126 Lane Repurposing Projects

Modification for Non-Conventional Projects:
Delete ***FDM 126***.

126.1 General

Lane repurposing projects (a.k.a., “road diets”, “lane elimination”, or “lane reduction”) are intended to reduce the number of travel lanes to achieve systemic improvements. Generally, the purpose of these projects is to reconfigure the existing cross section to enhance other uses and travel modes. Lane repurposing projects typically contribute to the economic development, livability, and vitality of a community. The recovered travelled way can be used to accommodate other uses such as separated bicycle lanes, buffered bicycle lanes, improving existing sidewalks, adding sidewalks, landscaping, on-street parking, bulb-outs, traffic calming, transit, and pedestrian refuge islands marked with crosswalks. Guidance on the development and review processes for repurposing lanes on the State Highway System (SHS) is provided in the Department’s ***FDOT Lane Repurposing Guidebook***. Lane repurposing projects will not be considered on the Strategic Intermodal System (SIS).

A local government entity (e.g., municipality, county~~, Metropolitan Planning Organization (MPO), Transportation Planning Organization (TPO)~~) or the Department can submit a request for the repurposing of travel lanes on the SHS. A private entity may only submit a request through a local government entity. Proposed lane repurposing projects may be part of a larger community vision. With sufficient advanced planning and analysis, lane repurposing projects are often delivered~~done~~ in conjunction with Resurfacing, Restoration and Rehabilitation (RRR) projects. ~~It is preferred that~~ Identify and analyze lane repurposing projects ~~should be identified should~~ in advance of RRR projects~~ahead of time~~ through a planning exercise such as a district area wide multimodal mobility plan, community vision plan, or downtown redevelopment plan. ~~Approval, by the Chief Engineer, for the lane repurposing must be received prior to the lane repurposing being incorporated into the RRR project.~~ Obtain approval for the lane repurposing project from the Chief Engineer prior to incorporating into a RRR project.

If the project has a PD&E phase, the requirements of this chapter are followed during the PD&E study prior to the selection of a preferred alternative. See ***Part 1, Chapter 2*** of the ***PD&E Manual*** for additional information.

126.2 Requirements

Lane repurposing projects must:

- ~~-C~~Comply with AASHTO and Department design criteria,
- Include a ~~,andmust a~~ safety analysis,~~,~~
- Include network-~~-~~wide traffic analysis with diversion ~~-~~(~~-~~see ***FDOT Traffic Analysis Handbook***),~~.~~
- Be consistent with ***Section 334.61, Florida Statute (F.S.)*** for Traffic Lane Repurposing (a "traffic lane" as described in this ***F.S.*** is the same as "travel lane" as defined in FDM 102.2.)

A Design Exception or Design Variation is required when an existing or proposed design element does not comply with the governing criteria. See ***FDM 122*** for information on Design Exceptions and Design Variations. ~~AnyFor lane~~Lane repurposing projects in the vicinity of interchanges require additional analysis and coordination with FHWA, per the ***FDOT Interchange Access Request User's Guide***.

Lane repurposing projects should be consistent with the relevant Long-Range Transportation Plan (LRTP), Transportation Improvement Program (TIP), and Transit Development Plan (TDP).

The analysis~~Analyze impacts~~ of a lane repurposing project ~~with consideration~~must also consider ~~for~~ the following:

- Utilities
- Access management
- Businesses
- Traffic operations
- Safety
- Pedestrian and bicyclist activities
- Transit and freight routes
- Environmental impacts
- Evacuation routes
- Emergency responders
- Functional classification
- Context classification
- Landscaping (shade or architectural)
- Speed (target, design and posted)
- ~~Traffic impact~~Impacts due to traffic diversion to parallel routes

Four-lane undivided roadways with AADT ≤ 20,000 are typically good candidates for a lane repurposing (e.g., converting to a two-lane, two-way road with a center-left-turn-lane). However, projects are evaluated for lane repurposing feasibility on a case-by-case basis.

If exclusive bus lanes/business access & transit (BAT) lanes are proposed in the lane repurposing project, coordinate with the Office of Modal Development/Public Transit and the local transit agency.

In addition to public involvement requirements in ***Section 334.61 Florida Statute (F.S.)***,~~impacts of lane repurposing projects,~~ conduct public involvement activities in accordance with the ***Public Involvement Handbook.***

126.2.1 Federal-Aid Projects

Follow the National Environmental Policy Act (NEPA) for lane repurposing projects that use federal funding.

126.2.2 Roadway Functional Reclassification

A lane repurposing project can potentially change the functional classification of a roadway, which could affect planning, funding eligibility, traffic analyses, project prioritization, and state and federal reporting requirements.

A request for a change in functional classification requires review and approval by the Department and FHWA. Approval is typically requested during the preliminary review process. More information is provided in the Department's ***Urban Area Boundary and Functional Classification Handbook***~~ Handbook~~. ~~This handbook can be found at the FDOT Transportation Data and Analytics website:~~

~~***https://www.fdot.gov/statistics/tsopubs.shtm***.~~

A proposed change in functional classification of a roadway on the National Highway System (NHS) requires coordination between the Department, local officials, and FHWA.

126.3 Application Process

Follow the lane repurposing process as given in the ***Lane Repurposing Guidebook***. This process allows the applicant, the district, and central office to agree on the purpose, need and methodology of the project.

The application process consists of three main steps: coordination between the Applicant and the District, a preliminary review and approval by the District, and the final review and approval by Central Office (CO). ***FDM 103******The Lane Repurposing Guidebook*** includes the ***Forms 126-A***, ***B***, ***C*** and ***D*** that are utilized during this process. ***Form 126-A*** is used as guidance for project meetings, reports and methodology, ***Form 126-B*** establishes the initial notification to CO Systems Implementation Office (SIO) and ***Form 126-C*** confirms the final review and approval from CO. Temporary, demonstration, or pilot lane repurposing projects must follow the same process as permanent projects.

126.3.1 Project Initiation

(1) The applicant submits the lane repurposing request to the District Lane Repurposing Coordinator.

(2) The applicant submits the required information in the Initial Meeting and Methodology Checklist (***Form 126-A***) to the district prior to the initial meeting.

(3) The District Lane Repurposing Coordinator schedules the initial meeting to discuss the proposed lane repurposing project with the District Review Team and Central Office SIO Review Team, which includes the following Ddistrict offices and positions:

(a) Planning

(b) Environmental Management

(c) Modal Development

(d) Design

(e) Safety

(f) Traffic Operations

Central Office Lane Repurposing Coordinator and Systems Management Administrator

(f)(g)

(4) The applicant attends this initial meeting to discuss the process and requirements of the lane repurposing request.

(5) The District Lane Repurposing Coordinator submits the initial notification to the Central Office Systems Implementation Office (SIO). This will include:

(a) Initial Meeting and Methodology Checklist (***Form 126-A***)

(b) Meeting Minutes

(c) Initial Notice to Central Office (***Form ~~126-~~B***), with concurrence from the District Planning and Environmental Administrator, District Design Engineer and District Traffic Operations Engineer.

(6) The Central Office Systems Management Administrator will review and approve or deny the proposed traffic analysis methodology.

126.3.2 District Preliminary Review

The District Preliminary Review is as follows:

(1) The applicant will submit a draft concept report containing a proposed typical section to the District Lane Repurposing Coordinator for review.

(2) The District Lane Repurposing Coordinator will coordinate the review of the project and concept report with the District Review Team.

After the District reviewer's acceptance, a Final Concept Report must be signed at the District level and submitted along with **Form ~~126-~~C** ~~and signed at the District level~~ to CO for review. The District Lane Repurposing Coordinator will work closely with CO staff during this review phase.

126.3.3 Central Office Final Review and Approval

The final review and approval process is to obtain the Chief Engineers final approval or disapproval. Follow the process found in the Lane Repurposing Guidebook.

The Final Review and Approval process is as follows:

(1) The District Lane Repurposing Coordinator submits the Final Review and Approval Notice to the Central Office Systems Implementation Office (***Form ~~126-~~C***), signed by the District Planning and Environmental Administrator, the District Design Engineer, and the District Traffic Operations Engineer, along with the Final Concept Report.

(2) The Systems Implementation Office coordinates the review of the lane repurposing request with the different offices in Central Office (e.g., Design, Traffic Engineering and Operations) and obtains concurrence from the Chief Planner.

(3) The Systems Implementation Office submits the lane repurposing request for obtaining the final approval or denial to the Chief Engineer. The Chief Engineer has the final authority to approve, deny or object (with comments) to the lane repurposing request.

(4) The Systems Implementation Office submits notification to the District Lane Repurposing Coordinator of the Chief Engineer's decision.

(a) Approved: application process is complete.

(b) Denied: includes an explanation for the denial.

(c) Objection with comments: the applicant may resubmit the lane repurposing proposal to the District, once the comments have been addressed. The resubmittal must include an updated concept report and signed ***Form 126-C*** (included in ***FDM 103***).

(5) Use ***Form D*** to withdraw projects that have been previously approved.

210 Arterials and Collectors

210.1 General

Design criteria presented in this chapter apply to new construction and reconstruction projects on arterials and collectors on the State Highway System. Roadways not on the State Highway System which are impacted by these new construction and reconstruction projects should also be designed in accordance with this manual; however, districts may allow the use of the Manual of Uniform Minimum Standards for Design, Construction and Maintenance for Streets and Highways (commonly known as the "***Florida Greenbook***").

This chapter also provides minimum criteria to be used with Resurfacing, Restoration, and Rehabilitation (RRR) projects as described in ***FDM 210.1.1***.

Facilities on the Strategic Intermodal System (SIS) are subject to special standards and criteria for number of lanes, Design Speed, access, and Level of Service. Design all SIS and Emerging SIS Highway Intermodal Connectors in accordance with the SIS criteria contained in this manual. With approval by the District Design Engineer, the ***Florida Greenbook*** may be used on SIS facilities that are not on the State Highway System.

Many design criteria are related to Design Speed; e.g., vertical and horizontal geometry, sight distance. The minimum design values are closely related to traffic safety and require an approved Design Exception or Design Variation when they are not met. See ***FDM 201*** for information on Design Speed. See ***FDM 122*** for information on Design Exceptions and Design Variations.

Example roadway typical sections are included in the exhibits in ***FDM 913***. Criteria regarding lanes, medians, and shoulders for bridges are illustrated in ***FDM 260.1.1.*** Subsequent sections of this chapter contain specific information and criteria regarding these and other typical section elements, as well as geometric features.

Existing project features which were constructed to meet minimum metric design criteria but are mathematically slightly less than equivalent minimum English design criteria do not require Design Exceptions or Design Variations to remain.

210.1.1 Criteria for RRR Projects

Criteria for RRR projects provided in this chapter are the minimum values allowed for roadway and structure elements to remain on the State Highway System without obtaining a Design Exception or Design Variation (see ***FDM 122***). Existing project features are to meet new construction criteria when RRR criteria are not provided.

New features installed on RRR projects are to meet new construction criteria. However, RRR criteria may be used for establishing the minimum requirements for adding auxiliary lanes, keyhole lanes, or other minor intersection improvements with the understanding that when existing R/W is adequate, new construction criteria will be used to the maximum extent feasible.

210.1.2 Railroad-Highway Grade Crossing

If a railroad-highway grade crossing is within or near the limits of the project, and there are federal funds associated with the project, see ***FDM 220.2.4*** for requirements.

210.1.3 Aviation and Spaceports

If an airport or spaceport is within 10 nautical miles of the project, refer to ***FDM 110.5.1*** for requirements.

210.2 Lanes

Design criteria for lane widths and pavement slopes are given by lane type, Design Speed and context classification. Minimum travel, auxiliary, and two-way left-turn lane widths are provided in ***Table 210.2.1***. Refer to ***FDM 202*** for speed management information and ***FDM 211*** for ramp lane widths.

Additional traveled way width may be provided in curves on undivided 2-lane roadways to accommodate large trucks. See ***AASHTO Green Book***, ***Section 3.3.10*** for guidance and information on traveled way widening in horizontal curves. Two-way left-turn lane widths (flush median) may be used on 3-lane and 5-lane typical sections with Design Speeds ≤ 40 mph. On new construction projects, flush medians are to include sections of raised or restrictive median and islands to enhance vehicular, bicycle, and pedestrian safety, improve traffic efficiency, and attain the standards of the Access Management Classification of that highway system. Sections of raised or restrictive median and islands are recommended on RRR projects.

Table 210.2.1 Minimum Travel and Auxiliary Lane Widths

Context Classification		Travel (feet) Design Speed (mph)			Auxiliary (feet) Design Speed (mph)			Two-Way Left Turn (feet) Design Speed (mph)	
		25-35	40-45	≥ 50	25-35	40-45	≥ 50	25-35	40
C1	Natural	~~11~~N/A	~~11~~N/A	12	~~11~~N/A	~~11~~N/A	12	N/A	
C2	Rural	~~11~~N/A	~~11~~N/A	12	~~11~~N/A	~~11~~N/A	12		
C2T	Rural Town	11	11	~~12~~N/A	11	11	~~12~~N/A	12	12
C3	Suburban	10	11	12	10	11	12	11	12
C4	Urban General	10	11	~~12~~N/A	10	11	~~12~~N/A	11	12
C5	Urban Center	10	~~11~~N/A	~~12~~N/A	10	~~11~~N/A	~~12~~N/A	11	~~12~~N/A
C6	Urban Core	10	~~11~~N/A	~~12~~N/A	10	~~11~~N/A	~~12~~N/A	11	~~12~~N/A

Notes:

N/A indicates this combination of Context Classification, Lane Width, and Design Speed is outside the intended design range and should be avoided. See ***Table 201.5.1*** for context classifications and design speed ranges.

Travel Lanes:

1. Minimum 11-foot travel lanes on designated freight corridors, SIS facilities, or when truck volumes exceed 10% on very low-speed roadways (Design Speed ≤ 35 mph) (regardless of context classification).
2. Minimum 12-foot travel lanes on all undivided two-lane, two-way roadways. However, very low-speed and low-speed table values may be used for roadway sections with both of the following:
   a. C2T, C4, C5 or C6 context classification
   b. Tangent horizontal alignment or curve radii large enough to accommodate the design vehicle within the travel lane in accordance with ***AASHTO Green Book, Section 3.3.10***
3. Consider wider lanes on very low-speed roadways (Design Speed ≤ 35 mph) when transit is present.
4. Travel lanes should not exceed 14 feet in width.
5. On RRR projects, 11-foot lanes may remain on divided multilane roadways with C3 context classifications and 50 mph design speeds.

Auxiliary Lanes:

~~(1) Auxiliary lanes are typically the same width as the adjacent travel lane.~~

~~(2)~~(1) Table values for right turn lanes may be reduced by 1 foot when a bicycle keyhole is present.

~~(3)~~(2) Median turn lanes should not exceed 15 feet in width.

