within a range of the present to 20 years in the future, depending on the nature of the improvement.
- The road has no foreseeable probability of changing to a higher functional classification through changes in land use, extensions to serve new developing land areas, or any other use which would generate daily or hourly traffic volumes greater than those listed above.
- There is no reasonable possibility of acquiring additional right of way without:
  - Incurring expenditures of public funds in an amount which would be excessive compared to the public benefits achieved
  - Causing substantial damage or disruption to abutting property improvements to a degree that is unacceptable considering the local environment

B OBJECTIVES

The major objective in geometric design is to establish a vehicle path and environment providing a reasonable ~~margin of safety~~accommodation for the motorist, transit, bicyclist, and pedestrian under the expected operating conditions and speed. It is recognized that Florida's design driver is aging and tourism is our major industry. This gives even more emphasis to focus on simplicity and easily understood geometry and roadway features. The achievement of this objective may be realized by meeting certain specific objectives, which include the following:

- Provide the most simple geometry attainable, consistent with the physical constraints
- Provide a design that has a reasonable and consistent ~~margin of safety~~accommodation at the expected operating speed
- Provide a design~~ that is safe at~~with consideration for night and ~~under ~~adverse weather conditions
- Provide a facility that is adequate for the expected traffic conditions and pedestrian, bicyclist and transit needs
- Provide a design that reasonably accommodates a variety of driver characteristics~~Allow for reasonable deficiencies in the driver~~, such as:
  - Periodic inattention
  - Reduced skill and judgment
  - Slow reaction and response
- Provide an environment that minimizes hazards, is as hazard free as practical, and is "forgiving" to a vehicle that has deviated from the travel path or is out of control.

C DESIGN ELEMENTS

C.1 Design Speed

The design speed is defined as a selected rate of travel used to determine the various geometric features of the roadway. The basic purpose in selection of a using the design speed, concept is to achieve consistency in the various design elements that influence vehicle operations. Since many critical design features (e.g., sight distance and curvature) are predicated upon design speed, the selection of the proper value is essential to allow for the safe design of a safe street or highway.

The selection of an appropriate design speed is dependent on the predicted driver behavior and is, therefore, rather complex. This selection of design speed should receive considerable preliminary investigation and thought so safety will be realized from the design.

The primary basis for selecting the design speed should be a rational prediction of the probable maximum operating speed (by approximately 90 percent of the vehicles) on the street or highway. The "average running speed" is not acceptable as a design speed.

In selecting design speeds, consideration should also be given to pedestrians and bicycle usage and to the present and future adjacent land use.

Recommended minimum values for design speed are given in Table 3 - 1. These values should be considered as general guidelines only. The maximum normal operating speed is dependent on many variables including:

- Topography
- General roadway geometry
- Surrounding Adjacent land use
- Degree of aAccess Management
- Frequency of traffic signals or other traffic control devices
- Posted speed limit and the degree of enforcement

The driver does not necessarily adjust speed to the classification of importance (or lack of it) of the street or highway.

The design speed shall not be less than the expected posted or legal speed limit. A design speed 5 mph to 10 mph greater than the posted speed limit will compensate for a slight overrunning of the speed limit by some drivers.

The use of the higher design speed (no speed restrictions) given in Table 3 - 1 is recommended for the following situations:

- Topography allowing or encouraging higher operating speeds
- Roadway geometry permitting high speeds
- Long uninterrupted sections of roadway

The design speed utilized should be consistent over a given section of highway. Required changes in design speed should be effected in a gradual fashion. When isolated reductions in design speed cannot reasonably be avoided, appropriate speed signs should be posted.

{Move Table Here}

C.2 Design Vehicles

A "design vehicle" is a selected motor vehicle whose weight, dimensions, and operating characteristics are used to establish highway design controls to accommodate vehicles of a designated type. For the purpose of geometric design, the design vehicle should be one with dimensions and minimum turning radii larger than those of almost all vehicles in its class. Design vehicles are listed in Table 3 - 2. One or more of these vehicles should be used as a control in the selection of geometric design elements. In certain industrial (or other) areas, special service vehicles may have to be considered in the design. Fire equipment and emergency vehicles should have reasonable access to all areas.

If a significant number or percentage (5 percent of all the total traffic) of vehicles of those classes larger than passenger vehicles are likely to use a particular street or highway, that class should be used as a design control. The design of major arterial streets and highways should normally be adequate to accommodate all design vehicles. The decision as to which of the design vehicles (or other special vehicles) should be used as a control is complex and requires careful study. Each situation must be evaluated individually to arrive at a reasonable estimate of the type and volume of expected traffic. *{Reference to AASHTO for more info on Design Vehicles.}*

- Design criteria significantly affected by the type of vehicle include:
- Horizontal and vertical clearances
- Alignment
- Lane widening on curves
- Shoulder width requirements
- Turning roadway and intersection radii
- Intersection sight distance
- Acceleration criteria

Particular care should be taken in establishing the radii at intersections, so vehicles may enter the street or highway without encroaching on adjacent travel lanes or leaving the pavement. It is acceptable for occasional trucks or buses to make use of both receiving lanes, especially on side streets.

C.3 Sight Distance

The provision for adequate horizontal and vertical sight distance is an essential factor in the development of a safe street or highway. An unobstructed view of the upcoming roadway is necessary to allow time and space for the safe execution of passing, stopping, intersection movements, and other normal and emergency maneuvers. It is also important to provide as great a sight distance as possible to allow the driver time to plan for future actions. The driver is continuously required to execute normal slowing, turning, and acceleration maneuvers. If a driver~~he~~ can plan in advance for these actions, traffic flow will be smoother and less hazardous. Unexpected emergency maneuvers will also be less hazardous if they are not combined with uncertainty regarding the required normal maneuvers. The appropriate use of lighting (CHAPTER 6 - ROADWAY LIGHTING) may be required to provide adequate sight distances for night driving.

Future obstruction to sight distance that may develop (e.g., vegetation) or be constructed should be taken into consideration in the initial design. Areas outside of the highway right of way that are not under the highway agency's jurisdiction should be considered as points of obstruction. Planned future construction of median barriers, guardrails, grade separations, or other structures should also be considered as possible sight obstructions.

C.3.a Stopping Sight Distance

Safe stopping sight distances shall be provided continuously on all streets and highways. The factors, which determine the minimum distance required to stop, include:

- Vehicle speed
- Driver's total reaction time
- Characteristics and conditions of the vehicle
- Friction capabilities between the tires and the roadway surface
- Vertical and horizontal alignment of the roadway

It is desirable that the driver be given sufficient sight distance to avoid an object or slow moving vehicle with a natural, smooth maneuver rather than an extreme or panic reaction.

The determination of available stopping sight distance shall be based on:

- a height of the driver's eye equal to 3.50 feet and
- a height of obstruction to be avoided equal to 0.50 feet.

It would, of course, be desirable to use a height of obstruction equal to zero (coincident with the roadway surface) to provide the driver with a more positive sight condition. Where horizontal sight distance may be obstructed on curves, the driver's eye and the obstruction shall be assumed to be located at the centerline of the travel lane on the inside of the curve.

The stopping sight distance shall be no less than the values given in Table 3 - 6.

C.3.b Passing Sight Distance

The passing maneuver, which requires occupation of the opposing travel lane, is inherently dangerous. The driver is required to make simultaneous estimates of time, distance, relative speeds, and vehicle capabilities. Errors in these estimates could result in frequent and serious crashes.

Highways with two or more travel lanes in a given direction are not subject to requirements for safe passing sight distance. Two-lane, two-way highways should be provided with safe passing sight distance for as much of the highway as feasible. The driver demand for passing opportunity is high and serious limitations on the opportunity for passing reduces the capacity and safe characteristics of the highway.

The distance traveled after the driver's final decision to pass (while encroaching into the opposite travel path) is that which is required to pass and return to the original travel lane in front of the overtaken vehicle. In addition to this distance, the safe passing sight distance must include the distance traveled by an opposing vehicle during this time period, as well as a reasonable margin of safety. Due to the many variables in vehicle characteristics and driver behavior, the passing sight distance should be as long as is practicable.

~~The determination of passing sight distance shall be based on a height of eye equal to 3.50 feet and a height of object passing equal to 3.50 feet.~~ Where passing is permitted, the passing sight distance shall be no less than the values given in Table 3 - 6.

The determination of passing sight distance shall be based on:

- -a height of eye equal to 3.50 feet
- ~~and~~ a height of object passing equal to 3.50 feet.

C.3.c Sight Distance at Decision Points

It is desirable to provide sight distances exceeding the minimum at changes in geometry, approaches to intersections, entrances and exits, and other potential decision points or hazards. The sight distance should be adequate to allow the driver sufficient time to observe the upcoming situation, make the proper decision, and take the appropriate action in a normal manner.

Minimum stopping distance does not provide sufficient space or time for the driver to make decisions regarding complex situations requiring more than simple perception-reaction process. In many cases, rapid stopping or lane changing may be extremely undesirable and cause hazardous maneuvers (i.e., in heavy traffic conditions); therefore, it would be preferable to provide sufficient sight distance to allow for a more gradual reaction.

The sight distance on a freeway preceding the approach nose of an exit ramp should exceed the minimum by 25 percent or more. A minimum sight distance of 1000 feet, measured from the driver's eye to the road surface is a desirable goal. There should be a clear view of the exit terminal including the exit nose.

C.3.d Intersection Sight Distance

Sight distances for intersection movements are given in the general intersection requirements (C.9 Intersection Design, this chapter).

C.4 Horizontal Alignment

C.4.a General Criteria

The standard of alignment selected for a particular section of highway should extend throughout the section with no sudden changes from easy to sharp curvature. Where sharper curvature is unavoidable, a sequence of curves of increasing degree should be utilized.

Winding alignment consisting of sharp curves is hazardous, reduces capacity, and should be avoided. The use of as flat a curve as possible is recommended. Flatter curves are not only less hazardous, but also frequently less costly due to the shortened roadway.

Maximum curvature should not be used in the following locations:

- High fills or elevated structures. The lack of surrounding objects reduces the driver's perception of the roadway alignment.
- At or near a crest in grade
- At or near a low point in a sag or grade
- At the end of long tangents

- At or near intersections, transit stops, or points of ingress or egress
- At or near other decision points

The "broken back" arrangement of curves (short tangent between two curves in the same direction) should be avoided. This is acceptable only at design speeds of 30 mph or less. This arrangement produces an unexpected and hazardous situation.

When reversals in alignment are used and superelevation is required, a sufficient length of tangent between the reverse curves is required for adequate superelevation transition.

Compound curves should be avoided, especially when curves are sharp. They tend to produce erratic and dangerous vehicle operations. When compound curves are necessary, the radius of the flatter curve should not be more than 50 percent greater than the sharper curve.

The transition between tangents and curves should normally be accomplished by the use of appropriate straight-line transitions or spirals. This is essential to assist the driver in maintaining his vehicle in the proper travel path.

For small deflection angles, curves should be suitably lengthened to avoid the distracting appearance of a kink. Curves should be at least 900 feet long for a central angle of 1 degree or 500 feet long for a central angle of 5 degrees. Gently flowing alignment is generally more pleasing in appearance, as well as, superior from a safety standpoint.

{Note: Consider adding maximum deflection without Horizontal Curve Table similar to PPM.}

C.4.b Superelevation

In the design of highway curves, it is necessary to establish a proper relationship between curvature of the roadway and design speed. The use of superelevation (rotation of the roadway about its axis) is employed to counteract centrifugal force and allow drivers to comfortably and safely travel through curves at the design speed.

The superelevation rates for rural highways, urban freeways, and high speed urban arterials are shown in Figure 3 - 1. These rates are based on a maximum rate of 0.10 foot per foot of roadway width (10%). Additional superelevation details, given in the Department's Design Standards, may be considered.

The superelevation rates recommended for urban highways are shown in Figure 3 -2. These rates are based on a maximum superelevation rate of 0.05 foot per foot of roadway width (5%) and are recommended for major streets in built up areas. Additional information regarding superelevation, given in the Department's Design Standards, and AASHTO – "A Policy on Geometric Design of Highways and Streets" -20041, may be considered.

Although superelevation is advantageous for traffic operations, various factors combine to make its use impractical in many built-up areas. Such factors include:

- Wide pavement areas
- Need to meet grade of adjacent property
- Surface drainage considerations
- Frequency of cross streets, alleys, and driveways

Therefore, horizontal curves on lower speed streets in subdivision and urban areas are usually designed without superelevation, only side friction being used to counteract the centrifugal force. Figure 3 - 2 may be used for determination of the maximum safe speed for horizontal curves on lower speed urban streets.

C.4.c Curvature

Where a directional change in alignment is required, every effort should be made to utilize the smallest degree (largest radius) curvature possible. The use of the maximum degree of curvature should be avoided when possible. Design speed maximum degree of curvature relationships are given in Table 3 - 3. The use of sharper curvature for the design speeds shown in Table 3 - 3 would call for superelevation beyond the limit considered practical or for operation with tire friction beyond safe or comfortable limits or both. The maximum degree of curvature is a significant value in alignment design.

C.4.d Superelevation Transition (superelevation runoffs plus tangent runoff)

Superelevation runoff is the general term denoting the length of highway needed to accomplish the change in cross slope from a section with the adverse crown removed (level) fully superelevated section, or vice versa. Tangent runoff is the general term denoting the length of highway needed to accomplish the change in cross slope from a normal cross section to a section with the adverse crown removed, or vice versa. Spiral curves can be used to transition from the tangent to the curve. Where the spiral curve is employed, its length is used to make the entire superelevation transition.

The Department's Design Standards show in detail superelevation transitions for various sections and methods for determining length of transition.

C.4.e Lane Widening on Curves

The travel lane should be widened on sharp curves due to the increased difficulty for the driver to follow the proper path. Trucks and transit vehicles experience additional difficulty due to the fact that the rear wheels may track considerably inside the front wheels thus requiring additional width. Adjustments to lane widths for mainline and turning roadways are given in Tables 3 - 20A and 3 - 20B. A transition length shall be introduced in changing to an increased/decreased lane width. This transition length shall be proportional to the increase/decrease in pavement width in a ratio of not less than 50 feet of transition length for each foot of change in lane width.

C.5 Vertical Alignment

C.5.a General Criteria

The selection of vertical alignment should be predicated to a large extent upon the following criteria:

- Obtaining maximum sight distances
- Limiting speed differences (particularly for trucks and buses) by reducing magnitude and length of grades
- A "hidden dip" which would not be apparent to the driver must be avoided.
- Steep grades and sharp crest vertical curves should be avoided at or near intersections.
- Flat grades and long gentle vertical curves should be used whenever possible.

C.5.b Grades

The grades selected for vertical alignment should be as flat as practical, and should not be greater than the value given in Table 3 - 4.

Recommended minimum gutter grades:

Rolling terrain - 0.5% Flat terrain - 0.3%

For streets and highways requiring long upgrades, the maximum grade should be reduced so the speed reduction of slow-moving vehicles (e.g., trucks and buses) is not greater than 10 mph. The critical lengths of grade for these speed reductions are shown in Figure 3 - 3. Where reduction of grade is not practical, climbing lanes should be provided to meet these speed reduction limitations.

C.5.b.1 Climbing Lanes

The criteria for a climbing lane and the adjacent shoulder are the same as for any travel lane except that the climbing lane should be clearly designated by the appropriate pavement markings. Entrance to and exit from the climbing lane shall follow the same criteria as other merging traffic lanes; however, the climbing lane should not be terminated until well beyond the crest of the vertical curve. Differences in superelevation should not be sufficient to produce a change in pavement cross slope between the climbing lane and through lane in excess of 0.04 feet per foot.

~~Recommended minimum gutter grades:~~

~~Rolling terrain - 0.5% Flat terrain - 0.3%~~

C.5.c Vertical Curves

Changes in grade should be connected by a parabolic curve (the vertical offset being proportional to the square of the horizontal distance). Vertical curves are required when the algebraic difference of intersecting grades exceeds the values given in Table 3 - 5. The length of vertical curve on a crest, as governed by stopping sight distance, is obtained from Figure 3 - 4. The minimum length of a crest vertical curve to obtain minimum passing sight distance is given in Figure 3 - 5. The minimum length of a sag vertical curve, as governed by vehicle headlight capabilities, is obtained from Figure 3 - 6.

Wherever feasible, curves longer than the minimum should be considered to improve both aesthetic and safety characteristics.

C.6 Alignment Coordination

Horizontal and vertical alignment should not be designed independently. Poor combinations can spoil the good points of a design. Properly coordinated horizontal and vertical alignment can improve appearance, enhance community values, increase safety, and encourage uniform speed. Coordination of horizontal and vertical alignment should begin with preliminary design, during which stage adjustments can be readily made.

Proper combinations of horizontal alignment and profile can be obtained by engineering study and consideration of the following general controls:

- Curvature and grades should be in proper balance. Tangent alignment or flat curvature with steep grades and excessive curvature with flat grades are both poor design. A logical design is a compromise between the two conditions. Wherever feasible the roadway should "roll with" rather than "buck" the terrain.

- Vertical curvature superimposed on horizontal curvature, or vice versa, generally results in a more pleasing facility, but it should be analyzed for effect on driver's view and operation. Changes in profile not in combination with horizontal alignment may result in a series of disconnected humps to the driver for some distance.
- Sharp horizontal curvature should not be introduced at or near the top of a pronounced crest vertical curve. Drivers cannot perceive the horizontal change in alignment, especially at night. This condition can be avoided by setting the horizontal curve so it leads the vertical curve or by making the horizontal curve longer. Suitable design can be made by using design values well above the minimums.
- Sharp horizontal curvature should not be introduced at or near the low point of a pronounced sag vertical curve to prevent an undesirable distorted appearance. Vehicle speeds are often high at the bottom of grades and erratic operation may result, especially at night.
- On divided highways, variation of the median width and the use of independent vertical and horizontal alignment should be considered. Where right of way is available, a superior design without significant additional costs can result from the use of independent alignment.
- Horizontal alignment and profile should be made as flat as possible at interchanges and intersections where sight distance along both highways is important. Sight distances above the minimum are desirable at these locations.
- Alignment should be designed to enhance scenic views for the motorists.
- In residential areas, the alignment should be designed to minimize nuisance to the neighborhood.