~~(4)~~(3) For high-speed curbed roadways, 11-foot minimum lane widths are allowed for the following:

- Dual left turn lanes.
- Single left turn lanes at directional median openings.

~~(5)~~(4) For RRR projects, 9-foot right-turn lanes are allowed on very low-speed roadways (Design Speed ≤ 35 mph).
Two-Way Left-Turn Lanes: ~~Two-way left turn lanes are typically one foot wider than the adjacent travel lanes.~~
For RRR projects, the values in the table may be reduced by 1-foot.

210.2.1 Bicycle Lanes

FDM 223 contains criteria for the accommodation of bicyclists.

210.2.2 Transit Facilities

Coordinate with the District Modal Development Office and local transit agency for the need for public transit facilities. ***FDM 225*** contains additional guidelines for street side bus stop facilities, location, and design.

210.2.3 On-Street Parking

On-street parking is a key element of urban contexts C6, C5, and C4, but may also be found in C2T. It provides necessary parking supply in these locations, helps manage traffic speeds, and provides separation between the sidewalk and the travel lanes. In these context zones, leave existing on-street parking in place unless local plans call for its removal. Where on-street parking is not present in C6, C5, or C4, determine whether it should be added per local plan, for speed management, or to increase available parking.

On-street parking is allowed on facilities with Posted Speeds of 35 mph or less. It is typically located at the outside edge of the roadway between the travel lane and the sidewalk. In C6 and C5 contexts it may sometimes be located within the median of a divided low-speed urban street. Median parking provides additional parking supply as well as speed management.

On-street parking may be either parallel or angle (traditional or reverse). See ***Chapter 316, F.S.*** for laws governing parking spaces.

Standard Plans, Index 711-001 provides dimensions and additional requirements for on-street parking.

See ***FDM 223*** for bicycle accommodations on roadways with on-street parking.

Parking restrictions to assure adequate clear sight triangles are provided in ***FDM 212.11.5***.

210.2.3.1 Existing On-Street Parking

For RRR projects with existing on-street parking and a Posted Speed greater than 35 mph, process a single Design Variation that addresses all of the following design elements:

- Intersection Sight Distance
- Stopping Sight Distance (as applicable)
- On-street parking

The single Design Variation described above should include all affected intersections within a corridor; i.e., it is not necessary to process individual Design Variations for each location. In addition to processing a Design Variation, consider the following mitigation strategies:

- Use speed mitigation strategies described in ***FDM 202*** to achieve a Target Speed of 35 mph.
- When possible, provide a 2-foot wide buffer between the on-street parking spaces and the travel lane.

210.2.4 Pavement Cross Slopes

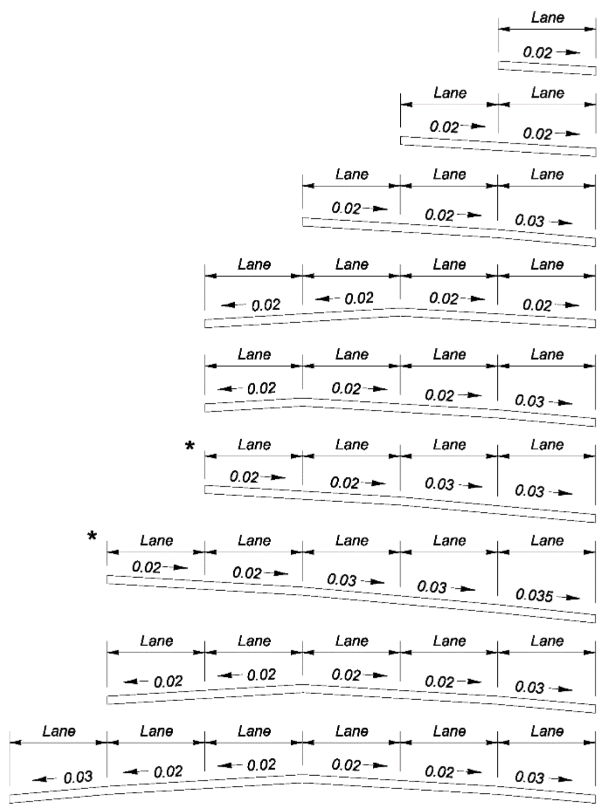
For roadways, the maximum number of travel lanes with cross slope in one direction is three lanes, except as shown in ***Figure 210.2.1***, which prescribes standard pavement cross slopes. A Design Variation or a Design Exception is required when proposed pavement cross slopes do not meet the requirements shown in ***Figure 210.2.1***.

Outside auxiliary lane cross slopes must match or exceed the adjacent travel lane cross slope. The outside auxiliary lane cross slope cannot exceed the values in ***Figure 210.2.1***. In superelevation transitions for separated free-flow turning roadways, do not exceed the maximum algebraic differences shown in ***Table 210.2.2.***

The maximum algebraic difference in cross slope between adjacent through lanes is 0.04. The maximum algebraic difference in cross slope between a through lane and an auxiliary lane at a turning roadway terminal is given in ***Table 210.2.2***.

Cross slopes on bridges are to be on a uniform, straight-line rate, typically 0.02 (see ***FDM 260.4***). Use transitions to adjust for differences in cross slope between the approach roadway section and the required straight-line slope for bridge decks. Whenever possible, the transition should be accomplished on the roadway section, outside the limits of the bridge and approach slabs. This will require detailing of the transition(s) in the roadway plans. Coordination between the Roadway, Drainage and Structures designers in the development of transitions is required to ensure compatibility and harmonizing at bridge approaches.

Figure 210.2.1 Standard Pavement Cross Slopes



All Travel Lanes One Direction

__Notes:__

(1) These sections show only the standard slopes for adjoining travel lanes; they do not prescribe needed lanes, lane usage or typical section requirements other than lane slope. These slopes are not applicable to parabolic crowns.

(2) Maximum pavement cross slopes for tangent sections are:

   (a) 0.04 for Design Speeds of 45 mph or less

   (b) 0.03 for Design Speeds greater than 45 mph

   (c) 0.035 may only be used for 5-lanes sloped in one direction as shown above.

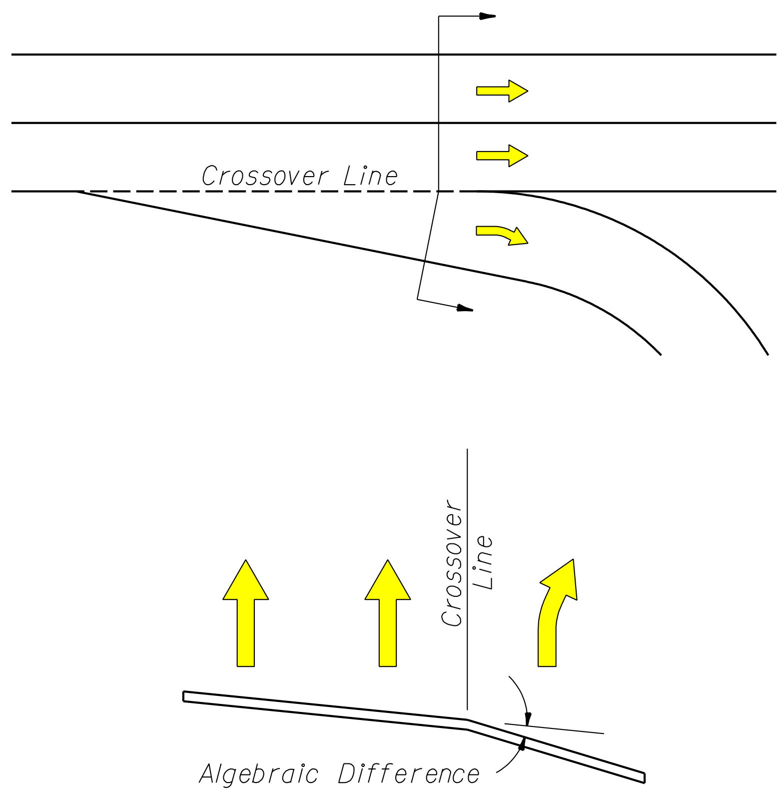
(3) The maximum change in cross slope between adjacent through lanes is 0.04.

(4) Slopes on multi-purpose lanes may be 0.03 to 0.05. Portions of multi-purpose lanes that are reserved for parking and access isles for the physically disabled are to have cross slopes not exceeding 1:50 (0.02) in all directions.

(5) 4 or 5 lanes sloped in one direction (*) may be used with Design Speeds of 65 mph or less and longitudinal grades not exceeding 5%.

Table 210.2.2 Maximum Algebraic Difference in Cross Slope at Turning Roadway Terminals

Design Speed of Exit or Entrance Curve (mph)	Maximum Algebraic Difference in Cross Slope at Crossover Line (%)
Less than 35	6.0
35 and over	5.0



210.2.4.1 RRR Criteria for Cross Slopes

Review the existing pavement and shoulder cross slopes for compliance with criteria. Field-verify existing pavement and shoulder cross slopes by one of the following:

(1) Full Digital Terrain Model for the roadway width – evaluate cross slope on tangent sections at 100-foot intervals.

(2) Vehicle Mounted Scanner – prior to design, using the results of the scan, determine roadway limits where cross slope is potentially out of tolerance and request Digital Terrain Model of the roadway width for these limits. Evaluate cross slope on tangent sections at 100-foot intervals.

If cross slopes do not meet the values in ***Table 210.2.3***, additional cross sections may be required to develop cross slope correction details and estimate material quantities. Resurfaced pavement and shoulder cross slopes should meet new construction criteria. When cross slope correction is not practical, documentation in the design file is required. If existing conditions are within the allowable ranges shown in ***Table 210.2.3***, the term "Match Existing" may be used on the Typical Section(s) to indicate that the existing cross slope is to remain. Superelevation requirements are covered in ***FDM 210.9***.

When cross slope correction is necessary, work closely with the District Pavement Design Engineer and the District Pavement Materials Engineer to determine the appropriate method of correction. Tabulate existing cross slopes in the plans at 100-foot intervals within the limits of cross slope correction. Include cross slope correction details showing the method of correction in the plans (see examples in ***FDM 913***). Do not show cross slope correction details on the roadway cross sections. Base cross slope correction material quantities on the method of correction shown in cross slope correction details.

Table 210.2.3 RRR Criteria for Existing Roadway Cross Slopes

Facility or Feature	Standard (ft/ft)	Allowable Range (ft/ft)
Two-Lane Roads	0.020	0.015 - 0.030
Multilane Roads	0.020	0.015 - 0.040
	0.030	0.025 - 0.040
	0.035	0.030 - 0.040
Outside Shoulders	0.060	Adjacent Lane Cross Slope - 0.080
Inside Shoulders	0.050	0.020 - 0.080
Parking Lanes	0.050	0.015 - 0.050

Notes:

(1) Existing multilane curbed roadways may have outside travel or auxiliary lanes with a maximum cross slope of 0.05.

(2) Outside auxiliary lanes on flush shoulder roadways must match or exceed the adjacent travel lane cross slopes with a maximum cross slope of 0.04.

(3) The maximum algebraic difference between adjacent through lanes must not exceed 0.06.

(4) When existing shoulders are to remain, the algebraic difference between the shoulder cross slope and adjoining roadway pavement cross slope must be ≤ 0.07.

(5) Parking spaces and access aisles dedicated to serving persons with disabilities must have cross slopes no steeper than 0.02 (1:50) in any direction.

Existing curbed roadways originally constructed with a parabolic crown section may be resurfaced using a series of tangents with a cross slope range from 0.015 to 0.05.

210.2.4.2 Hydroplaning Risk Analysis

Hydroplaning risk analysis procedures are outlined in ***FDM 211***. A hydroplaning risk analysis is required for projects with design speeds greater than or equal to 45 mph and cross slopes that do not meet the requirements shown in ***Figure 210.2.1*** or ***Table 210.2.3***. This analysis supports the utilization of a non-standard typical section and the benefit-cost analysis of correcting pavement cross slope. ~~The hydroplaning risk analysis predicts the water film thickness on the pavement being analyzed and the speed at which hydroplaning may occur. This information may support utilizing a non-compliant typical section when weighed against the cost of correcting pavement cross slope.~~ For projects with Design Speeds of 60 mph or greater with 3 or more lanes sloped in one direction, refer to ***FDM 211*** for guidance determination offor when a hydroplaning risk analysis is required and analysis procedures. Hydroplaning risk analysis procedures are outlined in ***FDM 211***.

210.2.5 Lane Tapers

The minimum merging roadway transition length (L) is calculated as follows:

(1) Use $L = (W*S^2)/60$ for Design Speeds ≤ 40 mph

(2) Use $L = W*S$ for Design Speeds ≥ 45 mph

Where: L = length of taper, feet

W = width of lateral transition, feet

S = Design Speed, mph

Exhibits 210-1 through ***210-6*** illustrate standard roadway transitions. For conditions not addressed in these exhibits, use the following minimum taper lengths:

- Merging Taper = L
- Shifting Taper = L/2
- Shoulder Taper = L/3

Where there is an abrupt change in roadway typical section (e.g., a 4-lane section to a 6-lane section), a striped lane transition may be considered when all the following conditions are met:

- New pavement widths are not substantially greater than the joining pavement,
- Grade differentials are slight, and
- Future widening is expected.

210.2.6 Number of Lanes on the State Highway System

See ***Section 335.02(3)*** of the ***Florida Statutes*** for the number of lanes to be provided on the State Highway System. Nothing in this statute precludes a number of lanes in excess of ten lanes. The Department will determine the appropriate number of lanes based on traffic demand. Consideration will be given to availability of right of way and the capacity to accommodate other modes of transportation within existing rights of way.

Exceptions to ***Section 335.02(3)*** of the ***Florida Statutes*** will be addressed on a case-by-case basis, with final approval resting with the FDOT Secretary.

Exhibit 210-1: Lane Divergence/Convergence

Exhibit 210-2: Paved Shoulder Treatment

Exhibit 210-3: 2 to 4 Lane Transitions: Left Roadway Centered

Exhibit 210-4: 4 to 2 Lane Transition: Left Roadway Centered

Exhibit 210-5: 2 to 4 Lane Transition: Right Roadway Centered

Exhibit 210-6: 4 to 2 Lane Transition: Right Roadway Centered

210.3 Medians, Islands, and Hardened Centerlines

210.3.1 Medians

Median width is expressed as the dimension between the inside edges of travel lanes. Medians perform the following functions:

- Provide separation of opposing traffic to minimize risk of head-on crashes,
- Provide a recovery area for errant vehicles,
- Provide a stopping area in case of emergencies,
- Allow space for speed changes and storage of left-turning and U-turning vehicles,
- Minimize headlight glare,
- Provide width for future lanes,
- Provide pedestrian refuge,
- Control access.

Provide a raised or restrictive median (i.e., not a two-way left turn lane or centerline pavement marking) on divided roadways that have a Design Speed of 45 mph or greater. Median widths for divided roadways are given in ***Table 210.3.1***.

Median ditches must be designed to meet the following requirements:

- Have sufficient depth to provide positive drainage of the adjacent sub-grades. Typically, this requires a median depth of at least one foot below the sub-grade shoulder point.
- Have recoverable side slopes within the clear zone in order to facilitate the recovery of errant vehicles. See ***FDM 215*** for additional information on roadside safety.
- Have sufficient longitudinal gradient and hydraulic capacity to ensure good drainage.

See ***FDM 260.5*** for information on bridge medians.

Table 210.3.1 Median Widths

Context Classification		Curbed Roadways and Flush Shoulder Roadways (feet)		High Speed Curbed Roadways (feet)	Flush Shoulder Roadways (feet)
		Design Speed (mph)			
		25-35	40-45	50-55	≥ 50
C1	Natural	N/A	N/A	30	40
C2	Rural	N/A	N/A	30	40
C2T	Rural Town	15.5	22	N/A	N/A
C3	Suburban	22	22	30	40
C4	Urban General	15.5	22	N/A	N/A
C5	Urban Center	15.5	N/A	N/A	N/A
C6	Urban Core	15.5	N/A	N/A	N/A

Notes:

(1) On reconstruction projects where existing curb locations are fixed due to severe right of way constraints, the minimum median width may be reduced to 19.5 feet for Design Speeds = 45 mph, and to 15.5 feet for Design Speeds ≤ 40 mph.

(2) A minimum 6-foot median may be used within C5 and C6 context classifications only where left-turn lanes are not expected.

(3) N/A indicates this combination of Design Speed and context classification is outside the intended design range and should be avoided. See ***Table 201.5.1*** for context classifications and Design Speed ranges.

210.3.2 Islands

An island is an area between traffic lanes that provides one or more of these primary functions:

(1) Channelization Islands: To control and direct traffic movements (usually turning) at intersections or driveways.

(2) Median Islands and Traffic Separators: To separate traffic in opposing or same direction (usually through movements), manage access points and turning movements, provide for delineation of narrow roadway medians, and provide for drainage. Typically referred to as "divisional islands" when separating traffic in opposing directions.

(3) Refuge Islands: To provide refuge for pedestrians.

Islands are generally elongated or triangular in shape and are located in areas where motorized vehicle use is restricted. The placement of mast arms in channelizing islands is discouraged.

Island delineation is divided into three types:

(1) Curbing that raises the island,

(2) Pavement markings or reflectorized markers placed on paved areas,

(3) Pavement edges, possibly supplemented by delineators or a mounded-earth treatment beyond and adjacent to the pavement edges.

Delineation of small islands is primarily by curbs. Large curbed islands may be sufficiently delineated by color and texture contrast of vegetative cover, mounded earth, shrubs, signs, or any combination of these. Use tubular markers at island noses as channelizing devices in addition to delineation. Curbed islands should not be used on high-speed flush shoulder roadways. Standard markings for islands are provided in the ***Standard Plans*, Index 711-001**. See ***FDM 202*** for more information on speed management.

210.3.2.1 Channelization Islands

Islands must be large enough to command attention. Meet the following requirements when designing channelization islands:

(1) Curbed islands should have an area of 100 square feet or more, however, must not be less than:

    (a) 50 square feet for intersections within C4, C5, or C6 context classifications

    (b) 75 square feet for intersections within C1, C2, C2T or C3 context classifications

(2) Triangular islands should be at least 15 feet on a side, but not less than 12 feet after rounding of corners.

(3) Side dimensions of curbed islands should not exceed 100 feet on high-speed facilities (e.g., high-speed curbed roadway).

The approach and departure noses are rounded with radii of at least 3.5 feet. ***Figure 210.3.1*** illustrates a small island with a parallel offset. ***Figure 210.3.2*** illustrates a large island with a tapered offset.

Approach ends of the island should be offset from the edges of the traveled way in order to funnel drivers smoothly into the desired path. The amount that a curbed island is offset from the through-traffic lane is influenced by the type of edge treatment and other factors such as island contrast, length of taper or auxiliary pavement preceding the curbed island. If a bike lane is adjacent to an island curb, no offset is needed.

Figure 210.3.1 Typical Small Curbed Island

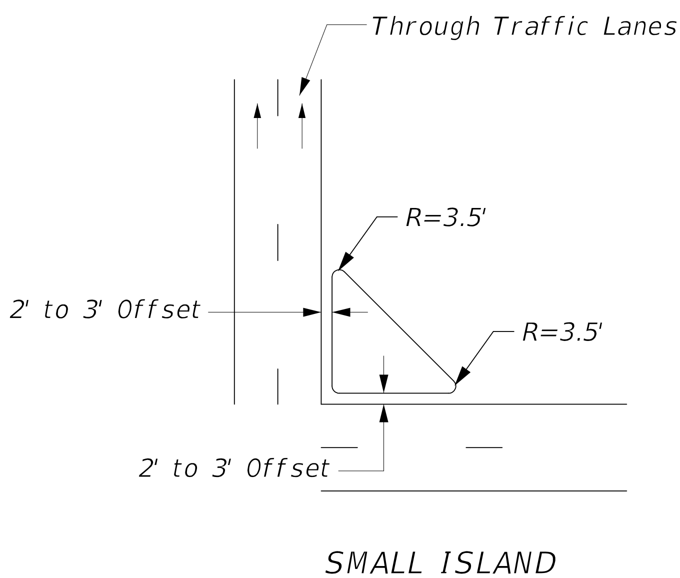
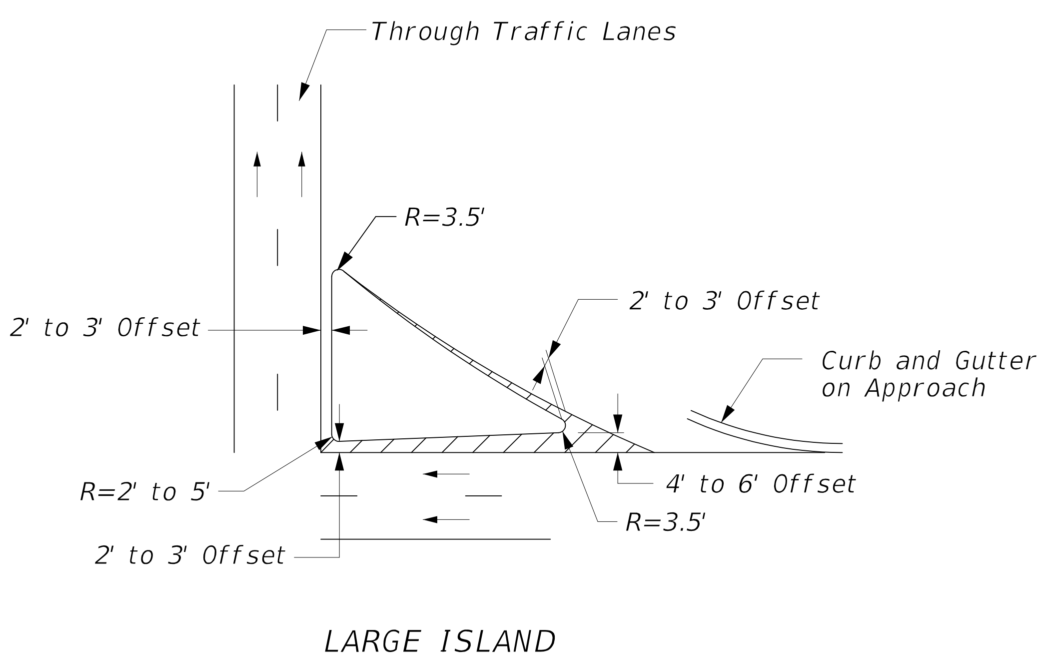


Figure 210.3.2 Typical Large Curbed Island



Where there are no curbs on the approach traveled way, the minimum offset of the edge of the curbed island to the through lane should be 1.5 to 3.5 feet. Where the approach roadway has a Type E curb, a similar curb on the island may be located at the edge of the through lane if there is sufficient length of curbed island to provide a gradual taper from the nose offset. Type F curbs should be offset from the through traveled way edge, regardless of the size of the curbed island. For intermediate and large-size islands that are uncurbed, offsets are desirable but not required. Fixed objects within the island areas must meet clear zone and lateral offset criteria found in ***FDM 215.2.3*** and ***215.2.4***.

210.3.2.2 Median Islands and Traffic Separators

Meet the following requirements when designing median islands and traffic separators:

(1) A minimum of 4 feet wide and 25 feet long. See ***FDM 223.2.4*** for width of separation for separated bicycle lanes.

(2) 100 feet or more in length is allowed on high-speed roadways when providing high visibility for the islands.

(3) Approach noses should be offset 2 to 6 feet from the through (approach) lanes to minimize impacts. Pavement markings in advance of the nose can be used to transition from the centerline to the edge of island.

(4) The shape of the island should be based on design turning paths and the island function. Curvilinear tapers comprised of parabolic or circular curves generally suffice.

(5) The length of the island should be related to the approach speed. An estimate is to use the length based on 3 seconds of driving time to the intersection.

(6) Median islands should begin on tangent alignments and on upgrades or beyond crest vertical curves. In some cases, it is appropriate to extend a median island to avoid its introduction on a horizontal curve or within an area of limited sight distance.

(7) Approach noses must extend across the crosswalk at intersections to control left-turn speeds and encourage pedestrian use of the crosswalk. Use tubular markers as shown in the figures as channelizing devices.

  (a) For median island widths greater than or equal to 6 feet, use a refuge island. ***Figure 210.3.3*** illustrates the geometrics for curbed roadways (i.e., standard 6-foot nose extension and minimum nose extension for RRR projects).

  (b) For median island widths less than 6 feet, use hardened centerlines. See ***FDM 210.3.3*** for hardened centerlines.

Commentary: At intersections, median islands and hardened centerlines are effective at improving vehicle approach angles to the crosswalks resulting in increased visibility of the pedestrians. They are also effective in managing vehicle left-turn speeds which is in-line with the Safe System approach. These factors also provide increased confidence for pedestrians that they will be safer when crossing within the designated crosswalk.

Standard Plans, Index 520-020 provides detailed dimensional design for traffic separators.

See ***FDM 222.2.3.1*** for more information on crosswalks at intersections.

210.3.2.3 Refuge Islands

Refuge islands provide an area for pedestrians and bicyclists to stop before finishing the crossing of a roadway. Complex intersections can be made more navigable and midblock crossings can be facilitated with refuge islands. Refuge islands have specific design criteria to support pedestrian or bicyclist movement. See ***FDM 222*** for more information on pedestrian facilities.

Refuge islands must be a minimum of 6 feet wide in the dimension between the traveled ways; however, the preferred width is 8 feet or greater. For curbed roadways, this dimension is from face of curb to face of curb. Consider the refuge island's storage capacity for higher volumes of pedestrian and bicycle traffic, as well as the space needed for pedestrians or bicyclists with items such as strollers, wheelchairs, wagons, cargo bikes, box bikes, and bikes with trailers.

Provide a clear path through the island without obstruction by objects such as poles, signposts, or utility boxes. The width of the clear path through the island must be at least 5 feet to meet ADA requirements and should be equal to the width of the crosswalk. For additional requirements and information on intersection refuge islands, see ***Figure 210.3.3***. See ***FDM 213.3.5*** for additional dimensional requirements for roundabout splitter islands. See ***FDM 222.2.3.2*** for more information on midblock crossings. For more information on depressed and raised sidewalks, see ***Standard Plans, Index 522-002***.

Refuge islands may be enhanced by low-growing landscaping of 18 inches tall or less and stormwater management features. See ***Drainage Manual, FDM 916*** (Drainage Structures Sheet), ***FDM 270*** (Planting Designs), ***FDM 271*** (Irrigation Designs), and ***FDM 273*** (Landscape Maintenance Guide).

Examples of refuge islands at midblock crossings are shown in ***Figures 210. 3.4*** and ***210. 3.5.*** For more information on pavement markings, see ***Standard Plans, Index 711-001***.

FDM 212.12 provides information on the design of turning roadways with corner islands.

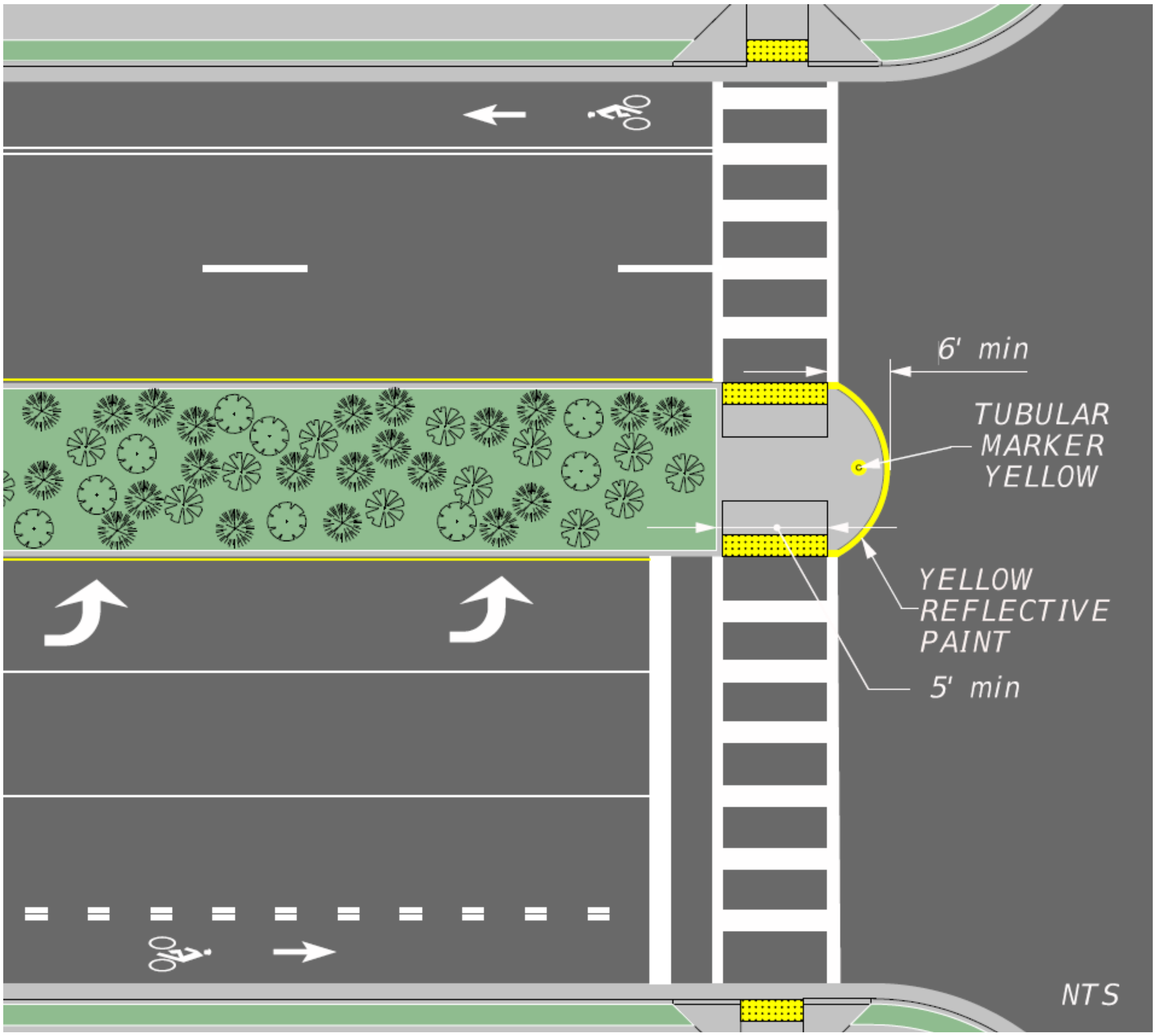
Roundabout splitter islands provide pedestrian refuge and are discussed in ***FDM 213.3.5***.