C.7 Cross Section Elements

The design of the highway cross section should be predicated upon the design speed, terrain, adjacent land use, classification, and the type and volume of traffic expected. The cross section selected should be uniform throughout a given length of street or highway without frequent or abrupt changes.

C.7.a Number of Lanes

The number of travel lanes is determined by ~~several interrelated~~ factors such as capacity, level of service, and service volume. ~~(~~For additional information, refer to AASHTO "A Policy on Geometric Design of Highways and Streets" ~~–~~ 2004~~latest edition~~, and the ~~current~~ Highway Capacity Manual.~~)~~

C.7.b Pavement

The paved surface of all travel lanes shall be designed and constructed in accordance with the requirements set forth in CHAPTER 5 - PAVEMENT DESIGN AND CONSTRUCTION.

C.7.b.1 Pavement Width

Traffic lanes should be 12 feet in width, but shall not be less than 10 feet in width. Streets and highways with significant truck/bus traffic should have 12 feet wide traffic lanes. For minimum lane widths, see Table 3 - 7 and Table 3 - 8. If additional lane width is required for bicycles, see CHAPTER 9 – BICYCLE FACILITIES.

C.7.b.2 Pavement Cross Slope (not in superelevation)

The selection of pavement cross slope should be a compromise between meeting the drainage requirements and providing for smooth vehicle operation. The recommended pavement cross slope is 0.02 feet per foot. When three lanes in each direction are necessary, the outside lane should have a cross slope of 0.03 feet per foot. The cross slope shall not be less than 0.015 feet per foot or greater than 0.04 feet per foot. The change in cross slope between adjacent through travel lanes should not exceed 0.04 feet per foot.

C.7.c Shoulders

The primary functions of a shoulder are to provide emergency parking for disabled vehicles and an alternate path for vehicles during avoidance or other emergency maneuvers. In order to fulfill these functions satisfactorily, the shoulder should have adequate stability and surface characteristics. The design and construction of shoulders shall be in accordance with the requirements given in CHAPTER 5 - PAVEMENT DESIGN AND CONSTRUCTION.

Shoulders should be provided on all streets and highways incorporating open drainage. The absence of a contiguous emergency travel or storage lane is not only undesirable from a safety standpoint, but also is disadvantageous from an operations viewpoint. Disabled vehicles that must stop in a through lane impose a severe safety hazard and produce a dramatic reduction in traffic flow. Shoulders should be free of abrupt changes in slope, discontinuities, soft ground, or other hazards that would prevent the driver from retaining or regaining vehicle control.

Paved shoulders are recommended for added safety to the motorist, public transit and pedestrians, for accommodation of bicyclists, reduced shoulder maintenance costs, and improved drainage.

C.7.c.1 Shoulder Width

Since the function of the shoulders is to provide an emergency storage or travel path, the desirable width of all shoulders should be at least 10 feet. Where economic or practical constraints are severe, it is permissible, but not desirable, to reduce the shoulder width. Outside shoulders shall be provided on all streets and highways with open drainage and should be at least 6 feet wide. Facilities with a heavy traffic volume or a significant volume of truck traffic SHOULD have outside shoulders at least 8 feet wide. The width of outside shoulders for two-lane, two-way shoulders shall not be less than the values given in Table 3 - 8.

Median shoulders are desirable on all multi-lane, non-curb and gutter divided streets and highways. For shoulder widths on multi-lane divided highways see Table 3 - 9.

C.7.c.2 Shoulder Cross Slope

The shoulder serves as a continuation of the drainage system, therefore, the shoulder cross slope should be somewhat greater than the adjacent travel lane. The cross slope of shoulders shall not be less than 0.03 feet per foot or greater than 0.08 feet per foot. For local subdivision type streets, a maximum cross slope of 0.12 feet per foot may be used.

Whenever possible, shoulders should be sloped away from the traffic lanes to aid in their drainage. The combination of shoulder cross slope and texture should be sufficient to promote rapid drainage and to avoid retention of surface water. The change in cross slope between a traffic lane and adjacent shoulder should not be greater than 0.07 feet per foot, except on local subdivision streets where the change in cross slope should not exceed 0.10 feet per foot. Shoulders on the outside of superelevated curves should be rounded (vertical curve) to avoid an excessive break in cross slope and to divert a portion of the drainage away from the adjacent travel lanes.

C.7.d Sidewalks

The design of sidewalks is affected by many factors, including, but not limited to, pedestrian volume, roadway type, characteristics of vehicular traffic, and other design elements. CHAPTER 8 - PEDESTRIAN FACILITIES of this Manual and the AASHTO – "A Policy on Geometric Design of Highways and Streets," present the various factors that influence the design of sidewalks and other pedestrian facilities.

Sidewalks should be constructed in conjunction with new construction and major reconstruction in an urban area. As a general rule, sidewalks should be constructed on both sides of the roadway. Exceptions may be made where physical barriers (e.g., a canal paralleling one side of the roadway) would substantially reduce the expectation of pedestrian use of one side of the roadway. Also, if only one side is possible, sidewalks should be used in the same side of the road as such features as transit stops or other pedestrian generators.

The decision to construct a sidewalk in a rural area should be based on engineering judgment, after observation of existing pedestrian traffic and expectation of additional demand, should a sidewalk be made available.

The standard width of a sidewalk should be 5 feet when separated from the back of curb by a buffer strip. A 4-foot sidewalk may be considered when physical constraints exist and where necessary right of way is unavailable or prohibitively expensive. Where practical, a 1-foot level area should be provided adjacent to the outside of the sidewalk. Edge drop-offs should be avoided or shielded.

When sidewalks must be constructed adjacent to the curb, the minimum width should be 6 feet. Sidewalks should be constructed as defined in this Manual - CHAPTER 8 - PEDESTRIAN FACILITIES. In areas of high use, refer to Chapter 18 of the Highway Capacity Manual for calculation of appropriate width. As noted in the Department's Bicycle Facilities Planning and Design Handbook, excessively wide sidewalks may not necessarily add to pedestrian and bicycle safety. Wide sidewalks may encourage higher speed bicycle use and can increase the potential for conflict with motor vehicles at intersections and driveways, as well as with pedestrians and fixed objects.

The mMaximum sidewalk cross slope shall be 2%, and longitudinal grades shall not exceed 8.33% (1:12). Level landings (5-foot x 5-foot) are required on grades between 5% and 8.33% when the overall change in grade exceeds 30 inches. Handrails are required on all grades greater than 5%.

Curb ramps shall be provided at all intersections (Section 336.045 (3), Florida Statutes). For additional details, refer to the current Americans with Disabilities Act (ADA) Accessibility Guidelines (as described in the Federal Register), and the Florida Accessibility Code For Building Construction (Rule 9B-7.0042).

C.7.e Medians

Median separation of opposing traffic lanes provides a beneficial safety feature and should be used wherever feasible. Separation of the opposing traffic also reduces the problem of headlight glare, thus improving safety and comfort for night driving. When sufficient width of medians is available, some landscaping is also possible if adequate intersection sight distance can be provided (See Section C.9).

The use of medians often aids in the provision of drainage for the roadway surface, particularly for highways with six or more traffic lanes. The median also provides a vehicle refuge area, improves the safety of pedestrian crossings, provides a logical location for left turn storage lanes, and provides the means for future addition of traffic lanes and mass transit. In many situations, the median strip aids in roadway delineation and the overall highway aesthetics.

Median separation is required on the following streets and highways:

- Freeways
- All streets and highways, rural and urban, with 4 or more travel lanes and with a design speed of 40 mph or greater[RQ4]

Median separation is desirable on all other multi-lane roadways to enhance pedestrian crossings.

The nature and degree of median separation required is dependent upon the design speed, traffic volume, adjacent land use, and the frequency of access. ~~There are basically two approaches to median separation. The first is the use of horizontal separation of opposing lanes to reduce the probability of vehicles crossing the median into incoming traffic. The second method is to attempt to limit crossovers by introducing a positive median barrier structure.~~[RQ5]

In rural areas, the use of wide medians is not only aesthetically pleasing, but is often more economical than barriers. In urban areas where space and/or economic constraints are severe, the use of barriers is permitted to fulfill the requirements for median separation.[RQ6]

Uncurbed medians should be free of abrupt changes in slope, discontinuities, soft ground, or other hazards that would prevent the driver from retaining or regaining control of the vehicle. Consideration should be given to increasing the width and decreasing the slope of medians on horizontal curves. The requirements for a hazard free median environment are given in CHAPTER 4 - ROADSIDE DESIGN, and shall be followed in the design and construction of medians.

C.7.e.1 Type of Median

A wide, gently depressed median is the preferred design. This type allows a reasonable vehicle recovery area and aids in the drainage of the adjacent shoulders and travel lanes. Where space and drainage limitations are severe, narrower medians, flush with the roadway, or raised medians, are permitted. Raised medians should be used to support pedestrian crossings of multi-laned highways.

C.7.e.2 Median Width

The median width is defined as the horizontal distance between the inside pavement edges of the opposing roadways. The selection of the median width for a given type of roadway is primarily dependent on design speed and traffic volume. Since the probability of crossover crashes is decreased by increasing the separation, medians should be as wide as practicable. Median widths in excess of 30 feet to 35 feet reduce the problem of disabling headlight glare from opposing traffic.

The minimum permitted widths of freeway medians are given in Table 3 - 10. Where the expected traffic volume is heavy, the widths should be increased over these minimum values. Median barriers shall be used on freeways when these minimum values are not attainable.

The minimum permitted median widths for multi-lane rural highways are given in Table 3 - 11. On urban streets, the median widths shall not be less than the values given in Table 3 - 11. Where median openings or access points are frequent, the median width should be increased.

The minimum median widths given in these Tables may have to be increased to meet the requirements for cross slopes, drainage, and turning movements (C.9 Intersection Design, this chapter). The median area should also include adequate additional width to allow for expected additions of through lanes and left turn storage lanes. Where the median width is sufficient to produce essentially two separate, independent roadways, the left side of each roadway shall meet the requirements for roadside clear zone. Changes in the median width should be accomplished by gently flowing horizontal alignment of one or both of the separate roadways.

C.7.e.3 Median Slopes

A vehicle should be able to transverse a median without turning over and with sufficient smoothness to allow the driver a reasonable chance to control the vehicle. The transition between the median slope and the shoulder (or pavement) slope should be smooth, gently rounded, and free from discontinuities.

The median cross slope should not be steeper than1:6 (preferably not steeper than 1:10). The depth of depressed medians may be controlled by drainage requirements. Increasing the width of the median, rather than increasing the cross slope, is the proper method for developing the required median depth.

Longitudinal slopes (median profile parallel to the roadway) should be shallow and gently rounded at intersections of grade. The longitudinal slope, relative to the roadway slope, shall not exceed a ratio of 1:10 and preferably 1:20. The change in longitudinal slope shall not exceed 1:8 (change in grade of 12.5 %).

C.7.e.4 Median Barriers

The primary objective for placing a barrier structure in the median is to prevent vehicles from entering the opposing traffic stream, either accidentally or intentionally. Median barriers may also be used to reduce the glare produced by oncoming vehicle headlights. When selecting the type of barrier, care should be exercised to avoid headlight flicker through barriers.

The use of median barriers to reduce horizontal separation is permitted on facilities with substantially full control of access. Frequent openings in the barrier for intersections or crossovers expose the barrier end, which constitute severe hazard at locations with an inherently high crash potential and should be shielded. Median barriers may be considered for urban freeways and major arterials with controlled access.

Median barriers shall be used on controlled access facilities if the median width is less than the minimum permitted values given in Table 3 - 10. The median barrier should not be placed closer than 10 feet from the inside pavement edge. Further requirements for median barriers are given in CHAPTER 4 - ROADSIDE DESIGN.

C.7.f Horizontal ClearanceRoadside Clear Zone

Horizontal clearance is the lateral distance from a specified point on the roadway such as the edge of travel lane or face of curb, to a roadside feature or object. Horizontal clearance applies to all roadways. Horizontal clearance requirements vary depending on design speed, whether rural or urban with curb, traffic volumes, lane type, and the object or feature.

Rural roadways with flush shoulders and roadways with curb or curb and gutter where right of way is not restricted have roadsides of sufficient widths to provide clear zones; therefore, horizontal clearance requirements for certain features and objects are based on maintaining a clear zone wide enough to provide the recoverable terrain in ***Table 3-12A***.

In urban areas, horizontal clearance based on clear zone requirements for rural roadways should be provided wherever practical. However, urban areas are typically characterized with lower speed, more dense abutting development, closer spaced intersections and accesses to property, higher traffic volumes, more bicyclists and pedestrians, and restricted right of way. In these areas, curb with closed drainage systems are often used to minimize the amount of right of way needed. Roadways with curb or curb and gutter in urban areas where right of way is restricted do not have roadsides of sufficient widths to provide clear zones; therefore, while there are specific horizontal clearance requirements for these roadways, they are based on clearances for normal operation and not based on maintaining a clear roadside for errant vehicles. These horizontal clearance requirements are shown in ***Table 3-12B***. These horizontal clearance requirements can only be applied if all of the following restricting conditions are met:

It should be noted that curb has no redirectional capabilities except at speeds less than the lowest design speeds used on the State Highway System. Therefore curb should not be considered effective in shielding a hazard. Curb is not to be used to reduce horizontal clearance requirements.

Crashworthy objects shall meet or exceed the offsets listed in either ***Table 3-12A*** or ***Table 3-12B*** depending on the condition. Objects that are not crashworthy are to be as close to the right of way as practical and no closer than the requirements listed in ***Table 3-12A*** and ***Table 3-12B.***

C.7.f.1 Roadside Clear Zone

The roadside clear zone is that area outside the traveled way available for use by errant vehicles. Vehicles frequently leave the traveled way during avoidance maneuvers, due to loss of control by the driver (e.g., falling asleep) or due to collisions with other vehicles. The primary function of the clear zone is to allow space and time for the driver to retain control of his vehicle and avoid or reduce the consequences of collision with roadside objects. This area also serves as an emergency refuge location for disabled vehicles.

The design of the roadway must also provide for adequate drainage of the roadway. Drainage swales within the clear zone should be gently rounded and free of discontinuities. Where large volumes of water must be carried, the approach should be to provide wide, rather than deep drainage channels. Side slopes and drainage swales that lie within the clear zone should be free of protruding drainage structures (CHAPTER 4 - ROADSIDE DESIGN, D.6.c. Culverts).

In the design of the roadside, the designer should consider the consequences of a vehicle leaving the traveled way at any location. It should always be the policy that protection of vehicles and occupants shall take priority over the protection of roadside objects. Further criteria and requirements for safe roadside design are given in CHAPTER 4 - ROADSIDE DESIGN.

C.7.f.21 Roadside Clear Zone Width

The clear zone width is defined as follows:

- Rural sections - measured from the edge of the outside motor vehicular travel way
- Urban sections - measured from the face of the curb

The clear zone must be wide enough so that the sum of all the recoverable terrain within is equal to or greater than the recoverable terrain value obtained in the appropriate ***Table 3-12A or Table 3-12B***. These are minimum values only and should be increased wherever practical. The process for determining the clear zone width is to extend the clear zone width as shown in ***Figure 3-14*** and ***Figure 3-15*** until the recoverable terrain is obtained. If non-recoverable terrain is encountered before obtaining the full amount of recoverable terrain, then the remaining amount must be provided beyond the non-recoverable terrain. Where right of way permits, the portion of recoverable terrain provided beyond the non-recoverable terrain must be a minimum of 10 feet. The clear zone is to be free of hazardous objects, hazardous terrain, and non-traversable terrain. Also, clear zones may be widened based on crash history.

~~The minimum permitted widths are provided in Table 3 - 12. These are minimum values only and should be increased wherever practical.~~

In rural areas, it is desirable, and frequently economically feasible, to increase the width of the clear zone. Where traffic volumes and speeds are high, the width should be increased. The clear zone on the outside of horizontal curves should be increased due to the possibility of vehicles leaving the roadway at a steeper angle.

C.7.f.3~~2~~ Roadside Slopes

The slopes of all roadsides should be as flat as possible to allow for safe traversal by out of control vehicles. A slope of 1:4 or flatter should be used. The transition between the shoulder and adjacent side slope should be rounded and free from discontinuities. The adjacent side slope, within the clear zone, shall not be steeper than 1:3. The side slopes should be reduced flatter on the outside of horizontal curves.

Where roadside ditches or cuts require backslope, these slopes should not exceed 1:3 in steepness within the clear zone. The desirable backslope is 1:4. Ditch bottoms should be at least 4 feet wide and can be flat or gently rounded.

C.7.f.4~~3~~ Criteria for Guardrail

If space and economic constraints are severe, it is permissible, but not desirable, to use guardrails in lieu of the requirements for width and slope of clear zone. Where the previously described requirements for clear zone are not met, guardrails (or other longitudinal barriers) should be considered. Guardrails should also be considered for protection of pedestrian pathways or protection from immovable roadside hazards.

The general policy to be followed is that guardrails should be used if impact with the guardrail is less likely or considered less severe than impact with roadside objects. Further requirements and design criteria for guardrails are given in CHAPTER 4 - ROADSIDE DESIGN.