Commentary: The FDM figures depict ideal situations. Site specific conditions and RRR scenarios may require working around obstacles, such as drainage structures, that may result in final configurations different than shown in the FDM figures. For example, crosswalks may need to be angled slightly, offset from the intersection more than is illustrated, or other modifications.

It may be necessary to assess tradeoffs between various safety measures. When doing so, approach decisions by considering which safety measure is most likely to reduce serious and fatal injury crashes. Consider prioritizing the safety measure that is most likely to reduce system kinetic energy. Look for creative solutions to work through concerns. For example, in some situations, signs or turn restrictions could help address pedestrian visibility concerns, and careful application of Design and Control Vehicle concepts could help address turning movements.

Figure 210.3.3 Intersection Refuge Island

For New and Reconstruction Projects with Raised Crossings:

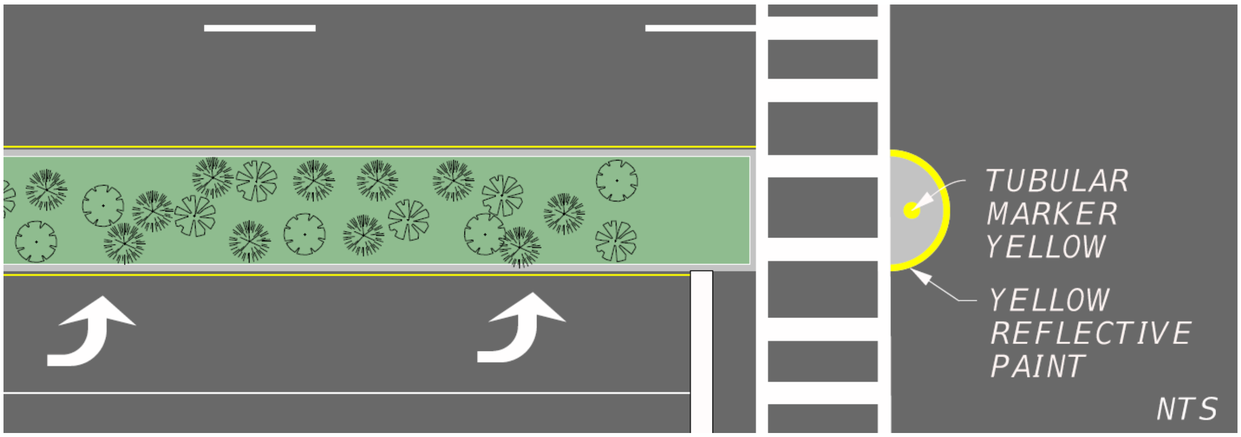


Notes:

- The median nose must be a concrete separator as shown in Standard Plan 520-020. Match the curb profile that is used for the adjacent median.

Figure 210.3.3 Intersection Refuge Island (Cont.)

For New and Reconstruction Projects with Depressed Crossings:



For RRR Projects Where Concrete Median Nose is Not Constructible in Constrained Conditions:

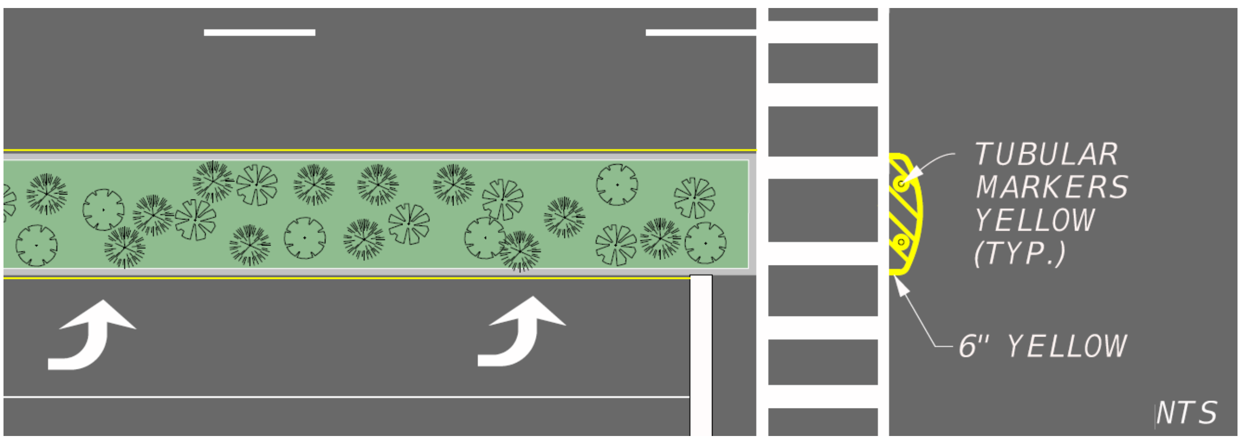


Figure 210.3.4 Midblock Refuge Island Example #1

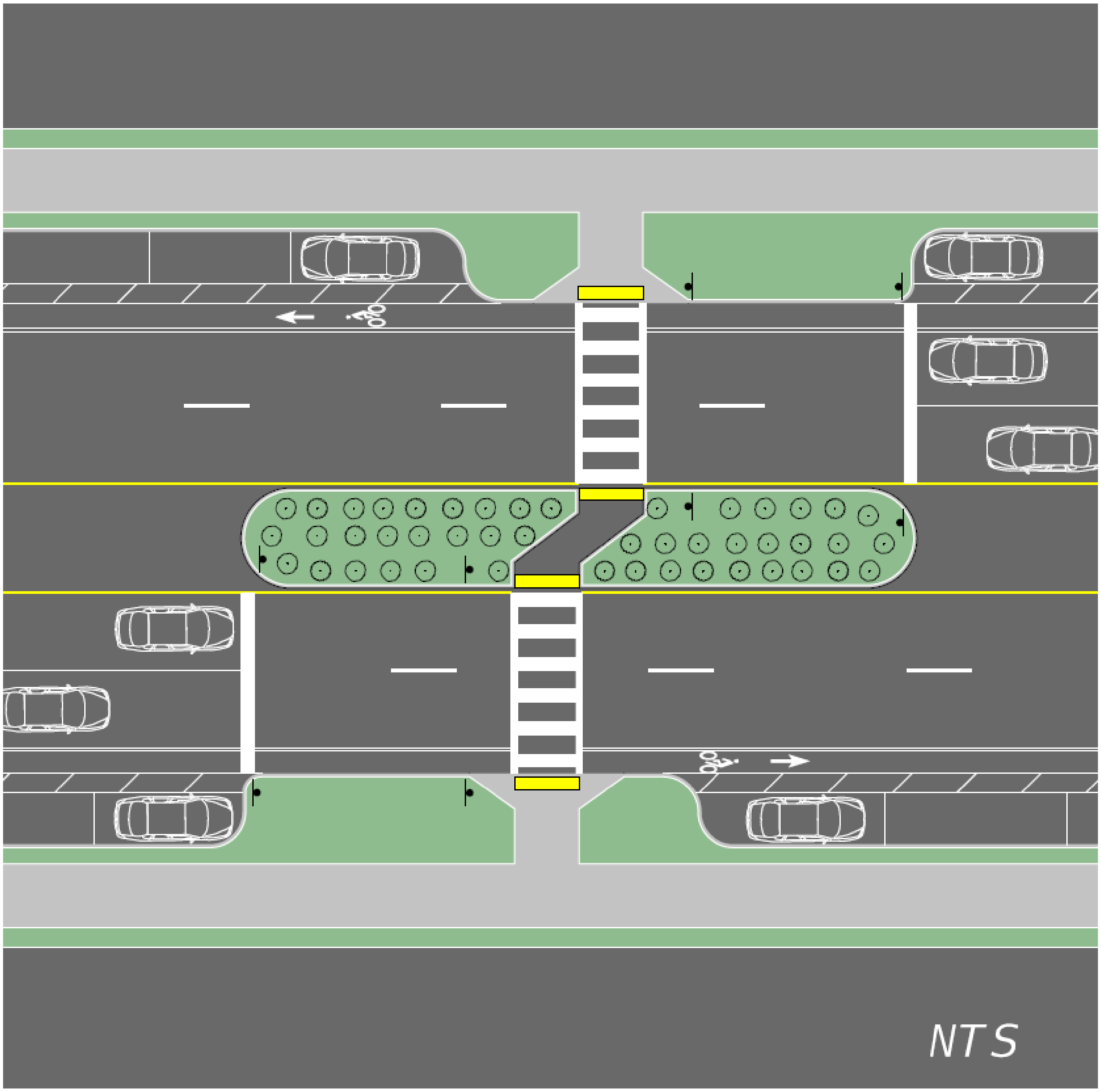
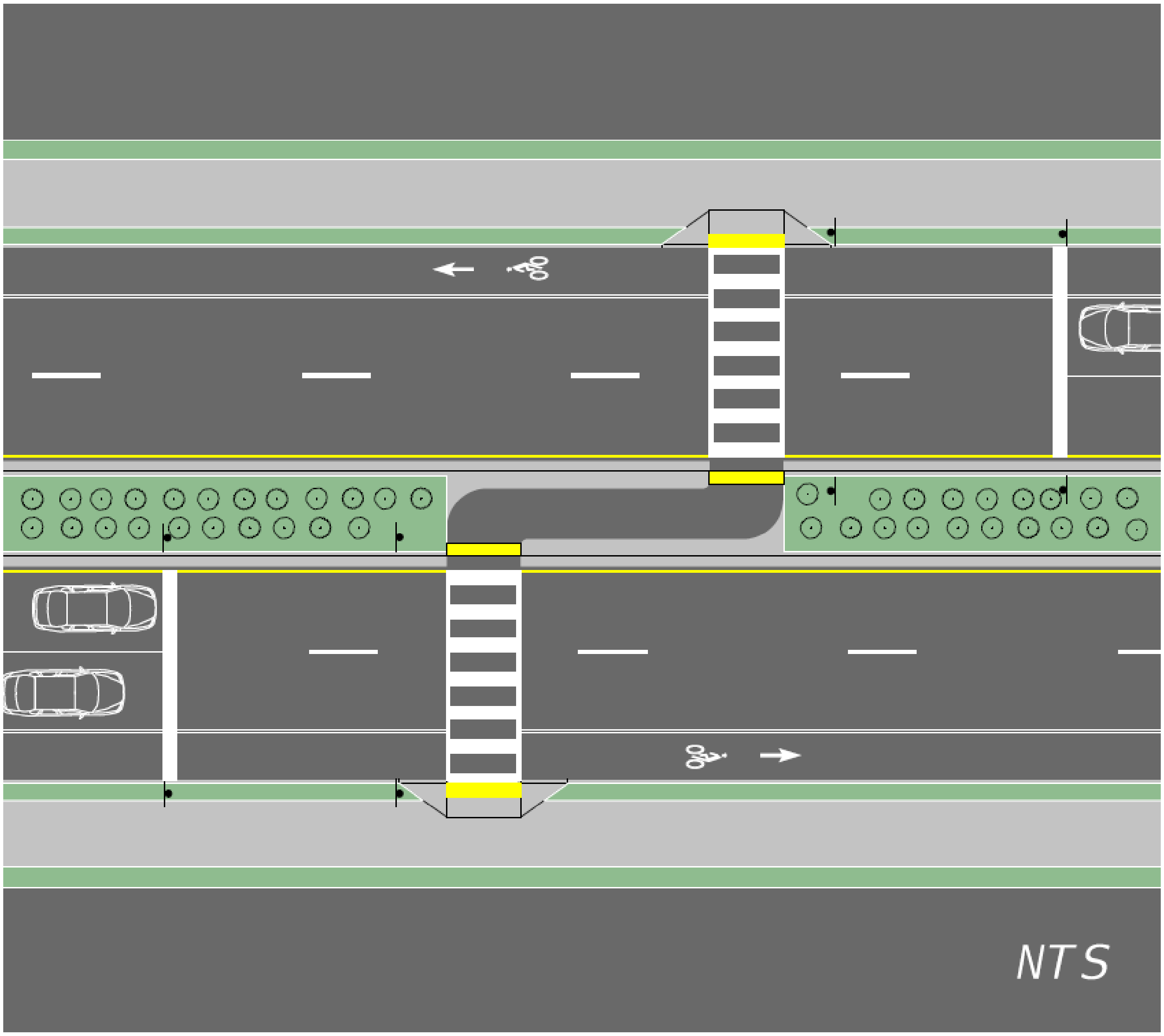


Figure 210.3.5 Midblock Refuge Island Example #2



210.3.2.4 Corner Islands

Where the inside edges of the traveled way for right-turns are designed to accommodate semi-trailer combinations or where the design permits passenger vehicles to turn at speeds greater than 10 mph, the pavement area within the intersection may become excessively large and may create longer crossing paths for pedestrians. This may also occur at intersections with turning angles greater than 90 degrees. To avoid this condition, a corner channelizing island can be provided to form a separate turning roadway.

FDM 212.12 provides information on the design of turning roadways with corner islands.

210.3.3 Hardened Centerlines

Hardened centerlines are an extension of the traffic separator or centerline past the crosswalk. Hardened centerlines improve pedestrian safety by reducing the turning speeds of left-turning motorists and by improving their approach angle to the crosswalk to increase pedestrian visibility. See ***FDM 222*** for more information on pedestrian facilities.

Provide a hardened centerline where it is not possible to provide a pedestrian refuge island.

The nose extension can be no less than 2 feet long and must provide 1-foot of clear distance from the edge of the crossing traffic lane or bicycle lane. A 6-foot nose extension is preferred, but the designer can adjust the length to balance control of the left-turning vehicle with the design vehicle turning path.

Where applicable, space multiple tubular markers a minimum of 2 feet and a maximum of 5 feet apart. Provide tubular markers for a minimum of 25 feet along the traffic separator or centerline approaching the crosswalk.

If tubular markers on the nose extension are not practicable to accommodate sight distance or turning radii, use a “channelizing curb” for the nose extension. Use ***Developmental Specification Dev703*** for channelizing curb. Detail channelizing curb in the plans showing the length of the nose extension as described above. Channelizing curb products are typically prefabricated in 6-foot lengths with additional length for the endcaps.

Hardened centerlines may be used with offset left-turn lanes.

Hardened centerlines may be omitted on RRR or other minor projects ~~where they require~~requiring the movement or reconstruction of curb ramps for accommodation.

Figure 210.3.6 Hardened Centerline with Traffic Separator

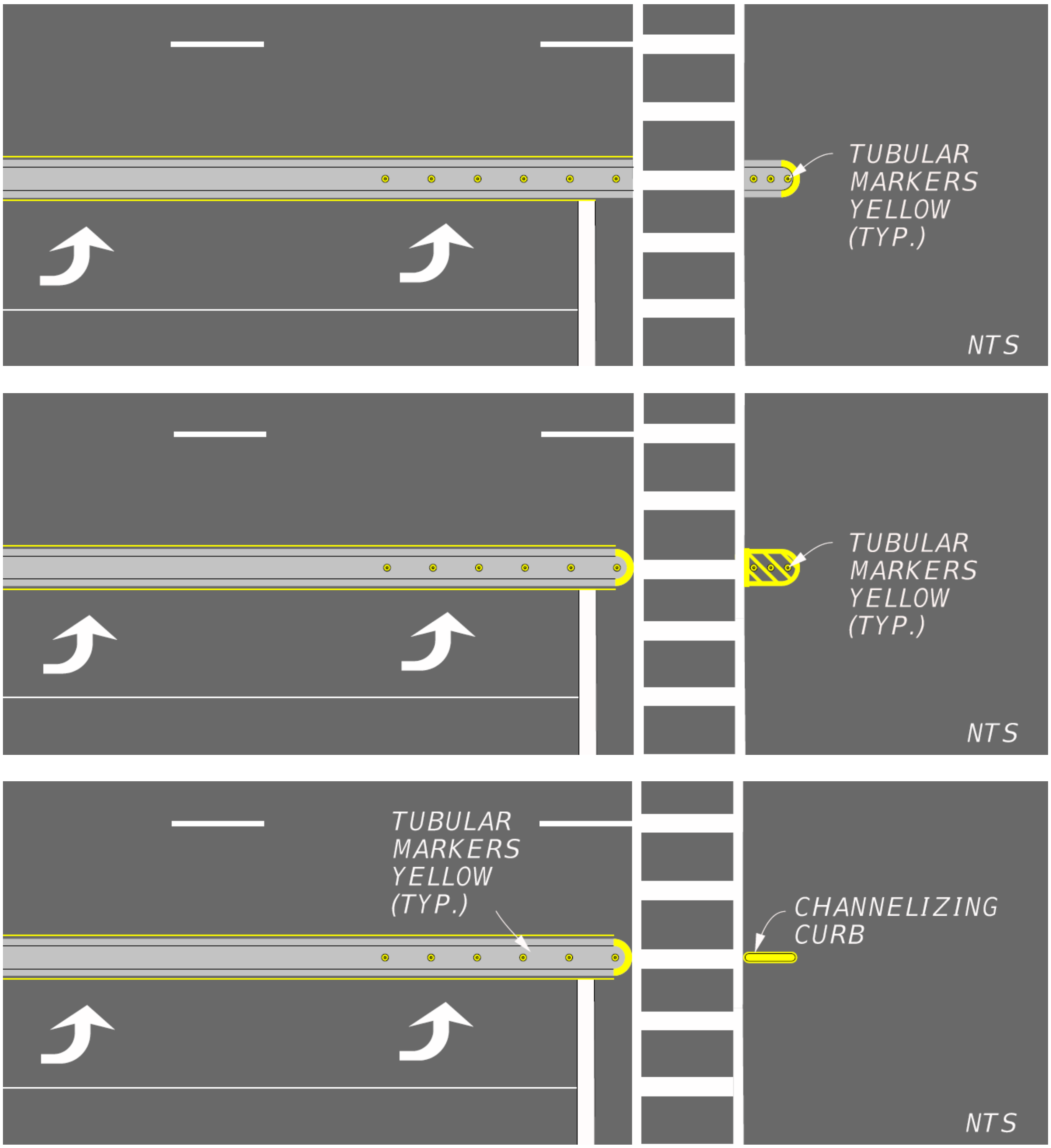
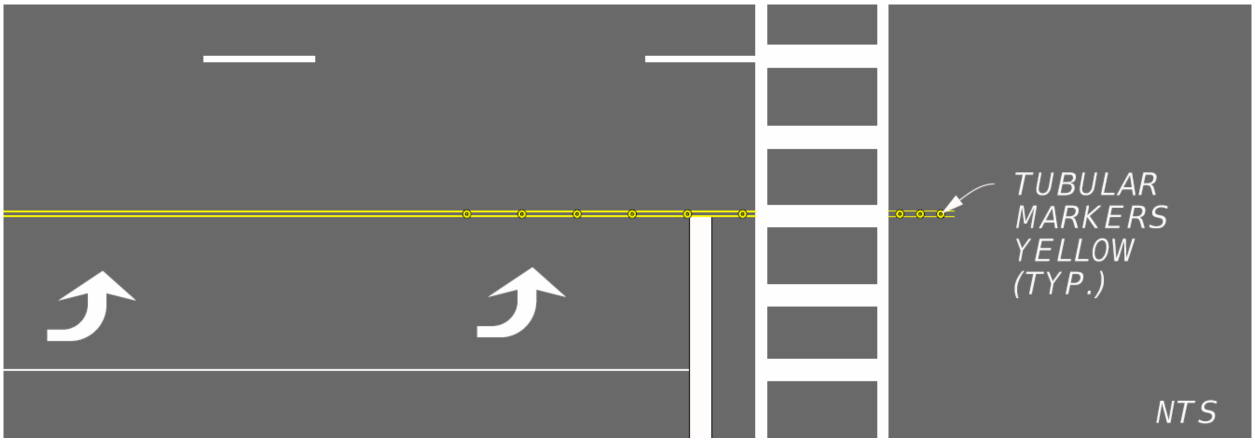
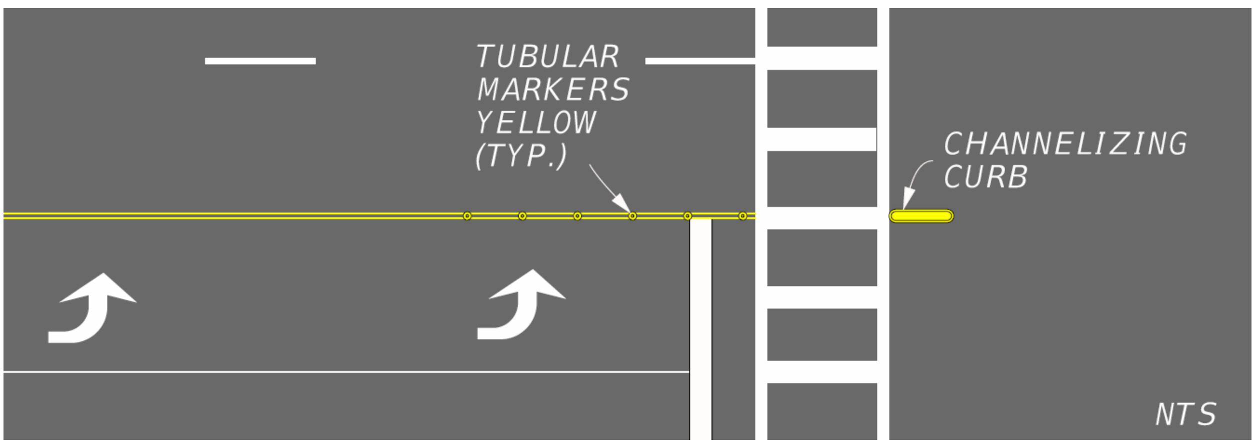


Figure 210.3.7 Hardened Centerline without Traffic Separator





210.4 Shoulders

Roadway shoulder width is measured from the edge of the traveled way to the shoulder break. A portion of the shoulder is required to be paved on all roadways on the State Highway System. A paved shoulder is the portion of the roadway contiguous with the traveled way for accommodation of errant vehicles, stopped vehicles, bicycle traffic, and emergency use.

When it is determined that the Helmeted Bicyclist Symbol and Bicycle Lane Arrow pavement markings (see ***FDM 223.2.2***) will be placed on the shoulder of a flush shoulder roadway, the paved width for the outside shoulder without shoulder gutter must be either ~~8 feet instead of the~~ 5 feet as shown in ***Table 210.4.1*** or 8 feet.

Commentary: Paved shoulder widths greater than 5 feet and less than 8 feet are challenging to construct on flush shoulder roadways.

Standard asphalt paving machines have a main screed width of 8 feet or 10 feet (10 feet screed is most common), with 5-foot-wide extensions, connected at pivot points, on either side of the paver. The pivot points are the only locations on the paver where a cross slope break can be constructed. As such, up to a 5-foot-wide shoulder can be paved in conjunction with the adjacent travel lane. Shoulder widths that are 8-feet-wide or greater can be paved with a standard paver.

Due to these dimensional limitations of standard asphalt paving machines, constructing a paved shoulder width that is greater than 5 feet and less than 8 feet is challenging, and should be avoided when possible.

Shoulder widths for roadways are given in ***Table 210.4.1***. See ***Figure 210.4.1*** for an illustration of roadway shoulders. Refer to ***FDM 211*** for ramp shoulder widths. Refer to ***FDM 260.3*** for bridge shoulder widths.

Use shoulder gutter for the following conditions:

- On embankments higher than 20 feet
- On embankments higher than 10 feet where the longitudinal slope is greater than 2 percent
- On embankments, with slopes steeper than 1:6 for more than five feet vertically, to minimize erosion
- At bridge ends where concentrated flow from the bridge deck could run down the slope

- In areas of guardrail where embankment slopes are steeper than 1:4 and any pavement is sloped toward the embankment.

Construct roadway paved shoulders up to the railroad crossing shoulder pavement as shown in ***Standard Plans***, ***Index 830-T01***. For additional information, see ***FDM 220*** and ***Standard Plans***, ***Index 509-070***.

Figure 210.4.1 Shoulder Width Identification

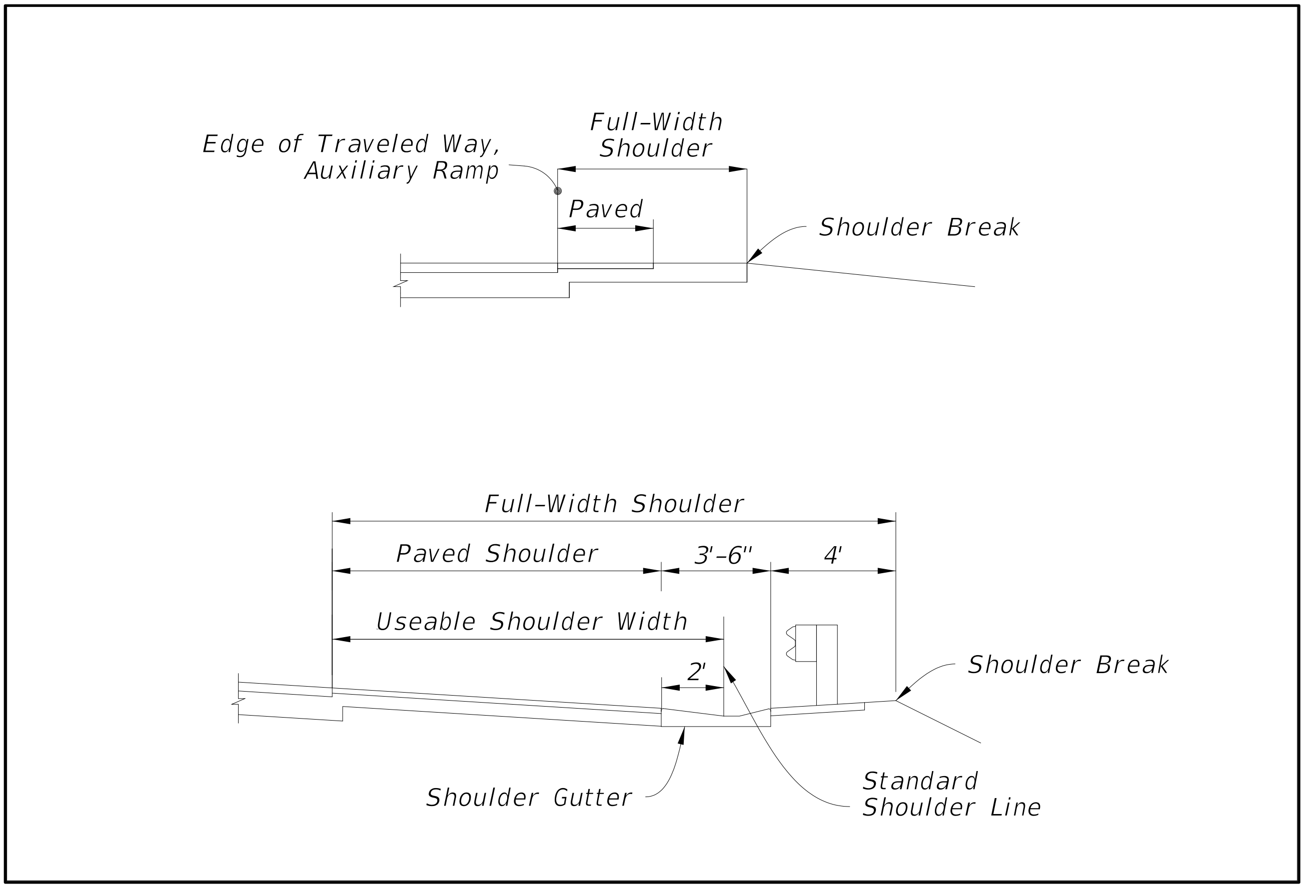


Table 210.4.1 Standard Shoulder Widths

Lane Type	# Lanes (One Direction)	Without Shoulder Gutter				With Shoulder Gutter			
		Outside		Median Or Left		Outside		Median Or Left	
		Full Width (feet)	Paved Width (feet)	Full Width (feet)	Paved Width (feet)	Full Width (feet)	Paved Width (feet)	Full Width (feet)	Paved Width (feet)
Travel Lanes	4-Lanes or more	10	5	10	4	15.5	8	15.5	8
	3-Lanes	10	5	10	4	15.5	8	15.5	8
	1-Lane & 2-Lanes	10	5	8	4	15.5	8	13.5	6
Aux. Lanes	ALL	10	5	8	4	11.5	4	11.5	4

Notes:

Without shoulder gutter:

(1) Consider 12-foot outside full width shoulder adjacent to travel lanes with high AADT or greater than 10% trucks.