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. Curbs with nearly vertical faces are used along the outside edge of the roadway to discourage vehicles from leaving the roadway. In Florida, the standard curb of this type is 6 inches in height. These curbs are not to be used on facilities with design speeds greater than 45 mph.

C.7.h Parking

On-street parking generally 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.

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.

~~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

{Could Border width be discussed here? Some suggested widths?}

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:

- ~~Allow d~~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 or other objects beyond the clear zone.

- ~~Allow~~ T~~t~~he layout of safe intersections, interchanges, and other access points.

- ~~Allow~~ A~~a~~dequate sight distance at all points, particularly on horizontal curves, at an intersection, and other access points.

- ~~Allow,~~ W~~w~~here appropriate, transit bus bays, additional buffer zones to improve roadside safety, noise attenuation, and the overall aesthetics of the street or highway.

- ~~Allow~~ A~~a~~dequate space for placement of pedestrian and bicycle facilities, including curb ramps, storage turning areas, and transit shelters, where applicable.

- ~~Allow for~~ Adequate space 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~~ T~~t~~reatment of stormwater runoff.

- ~~Allow~~ C~~c~~onstruction of future grade separations or other intersection improvements at selected crossroads.

- ~~Allow c~~Corner cuts for upstream corner crossing drainage systems and placement of poles, boxes, and other visual screens out of the critical sight triangle.

- ~~Allow~~ L~~l~~andscaping and/or 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 250, 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 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 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.

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

C.7.j.3 Special Use Lanes

To increase the efficiency and separation of different vehicle movements, special 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.

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 - 9. The designer should evaluate the economic practicality of utilizing dual versus single bridges for roadway sections incorporating wide medians.

[RQ7]

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[RQ8] 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 2½ 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 mountable curb with a gently sloped traffic face. See CHAPTER 17 – BRIDGES AND OTHER STRUCTURES for additional requirements.

C.7.j.4.(a) Horizontal Clearance

Supports for bridges, barriers, or other structures should be placed at or beyond the required shoulder.[RQ9] Where possible, these structures should be located outside of the required clear zone.[RQ10]

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

Vertical clearance should be adequate for the type of expected traffic. Freeways and major arterials shall have a vertical clearance of at least 16 feet. 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. [RQ11] Provision for additional clearance (3 inches to 6 inches) is recommended to allow for future resurfacing.

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

{Should this be moved into chapter 1 and combined with B.2 or combined with Section c.9 and made into it's own chapter?}

{Do we need to add some suggested access management criteria for roads other than limited access?(i.e., local roads, collectors, arterials, etc.)}

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.

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 in accordance with Section C.3 of this chapter.

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

Driveways should not be placed near 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 or minimize conflict points 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.[RQ12]

The use of a frontage road or other auxiliary roadways is recommended on minor 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 orand 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 Turn 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.

~~Acceleration lanes are desirable for entrance maneuvers onto high-speed streets and highways.~~

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 major 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.

[RQ13]C.8.b.6 Roundabouts

Roundabouts are another tool for the designer to consider in intersection design. ~~These have been used extensively in Europe and Australia.~~ The true 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 25 mph or less

The use of roundabouts should be determined by a detailed documented intersection analysis~~, as is also necessary for other type designs~~.

For further guidance, refer to the Federal Highway Administration (FHWA) Roundabout Guide, and the Florida Roundabout Guide

C.8.c {Access} 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 - 13. 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.[RQ14]

C.8.d {Access} Control ~~of~~ for Urban Streets

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.~~[RQ15]
- 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 commercial 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.[RQ16]

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

C.8.e {Access} Control for Rural Highways

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.f Land Development

It should be the policy of each agency with responsibility for 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 highway 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 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 special turn lanes should be in conformance with the criteria set forth in 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. Refer to Figures 3 - 8 and 3 - 9.
- 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 - ROADWAY 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 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 0.50 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 - 8 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 - 14. 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 - 7. 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.

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 - 14 or Figure 3 - 7. Due to the inability of vehicle headlights to adequately illuminate a sharply curved travel path, roadway lighting should be considered for turning roadways.

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 highway to decide when to enter or cross the intersecting 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 - 8 and 3 - 9 show typical departure sight triangles to the left and to the right of the location of a stopped vehicle on a minor road 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 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:

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

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 Green Book):

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).

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 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 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 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 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 highway 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 - 10). 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 Standards, Index 546, 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 A Policy on Geomtric Design of Highways and Streets.AASHTO Green Book.

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 for all travel lanes.

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 - 15. 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 - 11. Advance warning of the merging lane termination should be provided. Lane drops shall be marked as required by the Manual on Uniform Traffic Control Devices (MUTCD).

C.9.c.2 Acceleration Lanes

Acceleration lanes are required for all entrances to 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 - 16. Where acceleration occurs on a grade, the required distance is obtained by using Tables 3 - 16 and 3 - 17.

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 - 11), not less than that length set forth in Table 3 - 15. The termination of acceleration lanes should conform to the general configuration shown for merging lanes in Figure 3 - 11. Recommended acceleration lanes for freeway entrance terminals are given in Table 3 - 19.

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 - 16.

The required distance for deceleration on grades is given in Tables 3 - 16 and 3 - 17.

The length of deceleration lanes shall be no less than the values obtained from Tables 3 - 16 and 3 - 17, 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 - 12. The initial length of straight taper, shown in Table 3 - 16, 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 - 18.

- Storage Lanes - Where exit lanes are required (C.8 Access Control, this chapter), or desirable on low speed streets and highways, storage lanes may be used in place of or in conjunction with deceleration lanes. Storage lanes should be considered on all facilities. Although the primary function of storage lanes is to provide protection and storage for turning vehicles, it is desirable to provide sufficient length to allow for deceleration capabilities. Storage lanes should conform to the general configuration shown in Figure 3 - 13.

The length of storage lanes for unsignalized intersections may be obtained from the table in Figure 3 - 13. The full width portion of storage lanes should, where possible, be increased to allow for expected storage of vehicles (Table 3 - 2 for vehicle lengths). As a minimum requirement, storage for at least two passenger cars (40 - 50 feet)[RQ17] should be provided.

On collector or arterial streets (design speed 45 mph or less), tapers preceding storage lanes and approaching intersections at grade may be shorter than those given in Table 3 - 16 (AASHTO for recommended lengths).

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 - 22. 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" - 2001, should also be considered.
- Superelevation Transition - Minimum superelevation transition (runoff) rates (maximum relative gradients) are given in Tables 3 - 23 and 3 - 24. Other information given in AASHTO – "A Policy on Geometric Design of Highways and Streets" - 2001, should also be considered.

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 - 14. For additional guidance on vertical alignment for turning roadways, see AASHTO – "A Policy on Geometric Design of Highways and Streets" - 2001.

C.9.d.4 Cross Section Elements

- Number of Lanes - One-way turning roadways are often limited to a single travel 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.
- Travel Lanes - The width of all travel 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 - 21. 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 principal 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.

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 pavement edge should, however, be sufficient to allow the expected vehicles to negotiate the turn without encroaching the shoulder or adjacent travel lanes.

Where turning roadway criteria are not used, the radius of the inside pavement edge 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" - 2001.

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 main highway 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 travel 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 easily mounted curbs and flush medians and islands can provide adequate delineation in most cases. Island 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 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.

Interchanges, particularly along a given freeway, should be reasonably consistent in their design. A basic principle in the design should be to develop simple open interchanges that are easily traversed and understandable to the driver. Complex interchanges with a profusion of possible travel paths are confusing and hazardous to the motorist and are generally inefficient.

Intersections with minor highway or collector/distributor roads may be accomplished by simple diamond interchanges. The intersection of exit and entrance ramps with the crossroad shall meet all intersection requirements.

The design of freeway exits should conform to the general configurations given in Table 3 - 18. Exits should be on the right and should be placed on horizontal curves. Where deceleration on an exit loop is required, the deceleration alignment should be designed so the driver receives adequate warning of the approaching increase in curvature. This is best accomplished by gradually increasing the curvature and the resulting centrifugal force. This increasing centrifugal force provides warning to the driver that he must slow down. A clear view of the exit loop should also be provided. The length of deceleration shall be no less than the values shown in Table 3 - 18.

Entrances to freeways should be designed in accordance with the general configurations shown below Table 3 - 19. Special care should be taken to ensure vehicles entering from loops are not directed across through travel lanes. The entering roadway should be brought parallel (or nearly so) to the through lanes before entry is permitted. Where acceleration is required, the distances shown in Table 3 - 19 shall, as a minimum, be provided. Exits and entrances to all high-speed facilities (design speed greater than 50 mph), should, where feasible, be designed in accordance with Tables 3 - 18 and 3 - 19. The lengths obtained from Tables 3 - 18 and 3 - 19 should be adjusted for grade by using the ratios in Table 3 - 17.

The selection of the type and exact design details of a particular interchange requires considerable study and thought. The guidelines and design details given in AASHTO "A Policy on Geometric Design of Highways and Streets" - 2001, should generally be considered as minimum criteria.

C.9.h Horizontal ClearanceClear Zone at Intersections

The provisions of ample clear zone or proper redirection of energy absorbing devices is particularly important at intersections. Every effort should be made to open up the area around the intersection to provide adequate clear zone for vehicles that have left the traveled way. Drivers frequently leave the proper travel path due to unsuccessful turning maneuvers or due to the necessity for emergency avoidance maneuvers. Vehicles also leave the roadway after intersection collisions and roadside objects should be removed to reduce the probability of second impacts. The roadside areas at all intersections and interchanges should be contoured to provide shallow slopes and gentle changes in grade.

The roadside clear zone of intersecting roadways should be carried throughout intersections with no discontinuities or interruptions. Poles and support structures for lights, signs, and signals should not be placed in medians or within the roadside clear zone.

The design of guardrails or other barriers should receive particular attention at intersections. Impact attenuators should be used in all gore and other areas where structures cannot be removed.

Particular attention should be given to the protection of pedestrians in intersection areas - CHAPTER 8 - PEDESTRIAN FACILITIES. Further criteria and requirements for clear zone and protection devices at intersections are given in CHAPTER 4 - ROADSIDE DESIGN.

C.10 Other Design Factors

C.10.a Pedestrian Facilities

The layout and design of the highway network should include provisions for pedestrian traffic in urban areas. All pedestrian crossings and pathways within the highway right of way should be considered and designed as in integral part of any street or urban highway. Design shall be in compliance with the Americans with Disabilities Act Accessibility GuidelinesAccessibility Guidelines (as described in the Federal Register), and the Florida Accessibility Code For Building Construction (Rule 9B-7.0042).

C.10.a.1 Policy and Objectives - New Facilities

The planning and design of new streets and urban highways shall include provisions for the safe orderly movement of pedestrian traffic. Provisions for pedestrian travel outside of the highway right of way should be considered.

The overall objective is to provide a safe, secure, continuous, convenient, and comfortable trip continuity and access environment for pedestrian traffic.

C.10.a.2 Accessibility Requirements

Pedestrian facilities, such as walkways and sidewalks, must be designed to accommodate physically disabled persons whose mobility is dependent on wheelchairs and other devices. Note: Design shall be in compliance with the ADA Accessibility Guidelines (as described in the Federal Register), and the Florida Accessibility Code For Building Construction (Rule 9B-7.0042). Complete design criteria can be found in this publication.

C.10.a.3 Sidewalks

Sidewalks should provide a safe, comfortable space for pedestrians. The width of sidewalks is dependent upon the roadside environment; volume of pedestrians; and the presence of businesses, schools, parks, and other pedestrian attractors. The minimum width for sidewalks is 4 feet. Where sidewalks are placed adjacent to the curb, the walkway widths should be approximately 2 feet wider. To ensure compliance with the ADA Accessibility Guidelines (as described in the Federal Register), and the Florida Accessibility Code For Building Construction, sidewalk design shall meet the following criteria:

Minimum clear width	-	36 inches[1, 2]
Maximum cross slope	-	0.02.0%
Maximum slope	-	1:20[3]

[1] Sidewalks less than 60 inches wide must have passing spaces at least 60 inches by 60 inches at intervals not to exceed 200 feet.
[2] The minimum clear width may be reduced to 32 inches for a short distance. This distance must be less than 24 inches long and separated by 5-foot long sections with 36 inches of clear width.
[3] Slopes greater than 1:20 are considered ramps and must be designed as such.

Sidewalks 5 feet wide or wider will provide for two adults to walk comfortably side by side.

C.10.a.4 Curb Ramps

In areas with sidewalks, curb ramps must be incorporated at locations where crosswalks adjoin the sidewalks. The basic curb ramp type and design application depends on the geometric characteristics of the intersection or other crossing location.

Typical curb ramp width shall be a minimum of 3 feet with 1:12 curb transitions on each side when pedestrians must walk across the ramp. Ramp slopes shall not exceed 1:12 and shall have a slip resistant surface texture. Ramp widths equal to crosswalk widths are encouraged.

Curb ramps at marked crossings shall be wholly contained within the crosswalk markings excluding any flared sides.

If diagonal ramps must be used, any returned curbs or other well-defined edges shall be parallel to the pedestrian flow. The bottom of diagonal curb ramps shall have 48-inch minimum clear space within the crosswalk. If diagonal curb ramps have flared sides, they shall also have at least a 24-inch long segment of straight curb located on each side of the curb ramp and within the marked crossing.

It is important to visually impaired persons using the sidewalk that the location of the ramps be as uniform as possible. A contrasting surface texture should be used.[RQ18] On sections without curb and gutter, a contrasting surface texture should be used on the approach to crosswalks.

The Department's Design Standards, Index 304, which addresses the design of curb ramps, may be considered. Designers should keep in mind there are many variables involved making each street intersection a special problem. For this reason, standard guidelines will not fit all situations and cannot replace the need for the use of sound engineering judgment in the design of curb ramps.

Two ramps per corner are preferred to minimize the problems with entry angle and to decrease the delay to people in wheel chairs or visually impaired pedestrians entering and exiting the roadway.

C.10.a.5 Additional Considerations

For additional information on pedestrian facilities design, including physical separation from the roadway, over- and underpasses, pedestrian crossings, traffic control, sight distance and lighting, refer to CHAPTER 8 – PEDESTRIAN FACILITIES.

C.10.b Bicycle Facilities

Provisions for bicycle traffic should be incorporated into the original highway design. All new roadways and major corridor improvements, except limited access highways, should be designed and constructed under the assumption they will be used by bicyclists. Roadway conditions should be favorable for bicycling. This includes safe drainage grates, pavement markings, and railroad crossings, smooth pavements, and signals responsive to bicycles. In addition, facilities such as bicycle lanes, bicycle routes, and shoulder improvements, should be included to the fullest extent feasible. All rural arterial and collector sections should be given consideration for the construction of 4-foot or 5-foot paved shoulders. In addition, all urban arterial and collector sections should be given consideration for either undesignated or designated[RQ19] 4-foot bike lanes.

For additional information on bicycle facilities design and the design of shared use paths, refer to CHAPTER 9 – BICYCLE FACILITIES.

C.10.c Bridge Design Loadings

The minimum design loading for all new and reconstructed bridges shall be in accordance with CHAPTER 17 – BRIDGES AND OTHER STRUCTURES.

C.10.d Dead End Streets and Cul-de-sacs

The end of a dead end street should permit travel return with a turn around area, considering backing movements, which will accommodate single truck or transit vehicles without encroachment upon private property. Recommended treatment for dead end streets and cul-de-sacs is given in Exhibit 5-8 of AASHTO – "A Policy on Geometric Design of Highways and Streets" - 2004~~1~~.

C.10.e Bus Benches and Transit Shelters

Due to the length of exposure and discomfort from traffic, bus benches should be set back at least 10 feet from the travel lane in curbed sections and outside the clear zone (Table 3 - 12) in non curbed sections.

Any bus bench or transit shelter located adjacent to a sidewalk within the right of way of any road on the State Highway or County Road System shall be located so as to leave at least 36 inches clearance for pedestrians and persons in wheelchairs. Such clearance shall be measured in a direction perpendicular to the centerline of the road. A separate bench pad or sidewalk flareout should be considered. Transit shelters should be set back, rather than eliminated during roadway widening.

C.10.f Traffic Calming

Often there are community concerns with controlling travel speeds impacting the safety of a corridor such as in areas of concentrated pedestrian activities, those with narrow right of way, areas with numerous access points, on street parking, and other similar concerns. Local authorities may elect to use traffic calming design features that could include, but not be limited to, the installation of speed humps, speed tables, chicanes, or other pavement undulations. Roundabouts are also another method of dealing with this issue at intersections. For additional details and traffic calming treatments, refer to CHAPTER 15 – TRAFFIC CALMING.

C.11 Reconstruction

C.11.a Introduction

The reconstruction (improvement or upgrading) of existing facilities may generate equal or greater safety benefits than similar expenditures for the construction of new streets and highways. Modifications to increase capacity should be evaluated for the potential effect on the highway safety characteristics. The long-range objectives should be to bring the existing network into compliance with current standards.

C.11.b Evaluation of Streets and Highways

The evaluation of the safety characteristics of streets and highways should be directed towards the identification of undesirable features on the existing system. Particular effort should be exerted to identify the location and nature of features with a high crash potential. Methods for identifying and evaluating hazards include the following:

- Identification of any geometric design feature not in compliance with minimum or desirable standards. This could be accomplished through a systematic survey and evaluation of existing facilities.
- Review of conflict points along a corridor.
- Information from maintenance or other personnel.
- Review of crash reports and traffic counts to identify locations with a large number of crashes or a high crash rate.
- Review for expected pedestrian and bicycle needs.

C.11.c Reconstruction Priorities

A large percentage of highway reconstruction and improvements is directed toward increasing efficiency and capacity. The program of reconstruction should be based, to a large extent, upon priorities for the improvement of safety characteristics.

The priorities for safety improvements should be based on the objective of obtaining the maximum reduction in crash potential for a given expenditure of funds. Elimination of conditions that may result in serious or fatal crashes should receive the highest priority in the schedule for reconstruction.

Specific high priority problem areas that should be corrected by reconstruction include the following:

- Obstructions to sight distance which can be economically corrected. The removal of buildings, parked vehicles, vegetation, large poles or groups of poles that significantly reduce the field of vision, and signs to improve sight distance on curves and particularly at intersections, can be of immense benefit in reducing crashes. The purchase of required line of sight easements is often a wise expenditure of highway funds. The establishment of sight distance setback lines is encouraged.

- Roadside and median hazards which can often be removed or relocated farther from the traveled way. Where removal is not feasible, objects should be shielded by redirection or energy absorbing devices. The reduction of the roadside hazard problem generally provides a good return on the safety dollar. Details and priorities for roadside hazard reduction, which are presented in CHAPTER 4 - ROADSIDE DESIGN, should be incorporated into the overall priorities of the reconstruction program.

- Poor pavement surfaces which have become hazardous should be maintained or reconstructed in accordance with the design criteria set forth in CHAPTER 5 - PAVEMENT DESIGN AND CONSTRUCTION, and CHAPTER 10 - MAINTENANCE.

- Specific design features which could be applied during reconstruction to enhance the operations and safety characteristics of a roadway include the following:

  - Addition of roadway lighting.

  - The provision of frontage roads of other alternate paths. This may be utilized to improve the efficiency and safety of streets and highways with poor control of access.

  - Widening of pavements and shoulders. This is often an economically feasible method of increasing capacity and reducing traffic hazards. Provision of median barriers (CHAPTER 4 - ROADSIDE DESIGN) can also produce significant safety benefits.

  - The removal, streamlining, or modification of drainage structures.

  - Alignment modifications are usually extensive and require extensive reconstruction of the roadway. Removal of isolated sharp curves is a reasonable and logical step in alignment modification. If major realignment is to be undertaken, every effort should be made to bring the entire facility into compliance with the requirements for new construction.

- The use of traffic control devices. This is generally an inexpensive method of alleviating certain highway defects.
- Median opening modifications.
- Addition of median, channelized islands, and mid-block pedestrian crossings.
- Auxiliary lanes.
- Existing bridges that fail to meet current design standards which are available to bicycle traffic, should be retrofitted on an interim basis as follows: As a general practice, bridges 125 feet in length or longer, bridges with unusual sight problem, steep gradients (which require the cyclist longer time to clear the span) or other unusual conditions should display the standard W11-1 caution sign with an added sign "On Bridge" at either end of the structure. Special care should be given to the right most portion of the roadway, where bicyclists are expected to travel, assuring smoothness, pavement uniformity, and freedom from longitudinal joints, and to ensure cleanliness. Failure to do so forces bicyclists farther into the center portion of the bridge, reducing traffic flow and safety.[RQ20]
- Addition of bike accommodations designated or undesignated[RQ21].
- Addition of transit facilities, sidewalks, crosswalks, and other pedestrian features.

C.12 Design Exceptions

See CHAPTER 14 - DESIGN EXCEPTIONS for the process to use when the standard criteria found in this Manual cannot be met.

TABLE 3 – 1
RECOMMENDED MINIMUM DESIGN SPEED (MPH)

TYPE OF ROADWAY	URBAN		RURAL	
	*SPEED RESTRICTIONS		*SPEED RESTRICTIONS	
	WITH	WITHOUT	WITH	WITHOUT
Freeway or Expressway	50	60	---	70
Arterial (Major)	40	55	55	70
Arterial (Minor)	35	50	55	70
Collector (Major)	35	45	50	65
Collector (Minor)	30	40	40	60
Local **	20	30	30	50

* Speed restrictions are features of the design which would effectively limit the operating speed, such as:

a. Short length of roadway (i.e., dead-end street)
b. Closely spaced stop signs, traffic signals or other control devices
c. Locations that would by nature of the surrounding development or land use, indicate to the driver that lower speeds were necessary

** Design speeds lower that 30 mph may be used for local, subdivision type roads and streets. Streets with a design speed less than 30 mph shall be posted with appropriate legal speed limit signs.

TABLE 3 – 2
DESIGN VEHICLES

DESIGN VEHICLE		DIMENSIONS IN FEET					
Type	Symbol	Wheelbase	Overhang		Overall Length	Overall Width	Height
			Front	Rear			
Passenger Car	P	11	3	5	19	7	4.25
Single Unit Truck	SU	20	4	6	30	8	13.5
City Transit Bus	CITY-BUS	25	7	8	40	8.5	10.5
Articulated Bus	A-BUS	22+19.4=41.4	8.6	10	60	8.5	11
Motor Home	MH	20	4	6	30	8	12
Car & Camper Trailer	P/T	11+5+19=35**	3	10	48.7	8	10
Car & Boat Trailer	P/B	11+5+15=31**	3	8	42	8	---
Intermediate Semitrailer	WB-40	12.5+27.5=40	3	2.5	45.5	8	13.5
Intermediate Semitrailer	WB-50	14.6+35.4=50	3	2	55	8.5	13.5
Interstate Semitrailer	WB-62	21.6+40.4=62	4	2.5	68.5	8.5	13.5
Interstate Semitrailer	WB-65	21.6+43.4=65	4	4.5	73.5	8.5	13.5
Interstate Semitrailer	WB-67	21.6+45.4=67	4	2.5	73.5	8.5	13.5
"Double-Bottom"-Semitrailer/Trailer Combination	WB-67D	11+23+10*+23=67	2.33	3	73.3	8.5	13.5

* Distance between rear wheels of front trailer and front wheels of rear trailer

** Distance between rear wheels of trailer and front wheels of car

TABLE 3 – 3
HORIZONTAL CURVATURE

RURAL Based on e_{MAX} = 0.10			URBAN High-Speed Highways and Streets Based on e_{MAX} = 0.05		
Design Speed (MPH)	Max. Degree of Curvature	Min. Radius (FEET)	Design Speed (MPH)	Max. Degree of Curvature	Min. Radius (FEET)
15	104° 45'	55	---	---	---
20	57° 45'	100	---	---	---
25	36° 15'	160	---	---	---
30	24° 45'	230	30	20° 00'	285
35	17° 45'	320	35	14° 15'	400
40	13° 15'	430	40	10° 45'	535
45	10° 15'	555	45	8° 15'	695
50	8° 15'	695	50	6° 30'	880
55	6° 30'	880	55	5° 00'	1125
60	5° 15'	1095	---	---	---
65	4° 15'	1345	---	---	---
70	3° 30'	1640	---	---	---

LOW-SPEED URBAN STREETS				
Design Speed (MPH)	With e_{MAX} = 0.05		Without Superelevation (e_{MAX} = -0.02)	
	Max. Degree of Curvature	Min. Radius (FEET)	Max. Degree of Curvature	Min. Radius (FEET)
15	144° 45'	40	118° 15'	50
20	75° 00'	75	60° 00'	95
25	41° 30'	140	31° 45'	180
30	25° 45'	225	19° 15'	300

(TABLE CONTINUES ON NEXT PAGE)

TABLE 3 – 3
HORIZONTAL CURVATURE
(Continued)

LATERAL CLEARANCE FROM EDGE OF PAVEMENT TO OBSTRUCTION FOR MAXIMUM CURVATURE (DEGREES), BASED ON LINE OF SIGHT ON INSIDE LANE (Lateral Clearance = $M_{\text{Inside Lane}}$ – 6') Based on e_{MAX} = 0.10		
Design Speed (MPH)	Maximum Curvature	Clearance (FEET)
30	24° 45'	16
35	17° 45'	19
40	13° 15'	21
45	10° 15'	23
50	8° 15'	27
55	6° 30'	29
60	5° 15'	31
65	4° 15'	33
70	3° 30'	35

TABLE 3 – 4
RECOMMENDED MAXIMUM GRADES IN PERCENT

TYPE OF ROADWAY		FLAT TERRAIN DESIGN SPEED (MPH)												ROLLING TERRAIN DESIGN SPEED (MPH)											
		15	20	25	30	35	40	45	50	55	60	65	70	15	20	25	30	35	40	45	50	55	60	65	70
Freeway		---	---	---	---	---	---	---	4	4	3	3	3	---	---	---	---	---	---	---	5	5	4	4	4
Arterial *	Rural	---	---	---	---	---	5	5	4	4	3	3	3	---	---	---	---	---	6	6	5	5	4	4	4
	Urban	---	---	---	8	7	7	6	6	5	5	---	---	---	---	---	9	8	8	7	7	6	6	---	---
Collector *	Rural	---	7	7	7	7	7	7	6	6	5	---	---	---	10	10	9	9	8	8	7	7	6	---	---
	Urban	---	9	9	9	9	9	8	7	7	6	---	---	---	12	12	11	10	10	9	8	8	7	---	---
Local *		9	8	7	7	7	7	7	6	6	5	---	---	12	11	11	10	10	10	9	8	7	6	---	---
Industrial **		---	---	---	4	4	4	4	3	3	3	---	---	---	---	---	5	5	5	5	4	4	4	---	---

* May be increased by 2 percent for urban streets under extreme conditions.

** Local and collector streets with significant (15% or more) truck traffic.

For short sections less than 500' and for one-way downgrades, the maximum gradient may be 1% steeper.

TABLE 3 – 5
MAXIMUM CHANGE IN GRADE
WITHOUT USING VERTICAL CURVE

Design Speed (MPH)	15	20	25	30	35	40	45	50	55	60	65	70
Maximum Change in Grade in Percent	1.30	1.20	1.10	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20

TABLE 3 – 6
SIGHT DISTANCES AND LENGTHS OF VERTICAL CURVES

{Consider breaking this table into separate pieces. Portions are referenced in multiple locations.}

MINIMUM STOPPING SIGHT DISTANCES (FEET) (For application of stopping sight distance, use an eye height of 3.50 feet and an object height of 6 inches above the road surface)												
Design Speed (MPH)	15	20	25	30	35	40	45	50	55	60	65	70
Stopping Sight Distance (FEET)	80	115	155	200	250	305	360	425	495	570	645	730

ROUNDED K VALUES FOR MINIMUM LENGTHS VERTICAL CURVES												
L = KA L = LENGTH OF VERTICAL CURVE A = ALGEBRAIC DIFFERENCE OF GRADES IN PERCENT												
Design Speed (MPH)	15	20	25	30	35	40	45	50	55	60	65	70
K Values for Crest Vertical Curves	5	10	19	31	47	70	98	136	185	245	313	401
K Values for Sag Vertical Curves	10	17	26	37	49	64	79	96	115	136	157	181

- The length of vertical curve must never be less than three times the design speed of the highway
- Curve lengths computed from the formula L = KA should be rounded upward when feasible
- The minimum lengths of vertical curves to be used on major highways are shown in the table below

MINIMUM LENGTHS FOR VERTICAL CURVES ON MAJOR HIGHWAYS (FEET)			
Design Speed (MPH)	50	60	70
Crest Vertical Curves (FEET)	300	400	500
Sag Vertical Curves (FEET)	200	300	400

MINIMUM PASSING SIGHT DISTANCES (FEET) (For application of passing sight distance, use an eye height of 3.50 feet and an object height of 3.50 feet above the road surface)											
Design Speed (MPH)	20	25	30	35	40	45	50	55	60	65	70
Minimum Passing Sight Distance (FEET)	710	900	1090	1280	1470	1625	1835	1985	2135	2285	2480

TABLE 3 – 7
MINIMUM LANE WIDTHS

	Minimum Lane Width (FEET)
Freeways	12
Major Arterials	11
Minor Arterials	11
Collectors (Major and Minor)	11
Local Roads *	10
Auxiliary Lanes	10

* Pavement widths may be reduced for the paving of certain existing unpaved subdivision streets and low volume rural roads. See CHAPTER 3, SECTION A for conditions.

TABLE 3 – 8
MINIMUM WIDTHS OF PAVEMENT AND SHOULDERS FOR TWO (2) LANE RURAL HIGHWAYS

DESIGN SPEED (MPH)	AVERAGE DAILY TRAFFIC (2 - WAY)				
	250	250 - 400	400 - 750	750 - 1,600	ABOVE 1,600
	MINIMUM WIDTH OF PAVEMENT (FEET)				
30	20	20	22	22	24
35	20	20	22	22	24
40	20	20	22	22	24
45	20	20	22	22	24
50	20	20	22	24	24
55	20	22	22	24	24
60	20	22	22	24	24
65	20	22	24	24	24
	MINIMUM WIDTH OF SHOULDER (FEET)				
ALL	6	6	6	8	8

TABLE 3 – 9
SHOULDER WIDTHS FOR MULTILANE RURAL DIVIDED HIGHWAYS

NUMBER OF LANES EACH DIRECTION	SHOULDER WIDTH (FEET)			
	OUTSIDE		MEDIAN	
	ROADWAY	BRIDGE	ROADWAY	BRIDGE
2	10 (minimum)	10	6 (minimum)	6
3 or more	10 (minimum)	10	10 (minimum)	10

TABLE 3 – 10
MEDIAN WIDTH FOR FREEWAYS
(URBAN AND RURAL)

DESIGN SPEED (MPH)	MINIMUM PERMITTED MEDIAN WIDTH (FEET)
60 and Over	60 **
Under 60	40 *

* Applicable for urban areas ONLY.

** For new construction ONLY.
(40 feet minimum allowed when lanes added to median)

TABLE 3 – 11
MEDIAN WIDTH FOR RURAL HIGHWAYS
(MULTILANE FACILITIES)

DESIGN SPEED (MPH)	MINIMUM WIDTH (FEET)
55 and Over	40
Under 55	22

MEDIAN WIDTH FOR URBAN STREETS

DESIGN SPEED (MPH)	MINIMUM WIDTH (FEET)
50	19.5
45 and LESS	15.5

Paved medians with a minimum width of 10 feet may be used for two-way turn lanes and painted or raised medians when design speeds are 40 mph or less.

TABLE 3 – 12A
MINIMUM WIDTH OF RECOVERABLE TERRAIN
FOR DETERMINATION OF CLEAR ZONE

Rural and Urban Flush Shoulder Roadways

DESIGN SPEED (MPH)							
25 and Below	30	35	40	45	50	55	60 and Above
MINIMUM WIDTH OF RECOVERABLE TERRAIN -(FEET) (From edge of traveled way)							
6	6 Local 10 Collectors 14 Arterials	6 Local 10 Collectors 14 Arterials	10 Collectors 14 Arterials	14 Arterials and Collectors ADT < 1500 18 Arterials and Collectors ADT ≥ 1500	14 Arterials and Collectors ADT < 1500 18 Arterials and Collectors ADT ≥ 1500	18 Arterials and Collectors ADT < 1500 24 Arterials and Collectors ADT ≥ 1500	18 Arterials and Collectors ADT < 1500 30 Arterials and Collectors ADT ≥ 1500
Note: ADT in Table 3 - 12A refers to Design Year ADT.							

TABLE 3 – 12B
MINIMUM HORIZONTAL CLEARANCE[1]

Urban Curb or Curb and Gutter Roadways

DESIGN SPEED[2] (MPH)				
25 and Below	30	35	40	45
MINIMUM HORIZONTAL CLEARANCE (FEET) (From face of curb)				
1.5	4[3]	4[3]	4[3]	4[3]

1. These horizontal clearance requirements can be applied only if all of the following conditions are met:
   - The facility is an urban facility.
   - The facility's design speed is 45 mph or less.
   - The facililty is predominantly a curbed facility.
   - Right of way is restricted.
2. Curb and gutter not to be used on facilities with design speed > 45mph
3. On projects where the 4-foot minimum offset cannot be reasonably obtained and other alternatives are deemed impractical, the minimum may be reduced to 1.5 feet.

TABLE 3 – 12
MINIMUM WIDTH OF CLEAR ZONE

Type of Facility	DESIGN SPEED (MPH)							
	25 and Below	30	35	40	45	50	55	60 and Above
	MINIMUM CLEAR ZONE (FEET)							
Rural •	6	6 Local 10 Collectors 14 Arterials	6 Local 10 Collectors 14 Arterials	10 Collectors 14 Arterials	14 Arterials and Collectors ADT < 1500 18 Arterials and Collectors ADT ≥ 1500	14 Arterials and Collectors ADT < 1500 18 Arterials and Collectors ADT ≥ 1500	18 Arterials and Collectors ADT < 1500 24 Arterials and Collectors ADT ≥ 1500	18 Arterials and Collectors ADT < 1500 30 Arterials and Collectors ADT ≥ 1500
Urban *	1 ½	4 **	4 **	4 **	4 **	N/A ••	N/A ••	N/A ••

* From face of curb

** On projects where the 4 foot minimum offset cannot be reasonably obtained and other alternatives are deemed impractical, the minimum may be reduced to 1 ½'.

• Use rural for urban facilities when no curb and gutter is present. Measured from the edge of through travel lane on rural section.

•• Curb and gutter not to be used on facilities with design speed > 45mph.

NOTE: ADT in Table 3 - 12 refers to Design Year ADT.