(2) Consider providing a minimum 10-foot median shoulder where continuous barrier or guardrail is present.

(3) Outside shoulder widths for auxiliary lanes typically match those of the adjacent roadway; however, width may be reduced to 6-foot shoulder with 2-foot paved for right turn lanes when a bicycle keyhole is present.

(4) Pave the entire width of shoulders adjacent to concrete barriers. See ***FDM 215.4.6.1.***

(5) For RRR projects:

- (a) an existing full width shoulder of 6-feet or greater may be retained
- (b) the following minimum existing outside paved shoulder widths may also be retained:
  - i. 4-foot adjacent to travel lane
  - ii. 2-foot adjacent to auxiliary lane
- (c) an existing unpaved median or left shoulder may be retained. Consider providing a 4-foot median or left paved shoulder adjacent to travel and auxiliary lanes where there are documented safety or maintenance concerns.

With shoulder gutter:

(1) Paved shoulders less than 6 feet in width with adjoining shoulder gutter must be the same type, depth, and cross slope as the roadway pavement.

(2) Shoulders must extend 4 feet beyond the back of shoulder gutter and have a 0.06 cross slope back toward the gutter.

(3) Required shoulder widths for auxiliary lanes typically match those of the adjacent roadway.

210.4.1 Shoulder Cross Slopes

The standard cross slope is 0.06 on the outside shoulder and 0.05 on the median (or left) shoulder. ***Figure 210.4.2*** illustrates shoulder cross slopes in relationship to roadway cross slopes for normal and superelevated sections. For 5-foot (or less) paved shoulders, see ***Figure 210.4.3***. If the inside travel lane is sloping toward the median, the inside shoulder cross slope may be increased to 0.06.

For projects constructed with concrete pavement, the first one foot of the outside shoulder is cast with the outside travel lane and will have the same cross slope (and superelevation) as the outside lane. Superelevation of the shoulder pavement is to be rotated about the outside edge of the outside slab.

For shoulder cross slope criteria on bridges, see ***FDM 260.4***.

Figure 210.4.2 Shoulder Superelevation

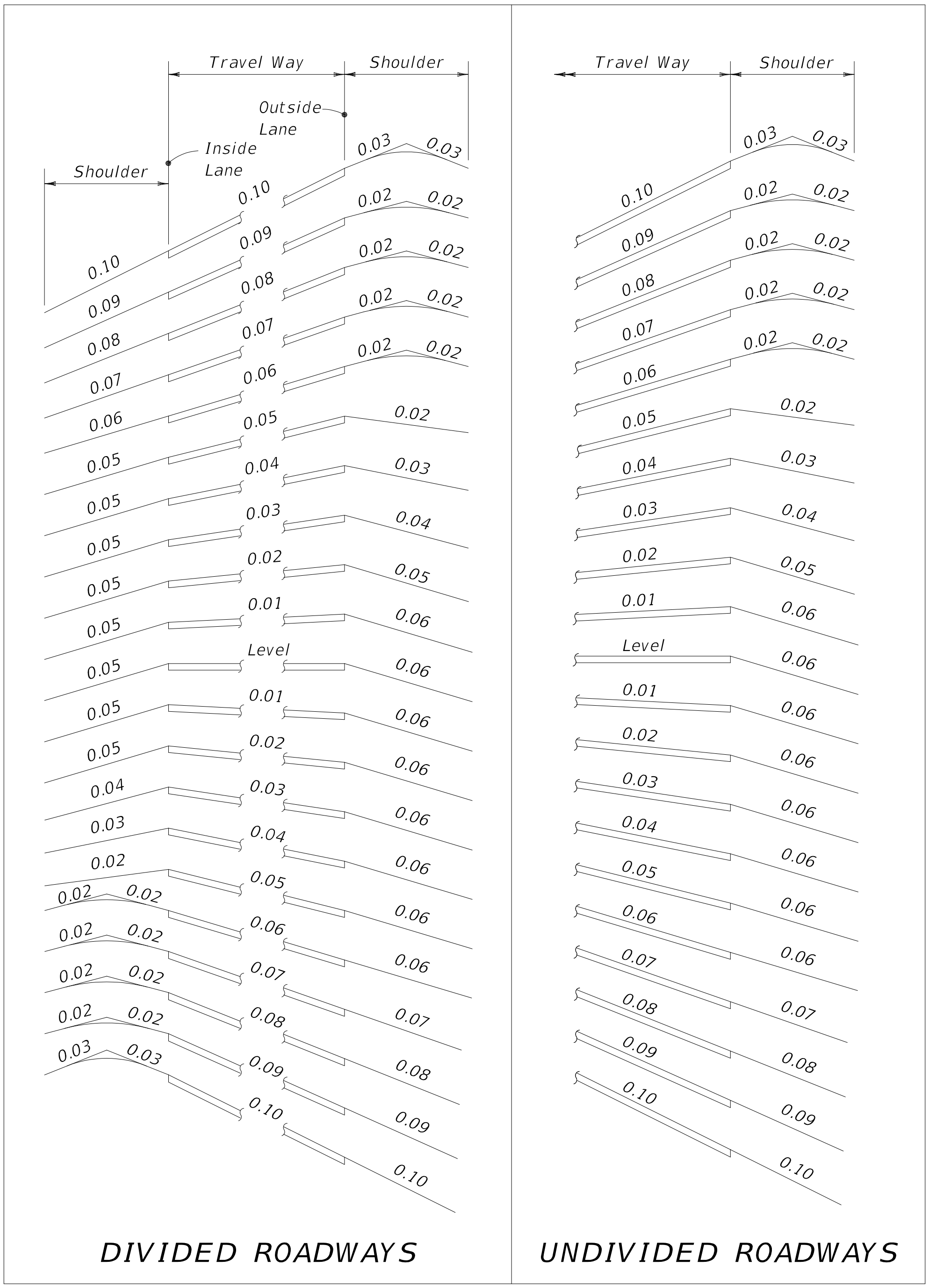
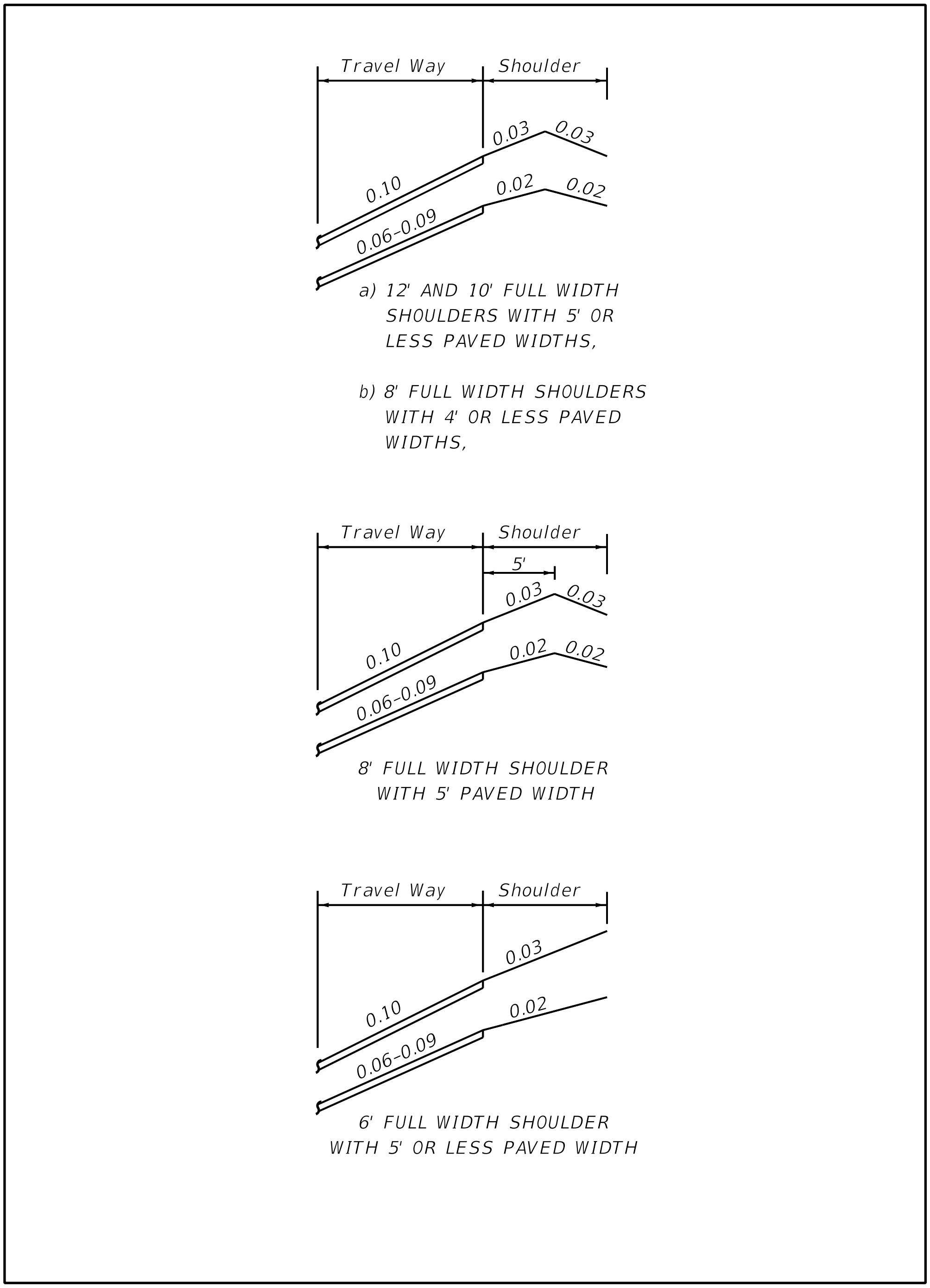


Figure 210.4.3 Special Shoulder Superelevation



210.4.2 Typical Paving under Bridges

See ***FDM 260.7*** for requirements for paving under bridges.

210.4.3 Limits of Friction Course on Paved Shoulders

Extend friction course ~~(closed and open graded)~~ over the full width of the median and outside paved shoulders.

210.4.4 RRR Shoulder Treatment

Identify the shoulder treatment option in the plans when using ***Standard Plans***, ***Index 570-010***. Use Treatment I only if the shoulder is established with good soil and turf and there is no significant shoulder erosion. Use Treatment II when an existing shoulder meets the overlay thickness requirements for Treatment I, but there is significant shoulder erosion.

210.4.5 Narrow Bridge Shoulder Warning Devices

The ***Standard Plans***, ***Index 700-106*** provides details for the shoulder treatment to be used on flush shoulder roadway approaches to a narrow bridge. This index provides standards for the placement of signing, striping, object markers, and raised pavement markers (RPMs) for use at structures where the bridge shoulder width is less than the width of the useable shoulder on the approach roadway.

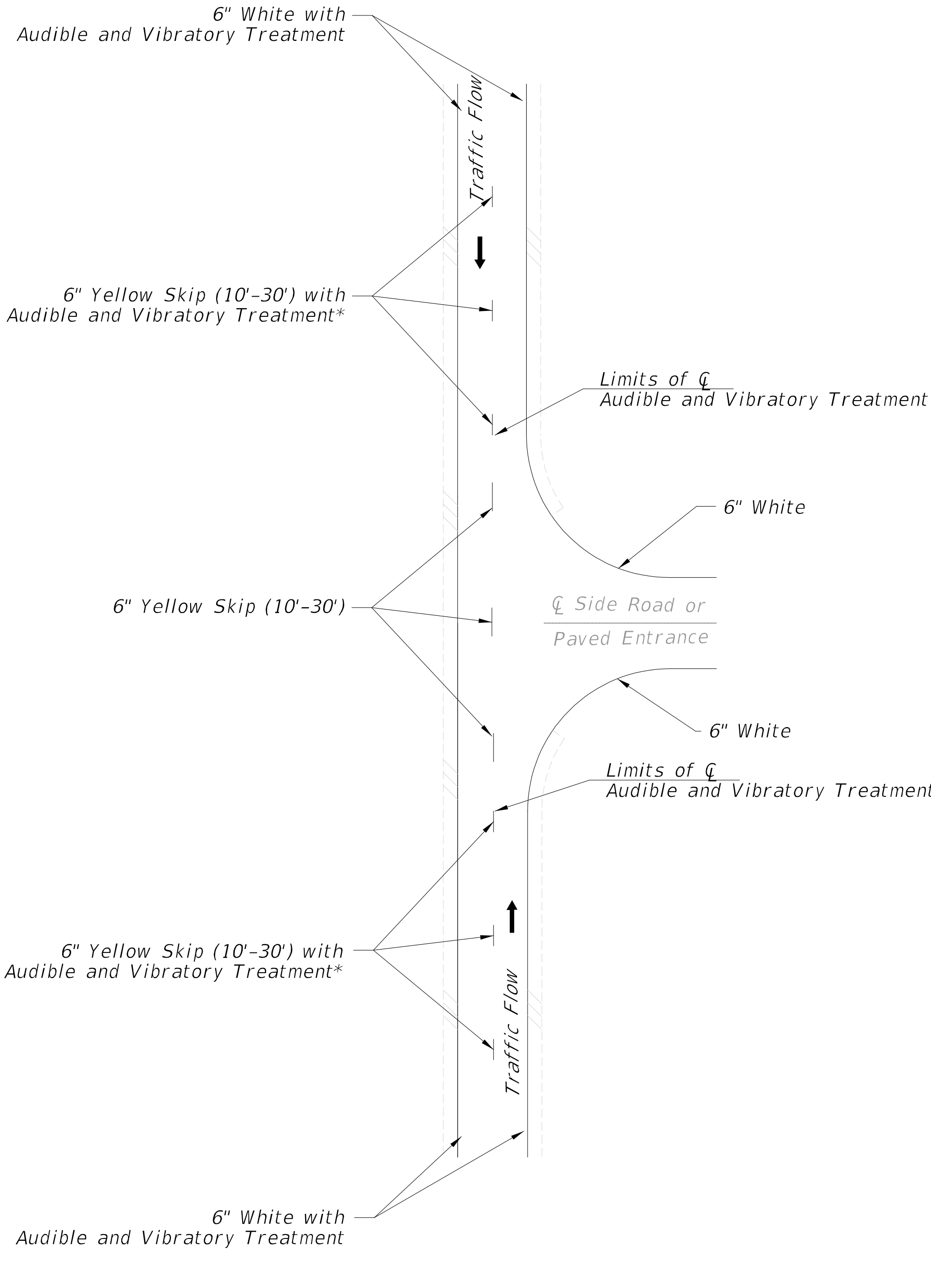
210.4.6 Audible and Vibratory Treatment

Provide audible and vibratory treatment (AVT) for edge lines and center lines on flush shoulder roadways with a Posted Speed of 50 mph or greater. Do not place edge line AVTs on lanes that are less than 11 feet wide. Do not exclude sections of the project where advisory speeds are used due to restricted horizontal or vertical geometry. Do not place AVTs within the limits of crosswalks.