TABLE 3 – 13
ACCESS CONTROL FOR ALL LIMITED ACCESS HIGHWAYS[RQ22]

	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	

TABLE 3 – 14
SIGHT DISTANCE FOR APPROACH TO STOPS
(Rounded Values)

DESIGN SPEED (MPH)	10	15	20	25	30	35	40	45	50	55	60	65	70
STOPPING SIGHT DISTANCE (FEET) (Minimum)	50	80	115	155	200	250	305	360	425	495	570	645	730

TABLE 3 – 15
LENGTH OF TAPER FOR USE IN CONDITIONS
WITH FULL WIDTH SPEED CHANGE LANES

DESIGN SPEED (MPH)	15	20	25	30	35	40	45	50	55	60	65	70
LENGTH OF DECELERATION TAPER (FEET)	80	110	130	150	170	190	210	230	250	270	290	300
LENGTH OF ACCELERATION TAPER (FEET)	60	80	100	120	140	160	180	210	230	250	260	280

TABLE 3 – 16
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)	Length 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)	Length 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 - 13 for allowable taper rates.

TABLE 3 – 17
RATIO OF LENGTH OF SPEED CHANGE LANE ON GRADE TO LENGTH ON LEVEL

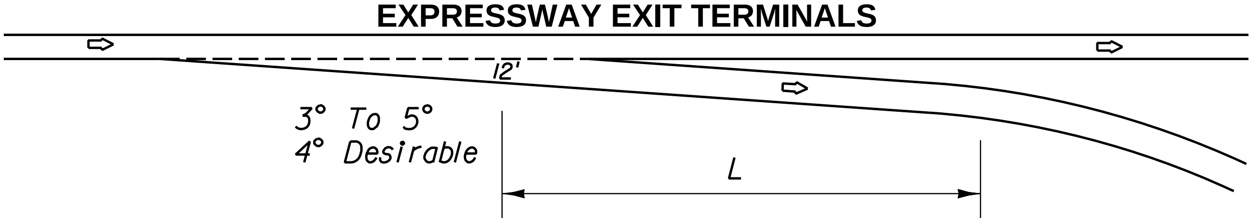
DECELERATION LANE			ACCELERATION LANE					
	Design Speed of Turning Roadway (MPH)			Design Speed of Turning Roadway (MPH)				
Design Speed of Highway (MPH)	All Speeds 3% -4% Upgrade	All Speeds 3%-4% Downgrade	Design Speed of Highway (MPH)	20	30	40	50	All Speeds
				3% - 4% Upgrade				3% - 4% Downgrade
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% Downgrade
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 - 16 give the length of speed change lane for the respective grade.

TABLE 3 – 18
MINIMUM DECELERATION LENGTHS FOR EXIT TERMINALS

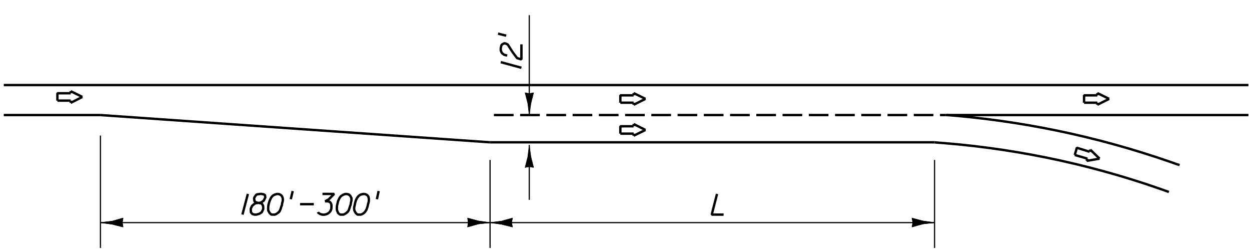
Highway Design Speed (MPH)	L = Deceleration Length (FEET)								
	For Design Speed of Exit Curve (MPH)								
	Stop Condition	15	20	25	30	35	40	45	50
30	235	200	170	140	---	---	---	---	---
35	280	250	210	185	150	---	---	---	---
40	320	295	265	235	185	155	---	---	---
45	385	350	325	295	250	220	---	---	---
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 EXIT TERMINALS



TAPER TYPE

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



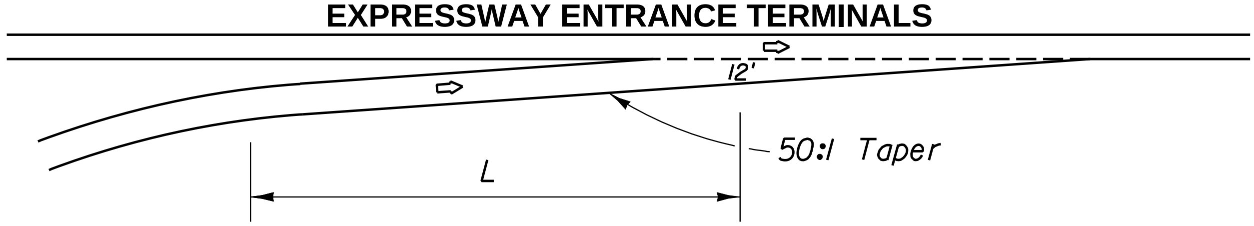
PARALLEL TYPE

Recommended when design speed at exit curve is less than 50 MPH or when approach visibility is not good.

TABLE 3 – 19
MINIMUM ACCELERATION LENGTHS FOR ENTRANCE TERMINALS

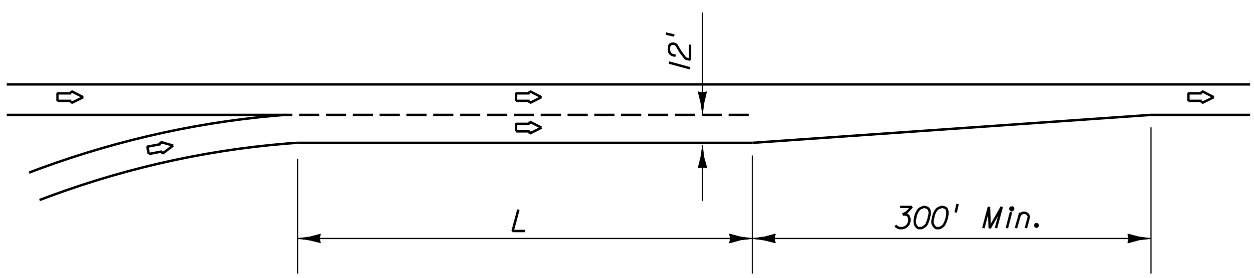
Highway Design Speed (MPH)	L = Acceleration Length (FEET)								
	For Entrance Curve Design Speed (MPH)								
	Stop Condition	15	20	25	30	35	40	45	50
30	180	140	---	---	---	---	---	---	---
35	280	220	160	---	---	---	---	---	---
40	360	300	270	210	120	---	---	---	---
45	560	490	440	380	280	160	---	---	---
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 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.

TABLE 3 – 20A
CALCULATED AND DESIGN VALUES FOR TRAVELED WAY WIDENING ON OPEN HIGHWAY CURVES
(TWO-LANE HIGHWAYS, ONE-WAY OR TWO-WAY)

Radius of Curve (FEET)	Roadway width = 24 feet.							Roadway width = 22 feet.							Roadway width = 20 feet.						
	Design Speed (MPH)							Design Speed (MPH)							Design Speed (MPH)						
	30	35	40	45	50	55	60	30	35	40	45	50	55	60	30	35	40	45	50	55	60
7000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.6	1.6	1.7	1.7	1.8	1.9	1.9
6500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.6	1.7	1.7	1.8	1.8	1.9	2.0
6000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.7	0.8	0.8	0.9	1.0	1.0	1.6	1.7	1.8	1.8	1.9	2.0	2.0
5500	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.7	1.7	1.8	1.9	1.9	2.0	2.1
5000	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.7	0.8	0.9	0.9	1.0	1.1	1.1	1.7	1.8	1.9	1.9	2.0	2.1	2.1
4500	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.8	0.8	0.9	1.0	1.1	1.1	1.2	1.8	1.8	1.9	2.0	2.1	2.1	2.2
4000	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.8	0.9	1.0	1.1	1.2	1.2	1.3	1.8	1.9	2.0	2.1	2.2	2.2	2.3
3500	0.0	0.0	0.1	0.2	0.3	0.3	0.4	0.9	1.0	1.1	1.2	1.3	1.3	1.4	1.9	2.0	2.1	2.2	2.3	2.3	2.4
3000	0.0	0.1	0.2	0.3	0.4	0.5	0.6	1.0	1.1	1.2	1.3	1.4	1.5	1.6	2.0	2.1	2.2	2.3	2.4	2.5	2.6
2500	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.2	2.3	2.4	2.5	2.6	2.7	2.8
2000	0.4	0.5	0.6	0.7	0.8	1.0	1.1	1.4	1.5	1.6	1.7	1.8	2.0	2.1	2.4	2.5	2.6	2.7	2.8	3.0	3.1
1800	0.5	0.6	0.8	0.9	1.0	1.1	1.2	1.5	1.6	1.8	1.9	2.0	2.1	2.2	2.5	2.6	2.8	2.9	3.0	3.1	3.2
1600	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.7	1.8	1.9	2.0	2.2	2.3	2.4	2.7	2.8	2.9	3.0	3.2	3.3	3.4
1400	0.8	1.0	1.1	1.2	1.4	1.5	1.6	1.8	2.0	2.1	2.2	2.4	2.5	2.6	2.8	3.0	3.1	3.2	3.4	3.5	3.6
1200	1.1	1.2	1.4	1.5	1.7	1.8	1.9	2.1	2.2	2.4	2.5	2.7	2.8	2.9	3.1	3.2	3.4	3.5	3.7	3.8	3.9
1000	1.4	1.6	1.7	1.9	2.0	2.2	2.4	2.4	2.6	2.7	2.9	3.0	3.2	3.4	3.4	3.6	3.7	3.9	4.0	4.2	4.4
900	1.6	1.8	2.0	2.1	2.3	2.5		2.6	2.8	3.0	3.1	3.3	3.5		3.6	3.8	4.0	4.1	4.3	4.5	
800	1.9	2.1	2.2	2.4	2.6	2.8		2.9	3.1	3.2	3.4	3.6	3.8		3.9	4.1	4.2	4.4	4.6	4.8	
700	2.2	2.4	2.6	2.8	3.0			3.2	3.4	3.6	3.8	4.0			4.2	4.4	4.6	4.8	5.0		
600	2.7	2.9	3.1	3.3	3.5			3.7	3.9	4.1	4.3	4.5			4.7	4.9	5.1	5.3	5.5		
500	3.3	3.5	3.7	3.9				4.3	4.5	4.7	4.9				5.3	5.5	5.7	5.9			
450	3.7	3.9	4.1					4.7	4.9	5.1					5.7	5.9	6.1				
400	4.2	4.4	4.7					5.2	5.4	5.7					6.2	6.4	6.7				
350	4.8	5.1	5.3					5.8	6.1	6.3					6.8	7.1	7.3				
300	5.6	5.9						6.6	6.9						7.6	7.9					
250	6.8							7.8							8.8						
200	8.5							9.5							10.5						

Notes: Values shown are for WB-50 design vehicle and represent widening in feet. For other design vehicles, use adjustments in Table 3-20B.
Values less than 2.0 feet may be disregarded.
For 3-lane roadways, multiply above values by 1.5.
For 4-lane roadways, multiply above values by 2.

TABLE 3 – 20B
ADJUSTMENTS FOR TRAVELED WAY WIDENING VALUES ON OPEN HIGHWAY CURVES (TWO-LANE HIGHWAYS, ONE-WAY OR TWO-WAY)

Radius of Curve (FEET)	Design Vehicle						
	SU	WB-40	WB-62	WB-65	WB-67D	WB-100T	WB-109D
7000	-1.1	-1.1	0.1	0.1	0.0	0.0	0.3
6500	-1.1	-1.1	0.1	0.1	0.0	0.1	0.3
6000	-1.2	-1.1	0.1	0.2	0.0	0.1	0.3
5500	-1.2	-1.1	0.1	0.2	0.0	0.1	0.4
5000	-1.2	-1.1	0.1	0.2	0.0	0.1	0.4
4500	-1.2	-1.1	0.1	0.2	0.0	0.1	0.5
4000	-1.2	-1.2	0.2	0.2	-0.1	0.1	0.5
3500	-1.3	-1.2	0.2	0.3	-0.1	0.1	0.6
3000	-1.3	-1.2	0.2	0.3	-0.1	0.1	0.7
2500	-1.4	-1.2	0.3	0.4	-0.1	0.1	0.8
2000	-1.5	-1.3	0.3	0.5	-0.1	0.2	1.0
1800	-1.5	-1.3	0.4	0.5	-0.1	0.2	1.1
1600	-1.6	-1.4	0.4	0.6	-0.1	0.2	1.3
1400	-1.7	-1.4	0.5	0.6	-0.2	0.2	1.5
1200	-1.8	-1.5	0.5	0.8	-0.2	0.3	1.7
1000	-2.0	-1.6	0.6	0.9	-0.2	0.3	2.0
900	-2.1	-1.7	0.7	1.0	-0.2	0.4	2.3
800	-2.2	-1.8	0.8	1.1	-0.3	0.4	2.6
700	-2.4	-1.9	0.9	1.3	-0.3	0.5	2.9
600	-2.6	-2.0	1.1	1.5	-0.4	0.6	3.4
500	-2.9	-2.2	1.3	1.8	-0.4	0.7	4.1
450	-3.2	-2.4	1.4	2.0	-0.5	0.7	4.6
400	-3.4	-2.5	1.6	2.3	-0.5	0.8	5.1
350	-3.8	-2.8	1.9	2.6	-0.6	1.0	5.9
300	-4.3	-3.0	2.2	3.0	-0.7	1.1	6.9
250	-4.9	-3.5	2.6	3.7	-0.9	1.4	8.3
200	-5.9	-4.1	3.3	4.6	-1.1	1.7	10.5

Notes: Adjustments are applied by adding to or subtracting from the values in Table 3-20A
Adjustments depend only on radius and design vehicle; they are independent of roadway width and design speed.
For 3-lane roadways, multiply above values by 1.5.
For 4-lane roadways, multiply above values by 2.0.

TABLE 3 – 21
DESIGN WIDTHS OF PAVEMENTS FOR TURNING ROADWAYS

Pavement Width (FEET)

Radius on Inner Edge of Pavement R (FEET)	**Case I One-Lane, One-Way Operation - No Provision for Passing a Stalled Vehicle**			**Case II One-Lane, One-Way Operation - With Provision for Passing a Stalled Vehicle**			**Case III Two-Lane Operation - Either One-Way or Two-Way**		
	Design Traffic and Conditions								
	A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
50	18	18	23	20	26	30	31	36	45
75	16	17	20	19	23	27	29	33	38
100	15	16	18	18	22	25	28	31	35
150	14	15	17	18	21	23	26	29	32
200	13	15	16	17	20	22	26	28	30
300	13	15	15	17	20	22	25	28	29
400	13	15	15	17	19	21	25	27	28
500	12	15	15	17	19	21	25	27	28
Tangent	12	14	14	17	18	20	24	26	26

Width Modification Regarding Edge of Pavement Treatment:

	Case I	Case II	Case III
No stabilized shoulder	None	None	None
Sloping curb	None	None	None
Vertical curb:			
one side	Add 1 ft	None	Add 1 ft
two sides	Add 2 ft	Add 1 ft	Add 2 ft
Stabilized shoulder, one or both sides	Lane width for Conditions B & C on tangent may be reduced to 12 ft where shoulder is 4 ft or wider	Deduct shoulder width; minimum pavement width as under Case I	Deduct 2 ft where shoulder is 4 ft or wider

Note:
Traffic Condition A = predominately P vehicles, but some consideration for SU trucks.
Traffic Condition B = sufficient SU vehicles to govern design, but some consideration for semitrailer combination trucks.
Traffic Condition C = sufficient bus and combination-trucks to govern design.

TABLE 3 – 22
SUPERELEVATION RATES FOR CURVES AT INTERSECTIONS

	Design Speed (MPH)							
	10	**15**	**20**	**25**	**30**	**35**	**40**	**45**
Minimum Superelevation Rate	0.00*	0.00*	0.02	0.04	0.06	0.08	0.09	0.10
Minimum Radius (FEET)	25	50	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.

TABLE 3 – 23
MAXIMUM RATE OF CHANGE IN PAVEMENT EDGE ELEVATION FOR CURVES AT INTERSECTIONS

Design Speed (MPH)	15	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)	0.78	0.74	0.70	0.66	0.62	0.58	0.54	0.50	0.47	0.45	0.43	0.40

TABLE 3 – 24
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

FIGURE 3 – 1
RURAL HIGHWAYS, URBAN FREEWAYS AND HIGH SPEED URBAN ARTERIALS

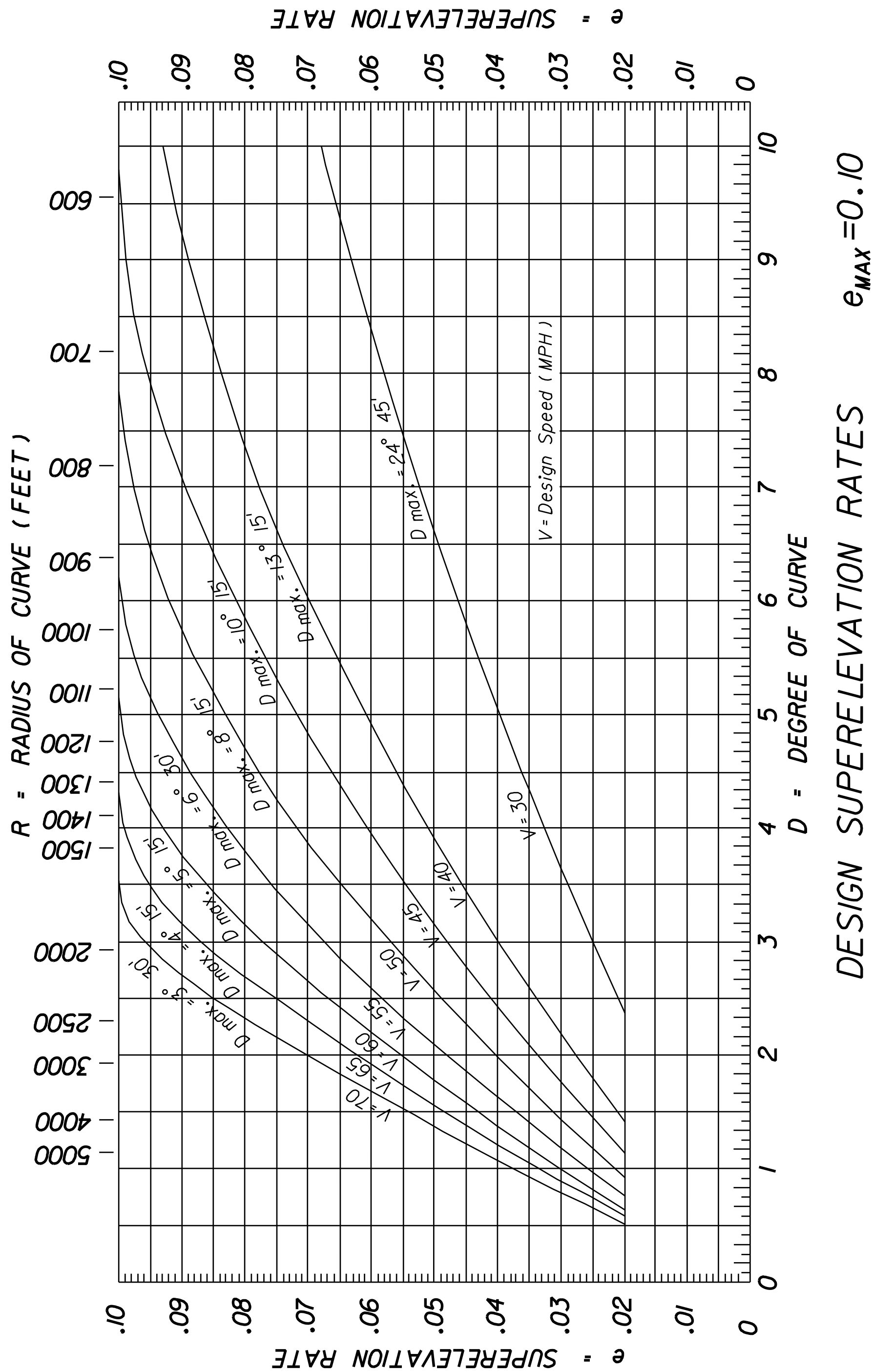
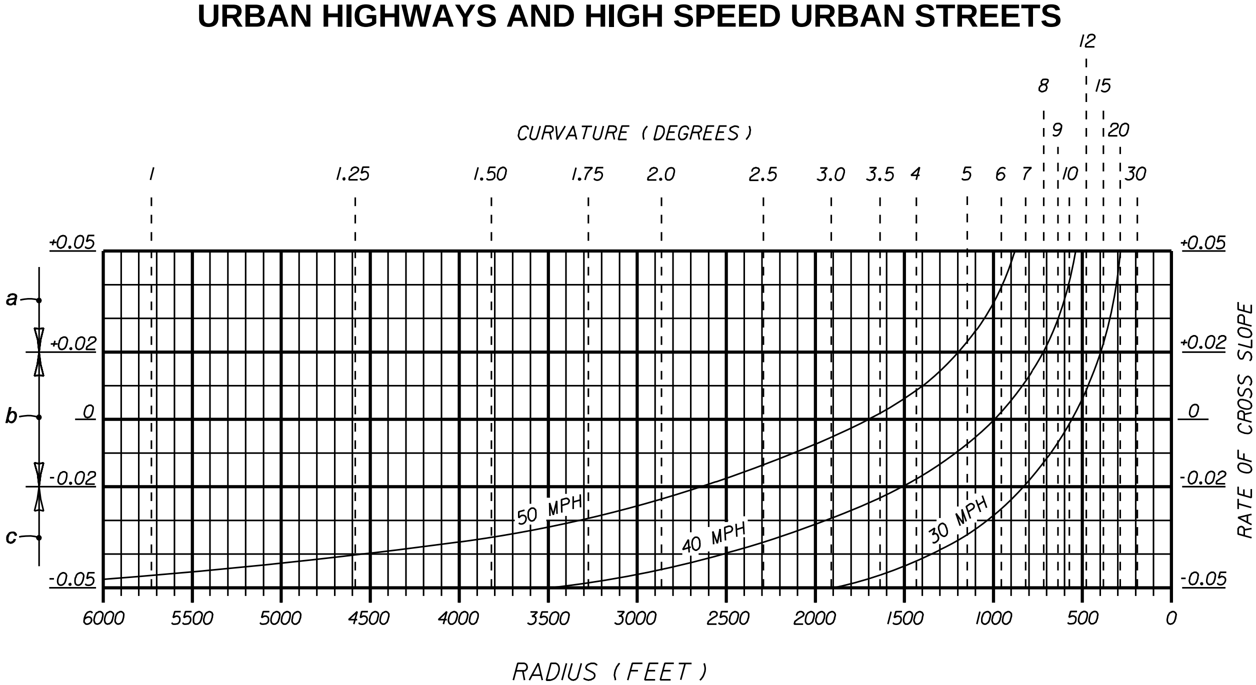


FIGURE 3 – 2
URBAN HIGHWAYS AND HIGH SPEED URBAN STREETS

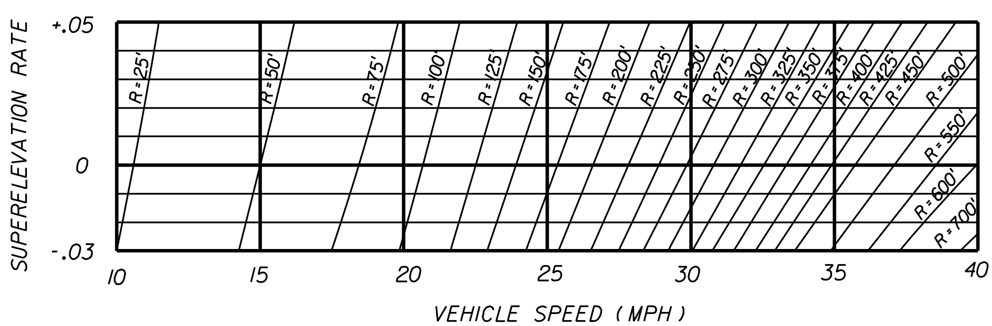


a. When the speed curves and the degree of curve lines intersect above this line, the pavement is to be superelevated (positive slope) at the rates indicated at the lines intersecting points.

b. When the speed curves and the degree of curve lines intersect between these limits, the pavement is to be superelevated at the rate of 0.02 (positive slope).

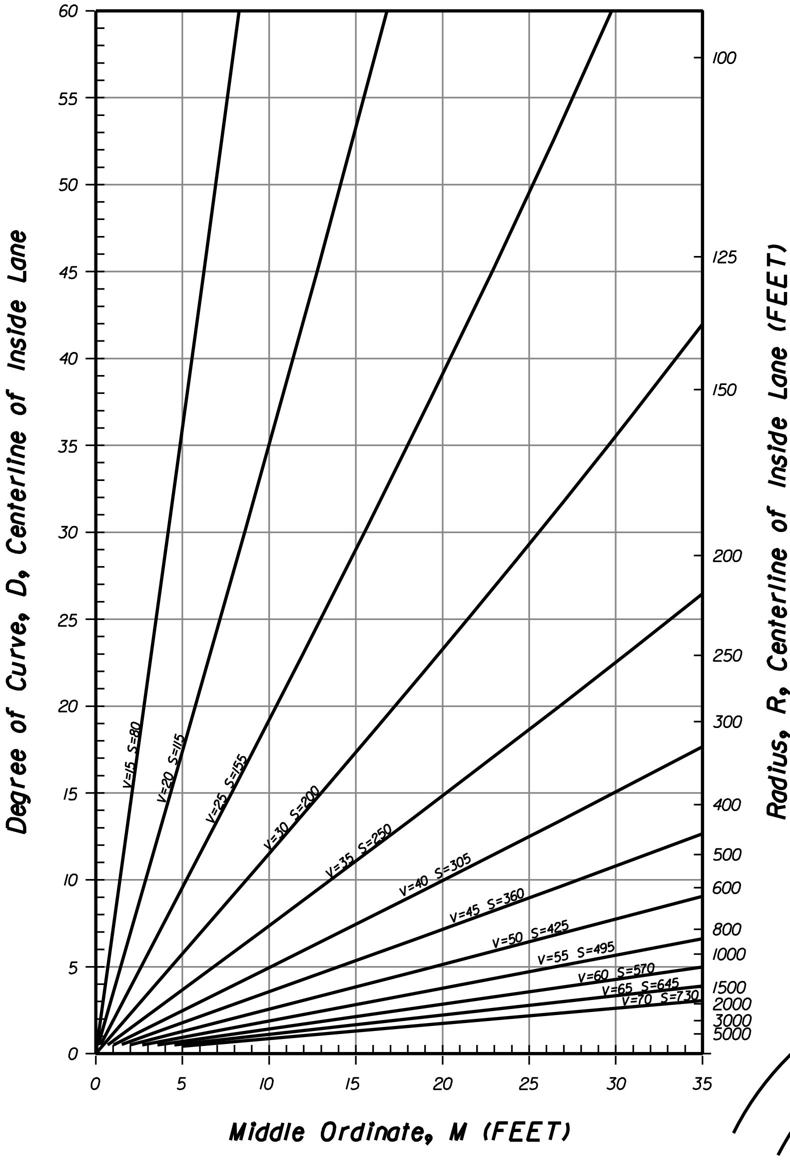
c. When the speed curves and the degree of curve lines intersect below this line, the pavement is to have normal crown (typically 0.02 and 0.03 downward slopes).

SUPERELEVATION RATES (e) FOR URBAN HIGHWAYS AND HIGH SPEED URBAN STREETS (e_{MAX} = 0.05)



MAXIMUM SAFE SPEED FOR HORIZONTAL CURVES URBAN-LOWER SPEED STREETS

FIGURE 3 – 2A
SIGHT DISTANCE ON CURVES



$$M = \frac{5730}{D}\left(1 - \cos\frac{SD}{200}\right)$$

$$R = \frac{5730}{D} \quad \text{and} \quad \theta = \frac{SD}{200}$$

$$M = R\,(1 - \cos\theta)$$

$$M = R\left(1 - \cos\frac{28.65\,S}{R}\right)$$

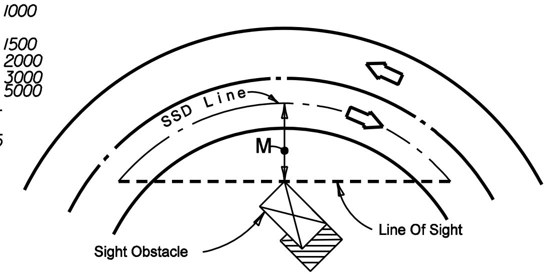
Where

S = Stopping Sight Distance (FEET)

D = Degree of Curve

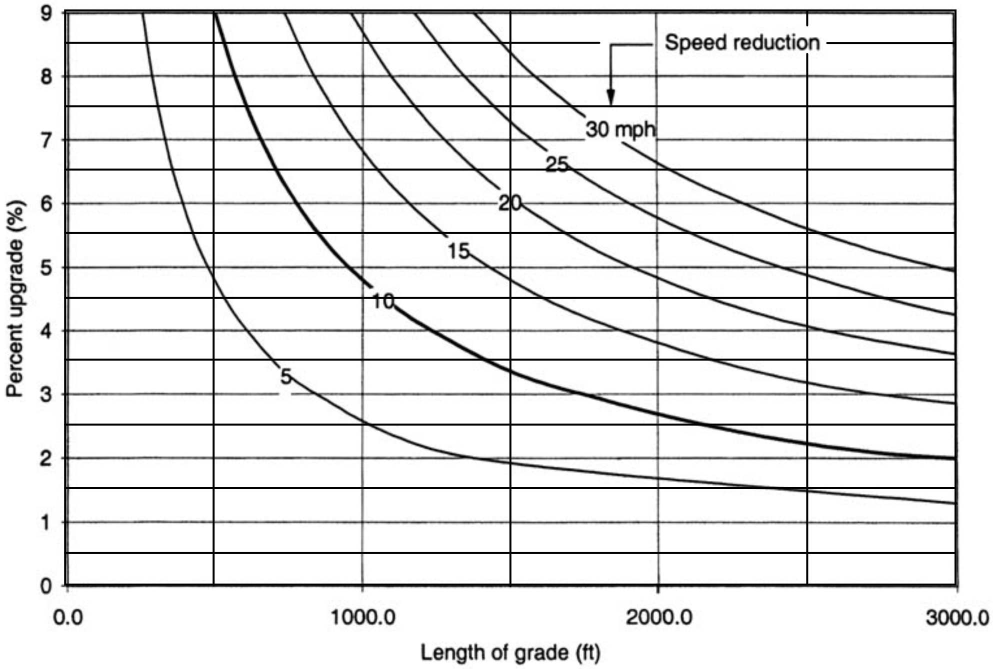
M = Middle Ordinate (FEET)

R = Radius (FEET)



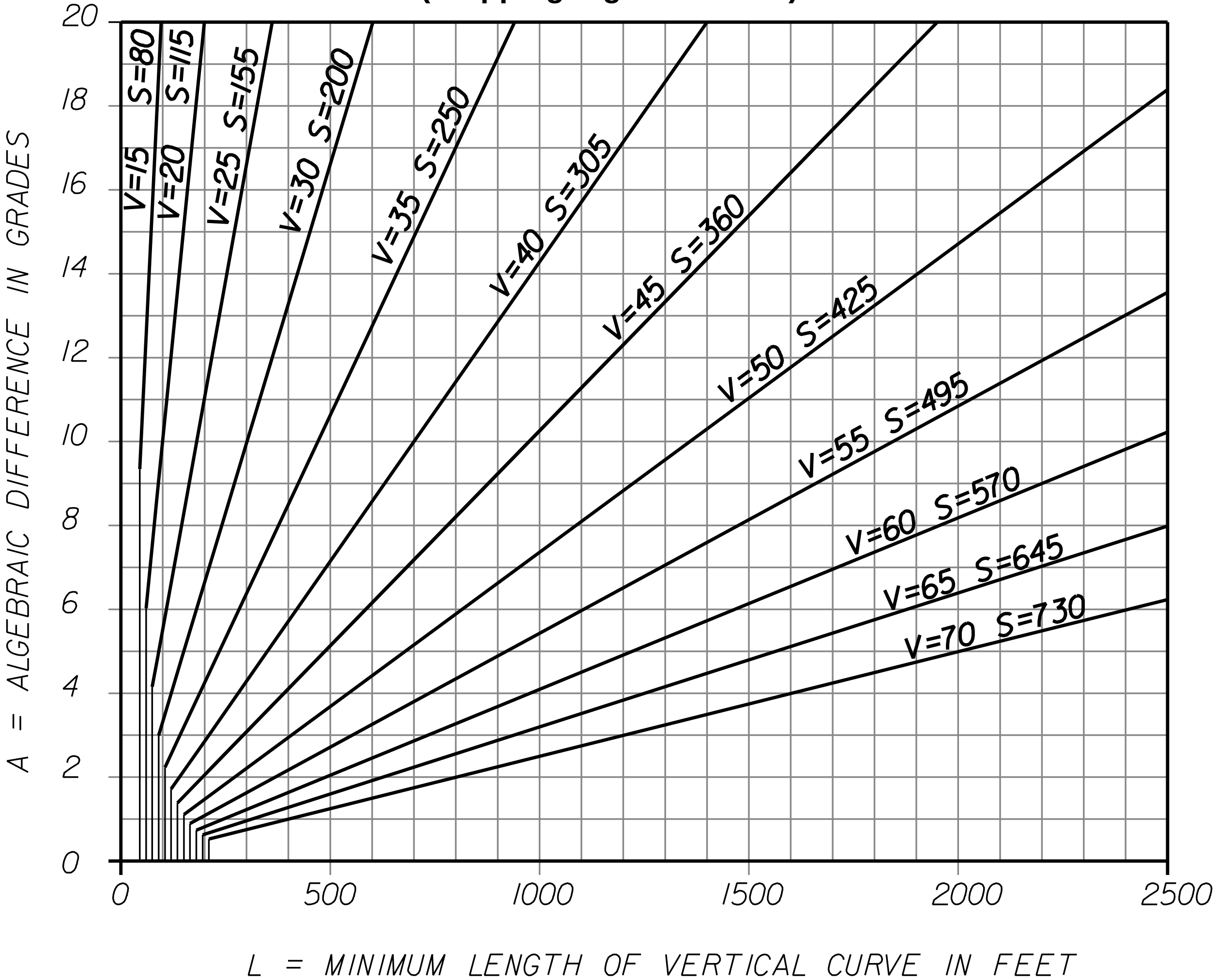
RELATION BETWEEN DEGREE OF CURVE AND VALUE OF MIDDLE ORDINATE NECESSARY TO PROVIDE STOPPING SIGHT DISTANCE ON HORIZONTAL CURVES UNDER OPEN ROAD CONDITIONS.