Use sinusoidal ground-in rumble strips on flexible pavements as shown in ***Standard Plans, Index 546-020***.

Use profiled thermoplastic on rigid pavements. Otherwise, the use of profiled thermoplastic for any project including RRR, permits, push-button safety, and restriping projects must be approved by the State Roadway Design Engineer. ***Figure 210.4.4*** provides guidance for placement of AVTs. See ***FDM 940*** for information regarding plan requirements. Ground-in rumble strips are to be quantified in the Signing and Marking Plans component.

Figure 210.4.4 Audible and Vibratory Treatment Placement



* Since the drawing applies both Profiled Thermoplastic and Ground-in Rumble Strips, a visable line style for the Continuous Array Ground-in Rumble Strips cannot be shown here.

Figure 210.4.4 Audible and Vibratory Treatment Placement (Cont.)

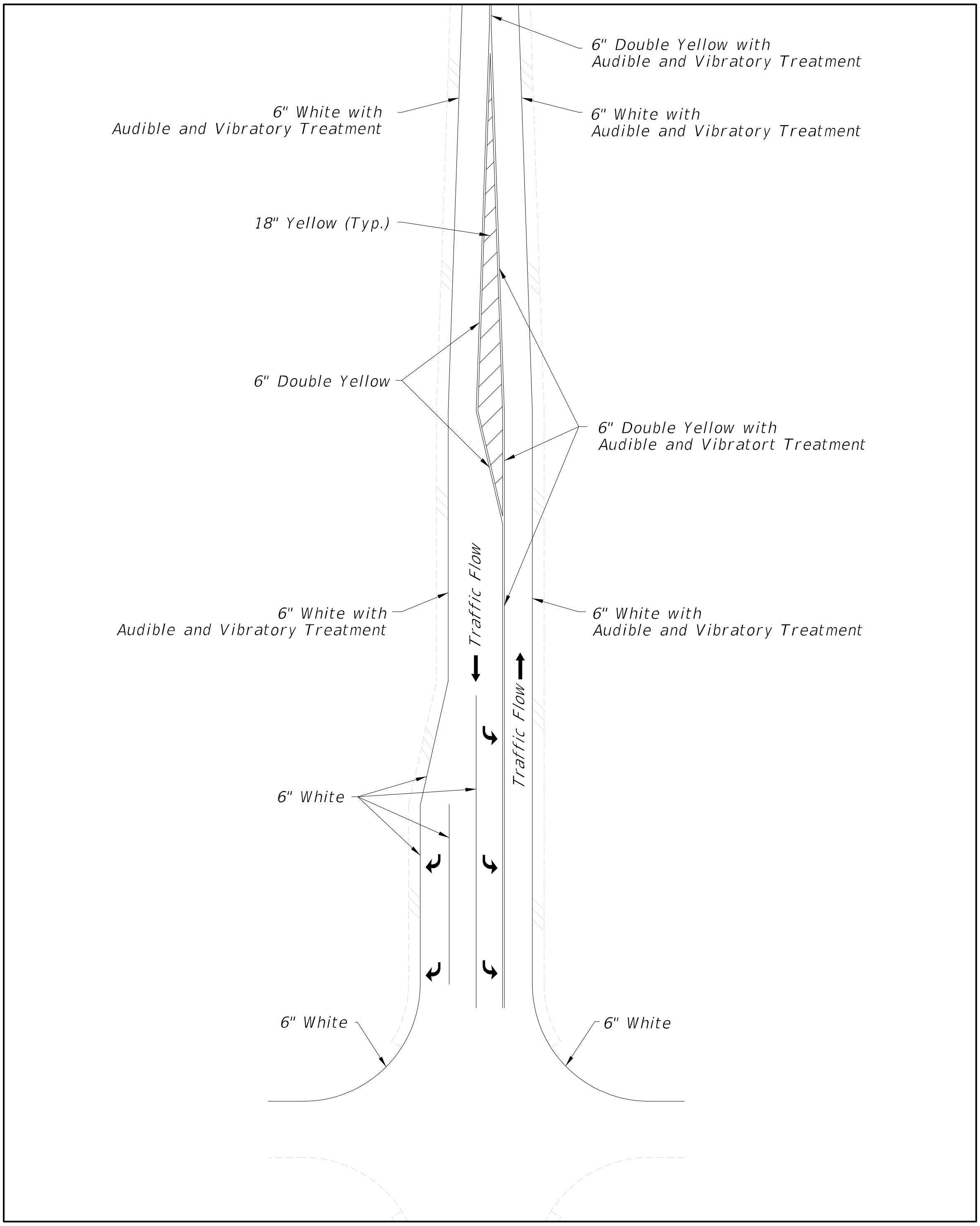


Figure 210.4.4 Audible and Vibratory Treatment Placement (Cont.)

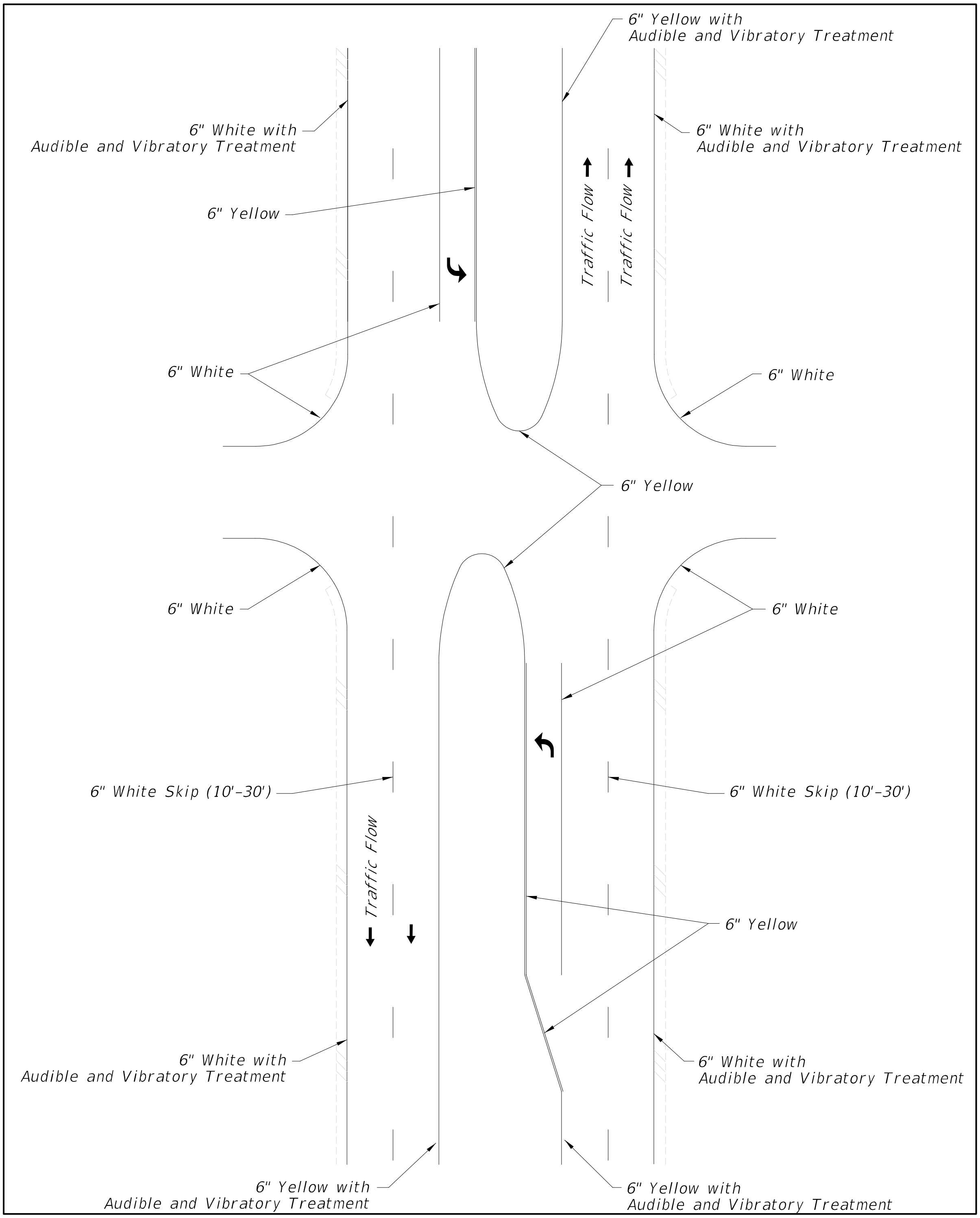


Figure 210.4.4 Audible and Vibratory Treatment Placement (Cont.)

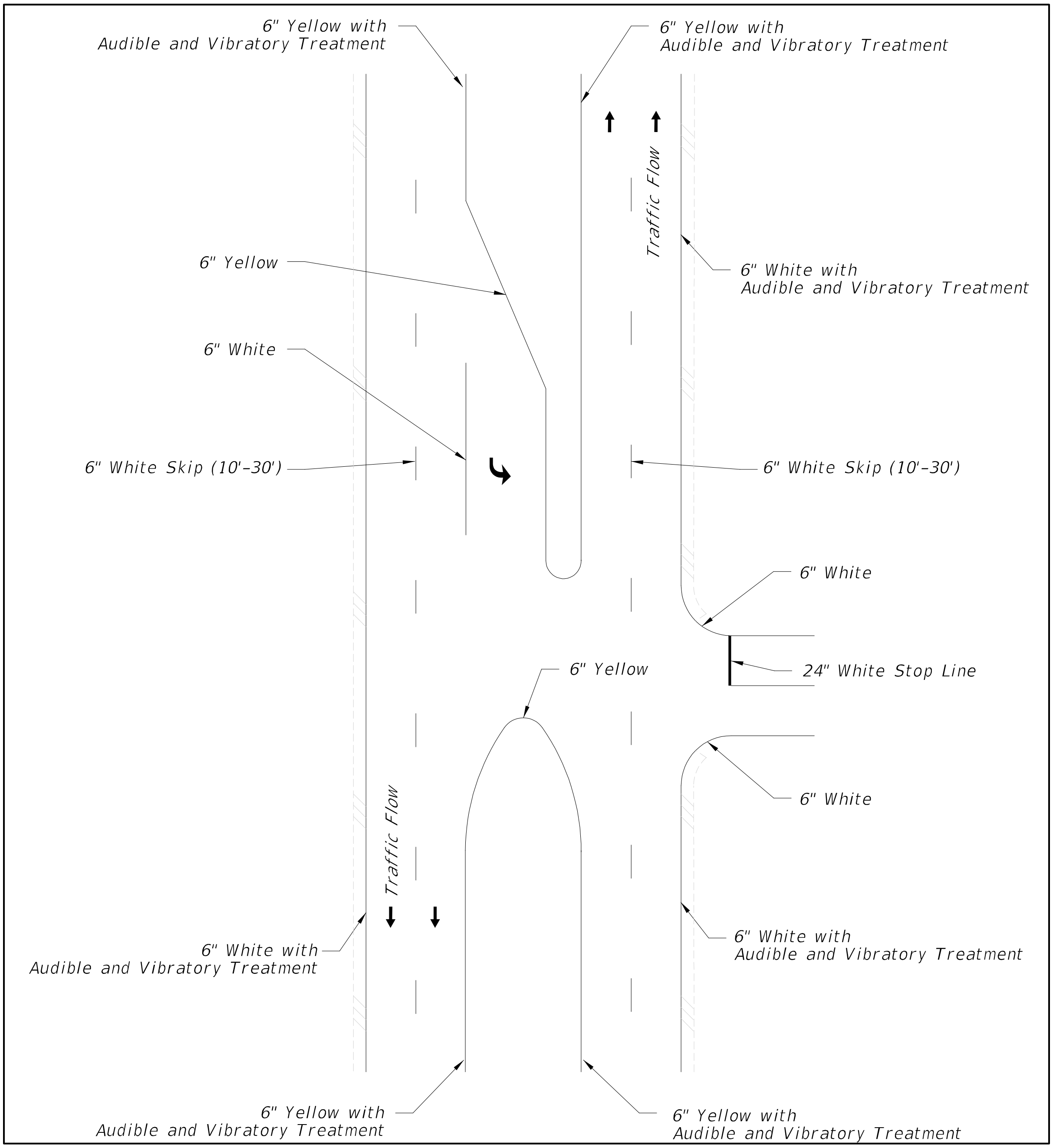
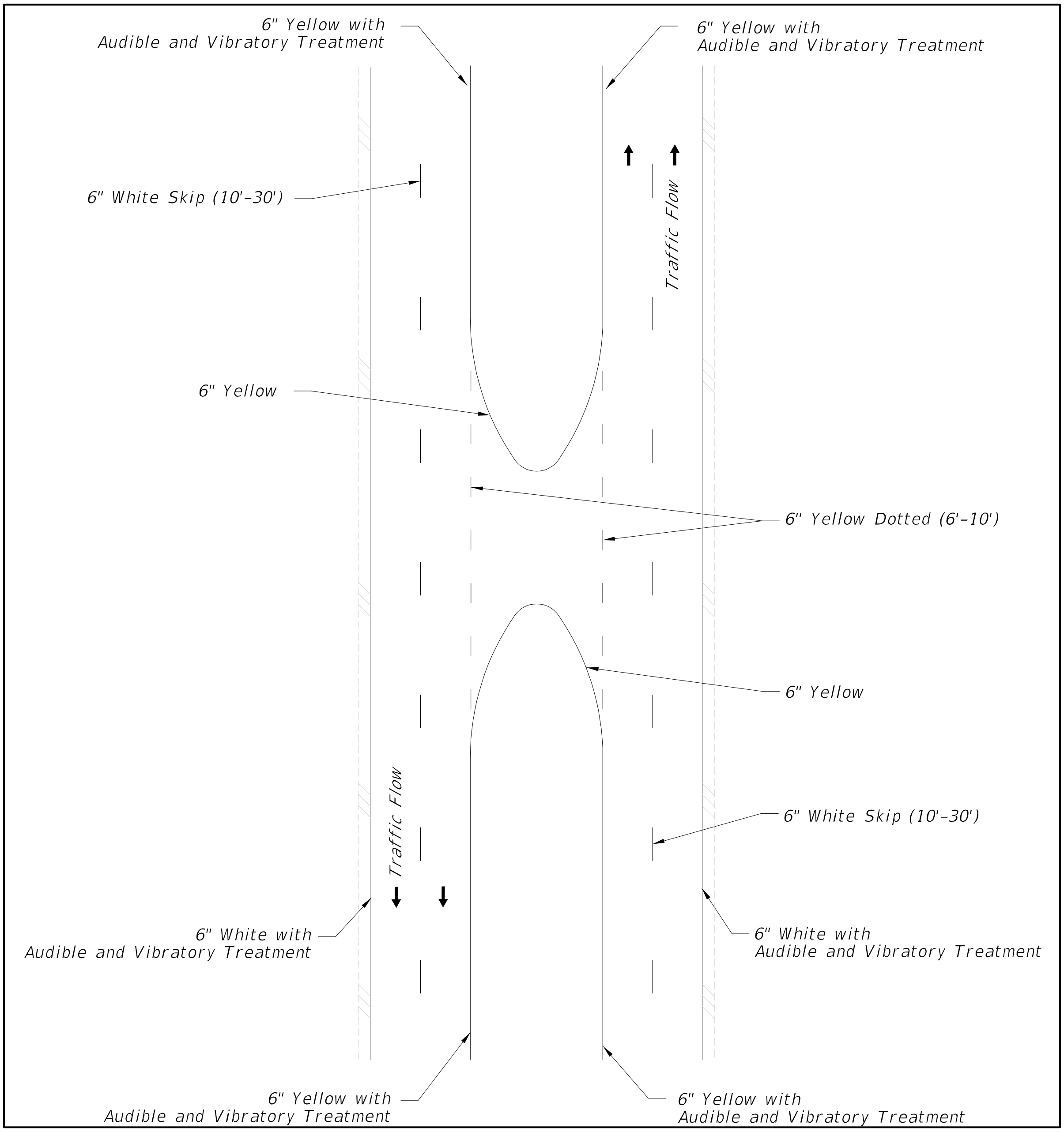


Figure 210.4.4 Audible and Vibratory Treatment Placement (Cont.)