FIGURE 3 – 3
CRITICAL LENGTH VERSUS UPGRADE



Critical Lengths of Grade for Design, Assumed Typical Heavy Truck of 200 lb/hp, Entering Speed = 70 mph
(REF: Exhibit 3-63, AASHTO A Policy on Geometric Design of Highways and Streets 2001)

FIGURE 3 – 4
LENGTH OF CREST VERTICAL CURVE
(Stopping Sight Distance)

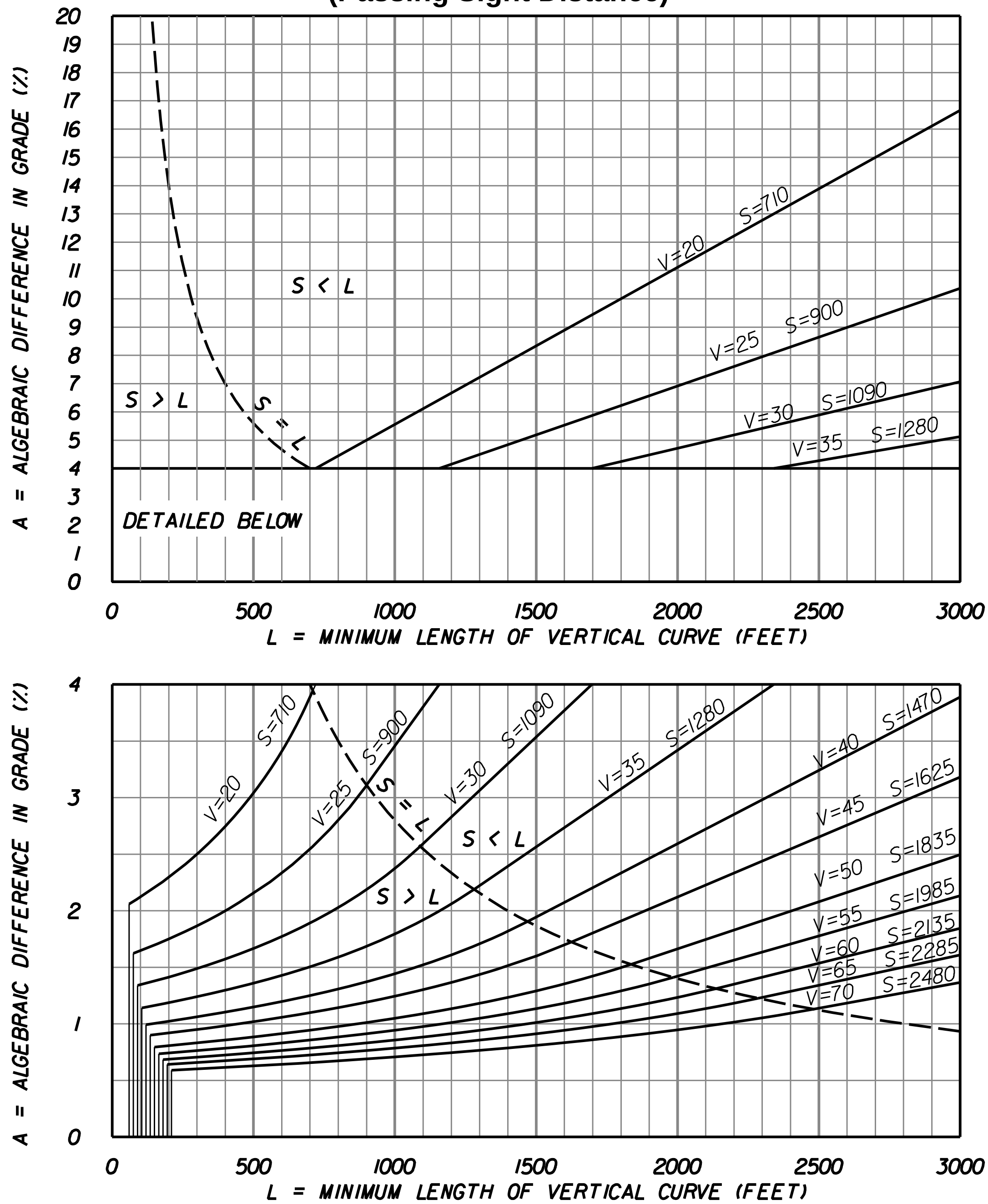


Lengths of vertical curves are computed from the formula:

A = Algebraic Difference In Grades In Percent
S = Sight Distance
L = Minimum Length Of Vertical Curve In Feet

$$L = \frac{AS^2}{1329}$$

FIGURE 3 – 5
LENGTH OF CREST VERTICAL CURVE
(Passing Sight Distance)



The sight distance is computed from the following formulas:

$S < L, \quad L = \frac{AS^2}{2800}$ $\qquad$ $S < L, \quad L = 2S - \frac{2800}{A}$

A = Algebraic Difference In Grades, Percent
S = Sight Distance
L = Length Of Vertical Curve

FIGURE 3 – 6
LENGTH OF SAG VERTICAL CURVE
(Headlight Sight Distance)

Lengths of vertical curves are computed from the formula:

$$L = \frac{AS^2}{400 + 3.5(S)}$$

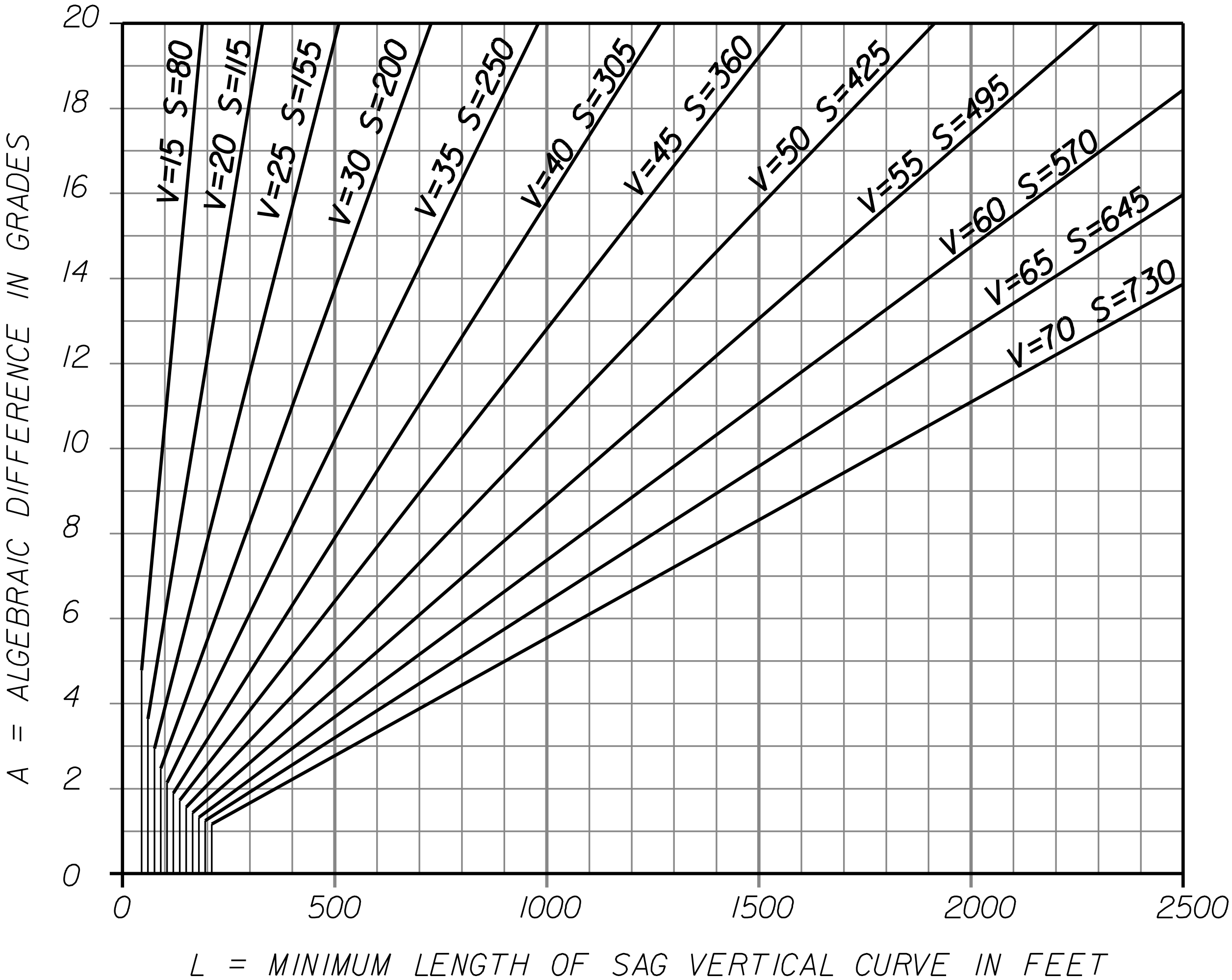
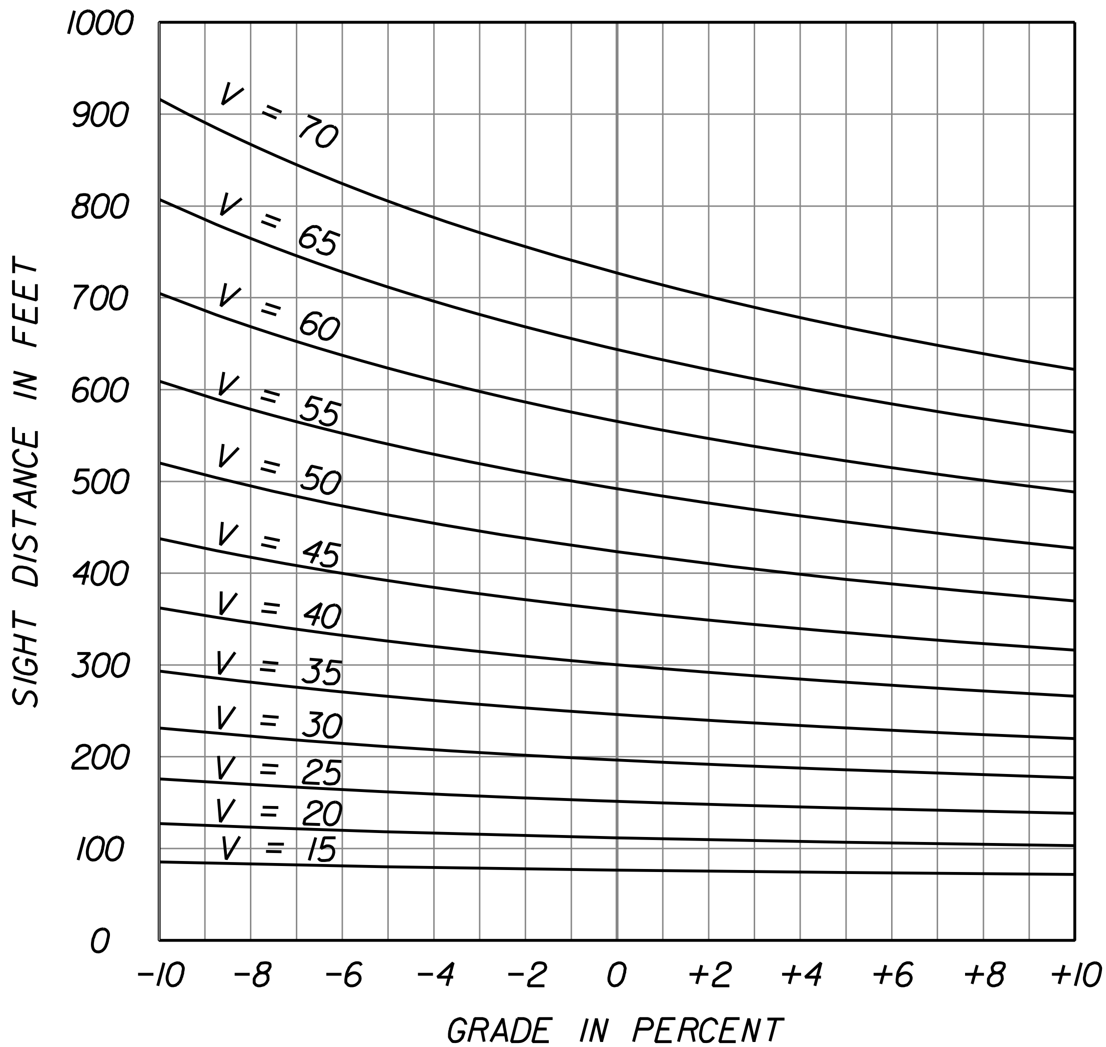


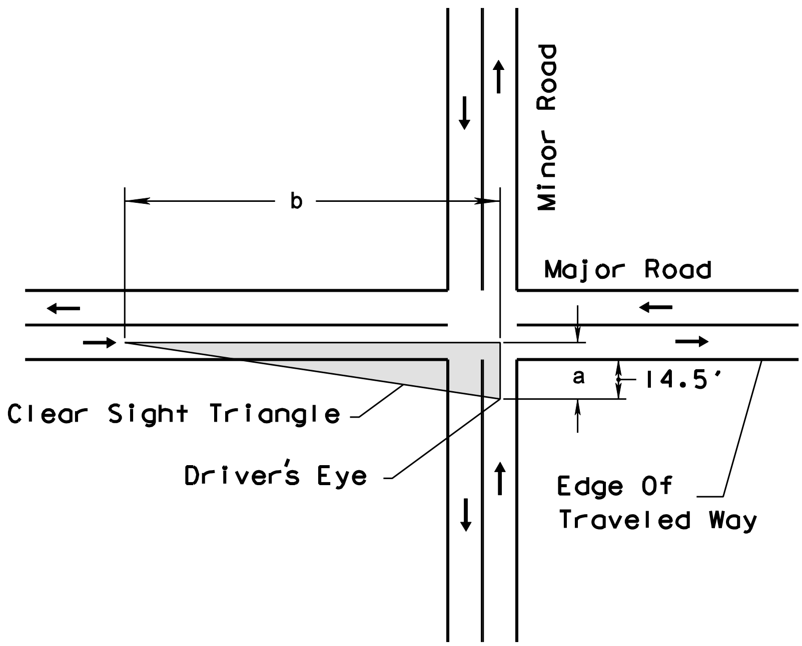
FIGURE 3 – 7
SIGHT DISTANCES FOR APPROACH TO STOP ON GRADES



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

S = Sight Distance
V = Design Speed
G = Grade

FIGURE 3 – 8
DEPARTURE SIGHT TRIANGLE
TRAFFIC APPROACHING FROM LEFT OR RIGHT



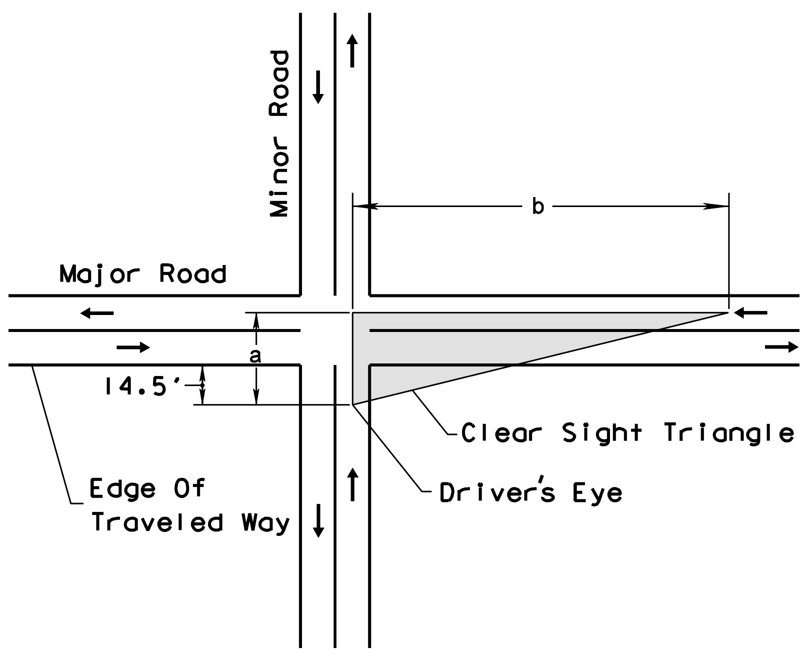
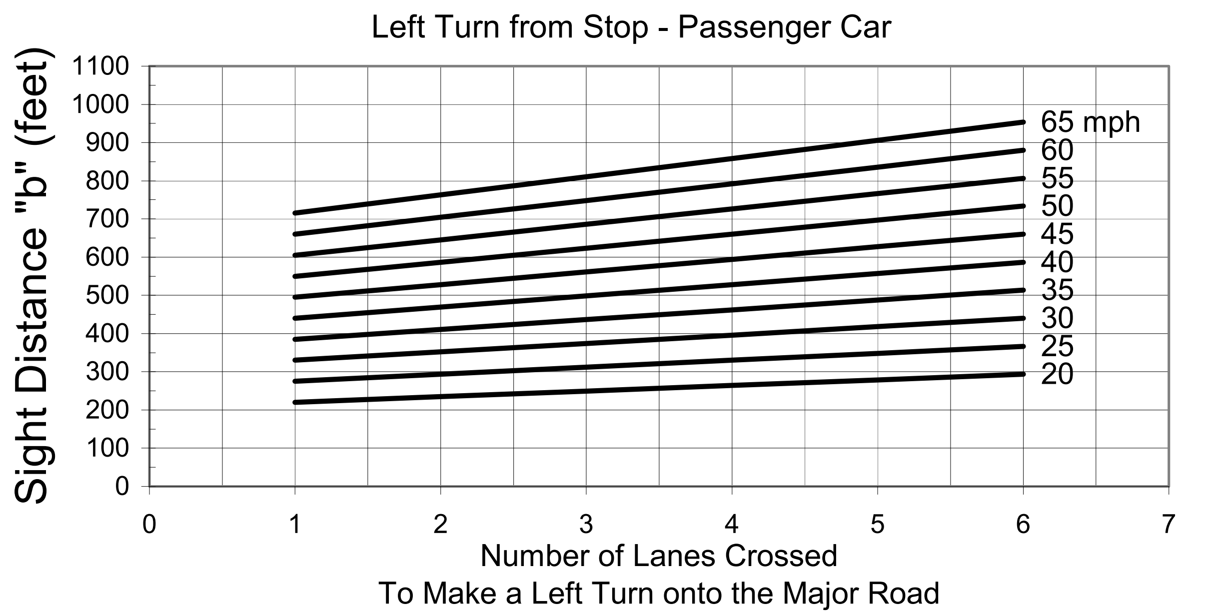
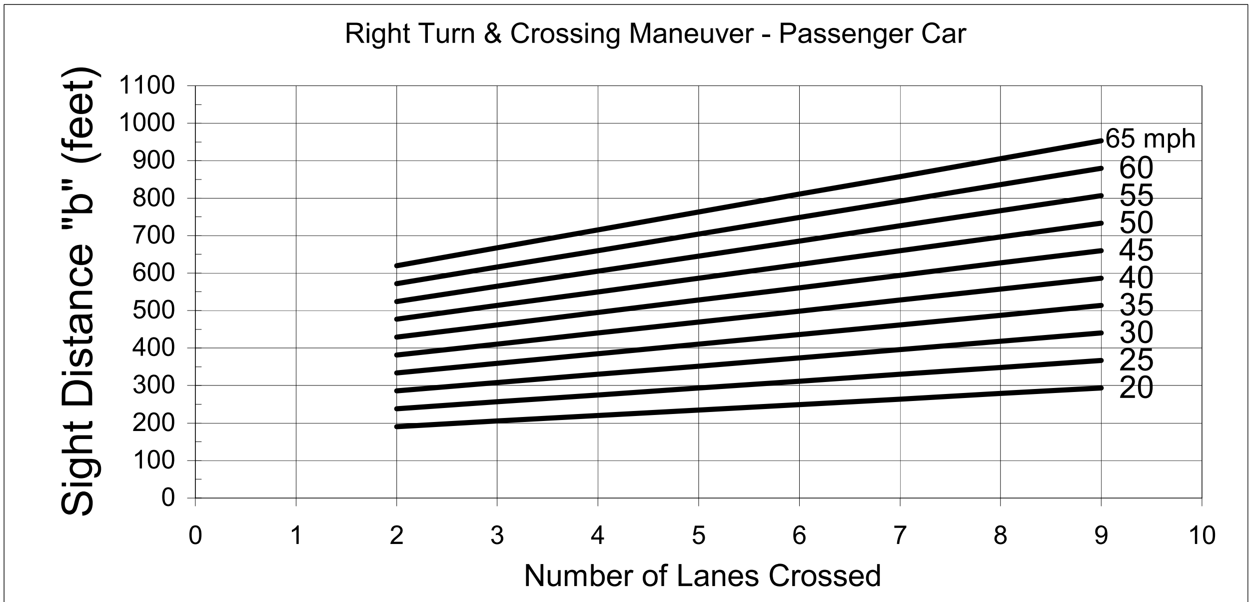


FIGURE 3 – 9
INTERSECTION SIGHT DISTANCE



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.

FIGURE 3 –10
SIGHT DISTANCE FOR VEHICLE TURNING LEFT FROM MAJOR ROAD

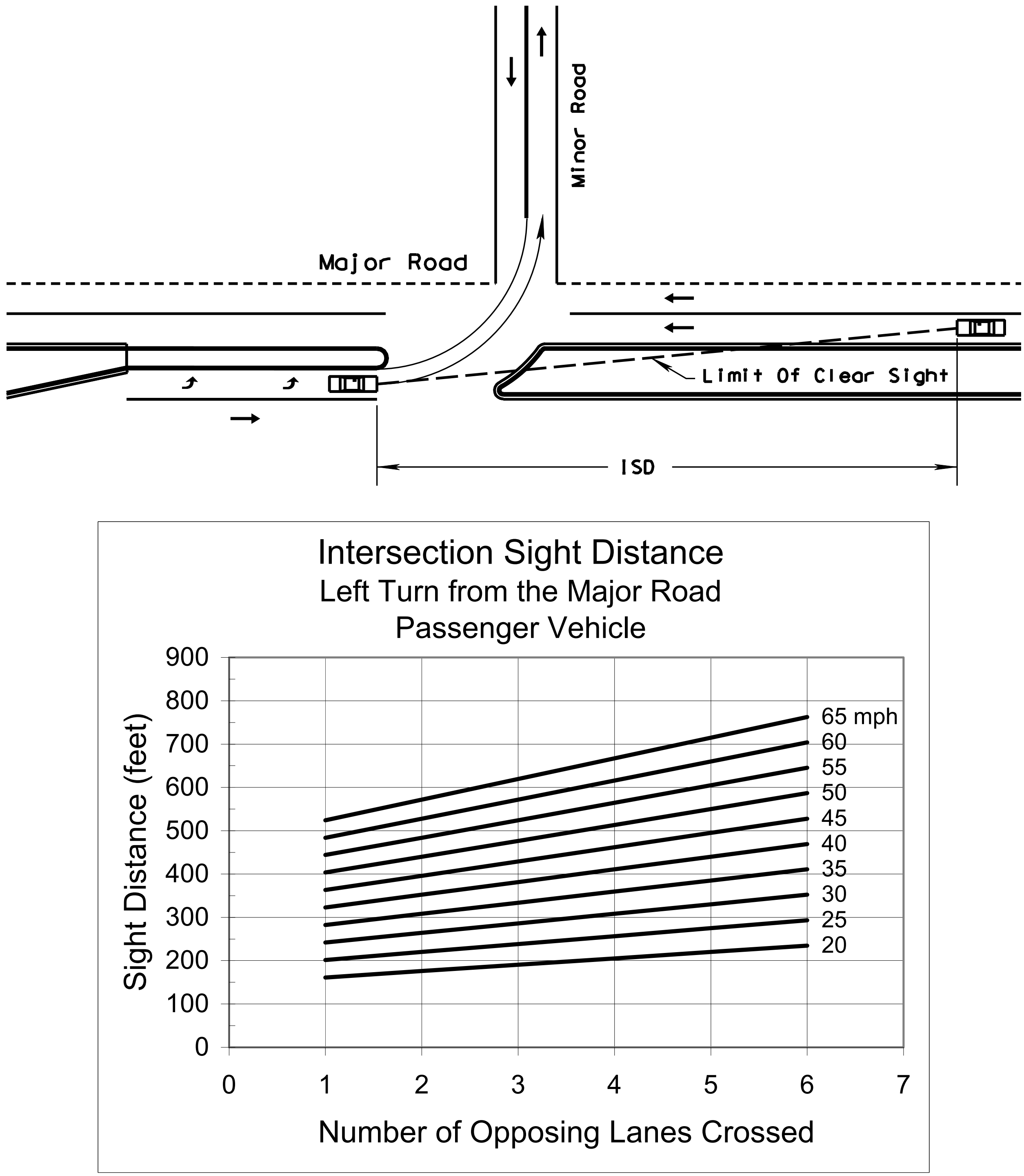


FIGURE 3 – 11
TERMINATION OF MERGING LANES

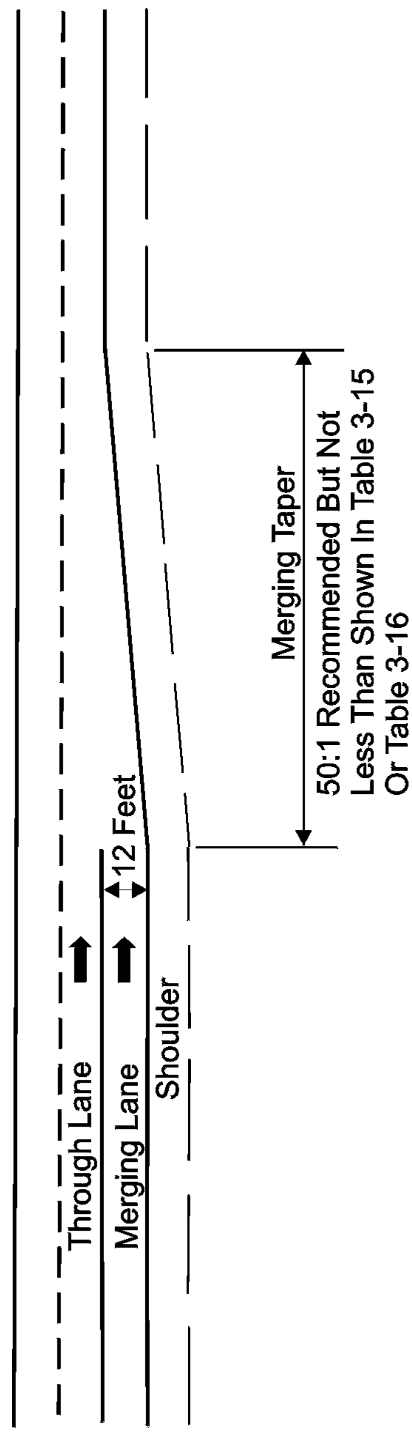


FIGURE 3 – 12
ENTRANCE FOR DECELERATION LANE

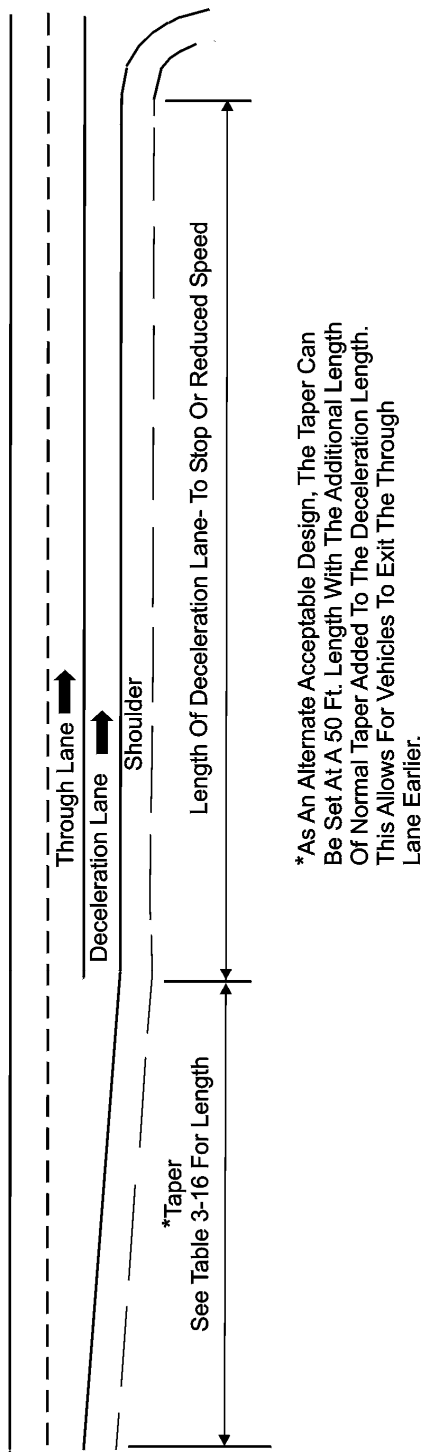
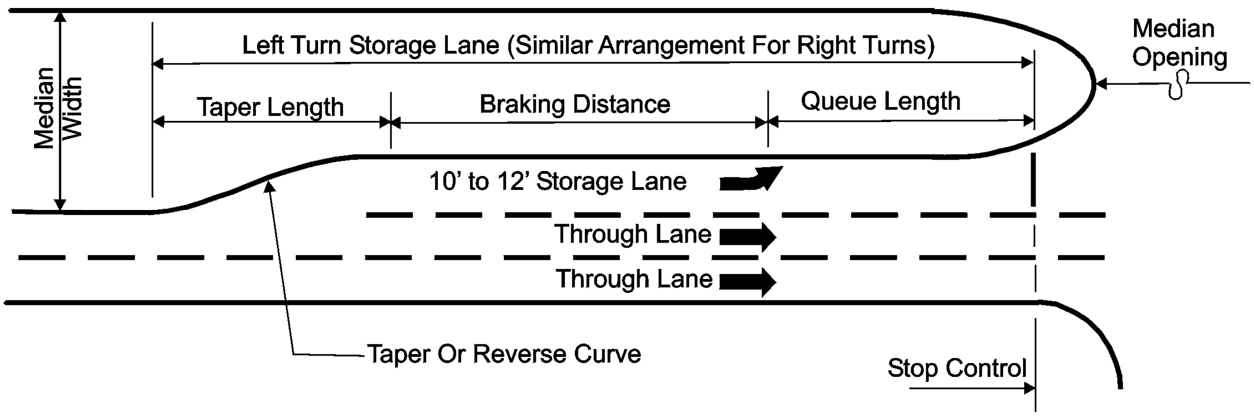


FIGURE 3 – 13
TYPICAL STORAGE LANE



Storage Queue Length - Unsignalized Intersections

Turning Vehicles Per Hour	30	60	100	200	300
Required Storage Length (FEET)	25	50	100	175	250

At signalized intersections, the required queue length depends on the signal cycle length, the signal phasing arrangement, and rate of arrivals and departures of turning vehicles.

In absence of a turning movement study, it is recommended that 100 ft. of queue length be provided in urban/suburban areas and 50 ft. of queue length be provided in rural/town areas as a minimum.

Taper Length And Braking Distance (FEET)

Highway Design Speed (MPH)	Storage Entry Speed* (MPH)	Taper Length[RQ23]	Brake To Stop	
			Urban**	Rural***
35	25	~~70~~	75	---
40	30	~~80~~	75	---
45	35	~~85~~	100	---
50	40/44	~~105~~	135	215
55	48	~~125~~	---	260
60	52	~~145~~	---	310
65	55	~~170~~	---	350

* Reaction Precedes Entry
** Minimum Braking Distance, Wet Conditions
*** Customary Braking Distance, Wet Conditions

The storage lane may be in place of or in addition to deceleration length (See Section C.9.c.3).

Figure 3-14 Clear Zone Plan View

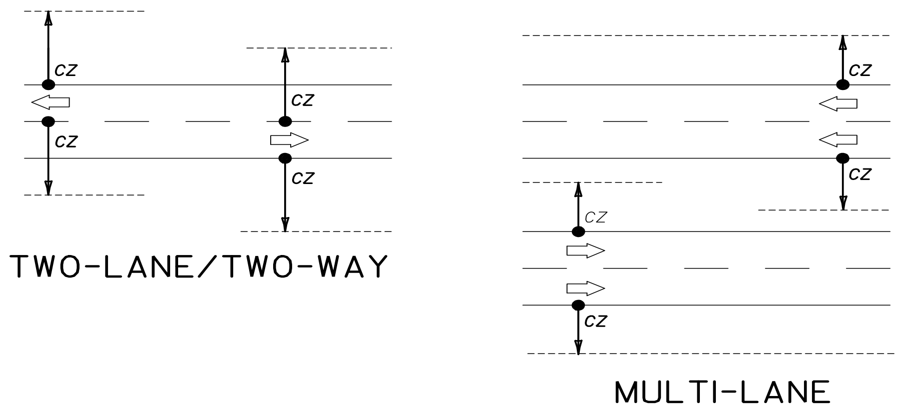
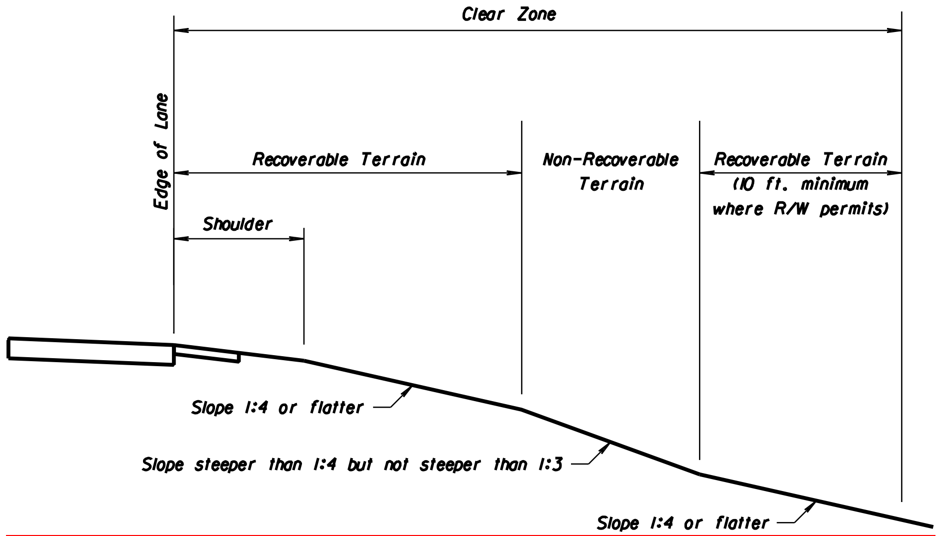


Figure 3-15 Clear Zone Cross Section



Note: Roadside Terrain includes all surfaces along the roadway other than Travel Lanes, Auxiliary Lanes, and Ramps. For the purpose of establishing Clear Zones, Roadside Terrain is defined as recoverable, non-recoverable, non-traversable, and hazardous as follows:

1. Recoverable when it is safely traversable and on a slope that is 1:4 or flatter.
2. Non-recoverable when it is safely traversable and on a slope that is steeper than 1:4 but not steeper than 1:3.
3. Non-traversable when it is not safely traversable or on a slope that is steeper than 1:3.
4. Hazardous when a slope is steeper than 1:3 and deeper than 6 feet.