210.5 Curbed Roadways

The term "curbed" includes all types of curbs and curb and gutter that are used on the State Highway System and detailed in ***Standard Plans***, ***Index 520-001***.

The method of collecting and conveying drainage runoff and the availability of R/W determines the cross section; i.e. flush shoulder or curbed. When it is determined that a closed drainage system will be used, the selection of curb type will be based on the Design Speed.

Curbed roadways with Design Speeds of 45 mph or less typically use Type F curb on the outside and Type E curb on the median (or left) side.

See ***FDM 215.2.7.2*** for additional information regarding curbs and their placement.

210.5.1 High-Speed Curbed Roadways

Curbs may be used on roadways where the anticipated operating speeds require a Design Speed of 50-55 mph and:

(1) Curbs are necessary to control drainage, or

(2) R/W is constrained

High-speed curbed sections are typically used within C3 context classification and transitional areas.

High-speed curbed roadways are to use Type E curb on both the median and the outside. Provide an offset from the edge of the traveled way to the lip of gutter as follows:

(1) 4-foot to median curb for 4-lane roadway sections.

(2) 6.5-foot to median curb for 6-lane roadway sections.

(3) 6.5-foot to outside curb for all roadway sections.

The above median offsets are not required for left-turn lanes adjacent to traffic separators or Type E curb. Outside offsets for right-turn lanes may be reduced to 4.5 feet when a bicycle keyhole is provided.

210.6 Roadside Slopes

Criteria and details for roadside slopes are included in ***FDM 215***.

The following guidance is being provided to designers for consideration during project design. Additional sod requirements are provided in the ***Standard Plans, Indexes 570-001*** and ***571-010***.

- Sod should be considered for slopes 1:4 or steeper. For all other areas, refer to ***FDOT Drainage Manual,*** Chapter 2, Table 2.5, for additional guidance on maximum velocity for each lining type.
- Sod should be used for projects with less than 10,000 square feet of disturbed area.
- Sod should be considered for narrow areas less than six feet.
- A minimum 48" of sod should be considered for back of sidewalk areas as applicable.
- Sod should be considered in areas of concentrated runoff (i.e., bottom of vertical curves, insides of superelevated curves, tangent sections, and outsides of curves). Refer to ***Standard Plans, Index 570-001*** for sodding requirements.
- Refer to ***Standard Plans, Index 570-010*** for milling and resurfacing projects or major projects with portions of milling and resurfacing.

210.7 Border Width

Border width provides space for:

(1) Roadside design components such as signing, signals, lighting, drainage features, guardrail, fencing and clear zone, sidewalks with ADA provisions, traffic control devices, fire hydrants, storm drainage features, bus and transit features, permitted public utilities and space for aesthetic features such as sod and other landscape items,

(2) A buffer between vehicles and pedestrians,

(3) Construction and maintenance of the facility, and

(4) Permitted public utilities.

Required border width is provided in ***Table 210.7.1***. Border width is measured to the R/W line as follows:

- Flush shoulder roadways: from the shoulder break.
- Curbed roadways: from the outside edge of pavement (lip of gutter).
- High-speed curbed roadways: from the outside edge of the traveled way.

Table 210.7.1 Minimum Border Width

Context Classification		Minimum Border Width (Feet)					
		Curbed and High-Speed Curbed Design Speed (mph)				Flush Shoulder Design Speed (mph)	
		25-40	45	50	55	25-45	≥ 50
C1	Natural	N/A	N/A	29	35	N/A	40
C2	Rural	N/A	N/A	29	35	N/A	40
C2T	Rural Town	12	14	N/A	N/A	33	N/A
C3	Suburban	12	14	29	35	33	40
C4	Urban General	12	14	N/A	N/A	33	N/A
C5	Urban Center	12	N/A	N/A	N/A	N/A	N/A
C6	Urban Core	14	N/A	N/A	N/A	N/A	N/A

Notes:

(1) On low-speed curbed roadways that have an adjacent bike lane, the required border width shown in the table may be reduced by 2 feet.

(2) On existing roadways:

a. When R/W is not being acquired:

i. Unmodified existing border width may remain (e.g., a resurfacing only project)

ii. Modified existing border width must not be less than 8 feet (e.g., when adding a right-turn lane)

b. When R/W is being acquired, border width should meet new construction criteria shown in the table. Provide a segment of sufficient length to assure continuity.

(3) N/A indicates this combination of Design Speed and context classification is outside the intended design range and should be avoided. See ***Table 201.5.1*** for context classifications and Design Speed ranges.

210.8 Horizontal Alignment

The centerline (CL) or baseline (BL) of construction defines the horizontal alignment for roadway and bridge construction. The CL or BL of construction is a series of tangents connected by horizontal curves established by the Engineer of Record (EOR). The CL or BL of construction may be the same alignment as the BL of survey.

Horizontal alignment should be consistent with the anticipated operating speeds and with environmental, physical, and economic constraints. Design Speed is the principal factor controlling horizontal alignment.

Avoid placing horizontal curves, points of intersection (PI), and superelevation transitions within the limits of a structure or approach slabs. Placement of stationing equations within the limits of a structure should be avoided. Such equations unnecessarily increase the probability of error in both the design and construction phases.

210.8.1 Deflections in Alignment

The point where tangents intersect is known as the PI. Avoid the use of a PI with no horizontal curve; however, there may be conditions where it is necessary (e.g., closely spaced intersections in areas with limited R/W). The maximum deflection without a horizontal curve is as follows:

- Flush shoulder and curbed roadways with Design Speeds of 40 mph and less is 2°00’00”.
- Flush shoulder roadways with Design Speeds of 45 mph and greater is 0°45’00”.
- Curbed roadways with Design Speeds of 45 mph is 1°00’00”.
- High-speed curbed roadways with Design Speeds of 50 mph and greater is 0°45’00”.

210.8.1.1 Intersections

Refer to ***FDM 212*** for information regarding deflections through intersections.

210.8.2 Horizontal Curves

A horizontal curve should not be introduced near the crest of a vertical curve. The combination of horizontal and vertical curves can negatively impact sight distance and can also greatly reduce the approaching driver's ability to perceive a horizontal curve ahead. The condition can be avoided by having the horizontal curvature lead the vertical curvature; i.e., the horizontal curve is made longer than the vertical curve.

Flatter curvature with shorter tangents is preferable to sharp curves connected by long tangents; i.e., avoid using minimum horizontal curve lengths.

Table 210.8.1 provides the horizontal curve lengths to be used in establishing the horizontal alignment. Refer to ***Table 210.8.3*** for compound curves.

Table 210.8.1 Length of Horizontal Curve

<table>
<tr><th colspan="11">Desired Length Based on Design Speed (mph)</th></tr>
<tr><th>mph</th><th>25</th><th>30</th><th>35</th><th>40</th><th>45</th><th>50</th><th>55</th><th>60</th><th>65</th><th>70</th></tr>
<tr><th>feet</th><td>400</td><td>450</td><td>525</td><td>600</td><td>675</td><td>750</td><td>825</td><td>900</td><td>975</td><td>1050</td></tr>
<tr><th colspan="6">Desired Length Based on Deflection Angle</th><td colspan="5" rowspan="3"><u>Notes:</u>
(1) The desired horizontal curve length shall be the greater of the lengths based on Design Speed and based on deflection angle.
(2) When desirable horizontal curve length cannot be attained, provide the greatest attainable length possible, but not less than 400 feet.</td></tr>
<tr><th>degrees</th><th>5°</th><th>4°</th><th>3°</th><th>2°</th><th>1°</th></tr>
<tr><th>feet</th><td>500</td><td>600</td><td>700</td><td>800</td><td>900</td></tr>
</table>

210.8.2.1 Existing Horizontal Curves

Evaluate existing curves against the values shown in ***Table 210.8.2***. The review should include crash history and an on-site review for evidence of roadway departure or operational problems in the area of concern.

Table 210.8.2 Minimum Radius for Evaluation of Existing Horizontal Curves

Maximum Superelevation (e_{max})		Minimum Radius (feet)									
		Design Speed (mph)									
		25	30	35	40	45	50	55	60	65	70
0.10	SHS	160	231	323	432	559	694	881	1091	1348	1637
	RRR	120	188	276	388	521	674	849	1042	1273	1528
0.05	SHS	194	286	402	533	694	881	N/A	N/A	N/A	N/A
	RRR	140	223	332	468	637	849	N/A	N/A	N/A	N/A

Condition #1 – A horizontal curve that meets or exceeds the SHS minimum radius shown in ***Table 210.8.2*** is satisfactory unless there is a significant crash history (3 or more crashes within the most recent available 5-year location verified data) or other evidence of safety or operational problems. If problems are identified, include corrective measures in the project.

Condition #2 – A horizontal curve that is below the SHS minimum radius shown in ***Table 210.8.2*** but meets or exceeds the RRR minimum radius shown in ***Table 210.8.2*** must be reviewed for specific safety problems at the curve. If the review indicates that significant operational or safety problems exist, the curve should be reconstructed. If problems are identified but reconstruction is not warranted, include corrective measures in the project.

Condition #3 – A horizontal curve that does not meet the RRR minimum radius shown in ***Table 210.8.2*** must be reconstructed or a Design Exception or Design Variation must be obtained. A reconstructed curve must meet the new construction values shown in ***Tables 210.8.1***, ***210.9.1***, ***210.9.2***, and ***210.9.3***.

210.8.2.2 Compound Curves

Although the use of compound curves is discouraged, there may be conditions where it is necessary. Avoid sudden changes from flat to sharp curves. For compound curves on open highways, the ratio of the flatter radius to the sharper radius is not to exceed 1.5:1. For compound curves on turning roadways and at intersections, a ratio of 2:1 may be used where the flatter radius precedes the sharper radius in the direction of travel.

The length of compound curves (arc length) for turning lanes are provided in ***Table 210.8.3***.

Table 210.8.3 Minimum Compound Curves Arc Lengths on Turning Roadways

Minimum Arc Length (feet)							
	Radius (feet)						
	100	150	200	250	300	400	≥ 500
Desirable	65	70	100	120	150	180	200
Minimum	40	50	65	85	100	120	150

Notes:

(1) Provide the desirable arc length. When the desirable length cannot be attained, provide the greatest attainable length possible, but not less than the minimum values.

210.8.2.3 Reverse Curves

Reverse curves are curves in opposite directions on a common tangent that are located in close proximity to each other. Avoid using reverse curves unless a sufficient length (see ***FDM 210.9.1***) of tangent is included between the curves to provide for superelevation transitions.

210.9 Superelevation

Use a maximum superelevation rate of 0.10 on high-speed roadways. Tabulated superelevation rates for high-speed roadways are provided in ***Table 210.9.1***.

Use a maximum superelevation rate of 0.05 on low-speed roadways. Tabulated superelevation rates for low-speed roadways are provided in ***Table 210.9.2***.

Design non-limited access ramps using the arterial roadway criteria. Additional data is contained in the ***Standard Plans, Index 000-510*** and ***000-511***.

Provide the following minimum lengths of full superelevation within horizontal curves:

(1) 100 feet for Design Speeds ≤ 45 mph.

(2) 200 feet for Design Speeds ≥ 50 mph.

210.9.1 Superelevation Transitions

The standard superelevation transition places 80% of the transition on the tangent and 20% on the curve. Superelevation transition slope rates are provided in ***Table 210.9.3***.

In transition sections where the travel lane(s) cross slope is less than 1.5%, provide one of the following minimum grade criteria:

(1) Maintain a minimum profile grade of 0.5%.

(2) Maintain a minimum edge of pavement grade of 0.2% (0.5% for curbed roadway).

When superelevation is required for reverse curves, a suitable tangent length between the curves is determined as follows:

(1) 80% of the transition for each curve should be located on the tangent.

(2) Tangent length is equal to or greater than the sum of the two 80% distances.

(3) Where alignment constraints require an adjustment to the superelevation transition, no more than 50% of the transition may be placed on the curve.

210.9.2 RRR Criteria for Superelevation

Superelevation and transition requirements are provided in ***FDM 210.9.***

For all curves:

- If there are any crashes within the last 5 years that are attributed to superelevation, correct the superelevation rates to the new construction values provided in ***Tables 210.9.1*** and ***210.9.2***.

For low-speed curves:

- If the existing superelevation rates are within 0.5% (+/-) of the new construction values in ***Table 210.9.2,*** superelevation rate correction is not required.
- If the existing superelevation rates are not within 0.5% (+/-) of the new construction values in ***Table 210.9.2***, correct the superelevation rates. A Design Variation is required to leave the deficient curve in place.

For high-speed curves and all ramps (regardless of speed):

- If the existing superelevation rates are within the range of derived values from the e_{max} = 6% and e_{max} = 12% tables in ***AASHTO A Policy on Geometric Design of Highways and Streets*** (***AASHTO Green Book***), superelevation rate correction is not required.
- If the existing superelevation rates are outside of the range of derived values from the ***AASHTO Green Book*** e_{max} = 6% and e_{max} = 12% tables, correct the superelevation rates. A Design Exception is required to leave the deficient curve in place.

210.9.2.1 Superelevation Correction

This type of work may involve variable depth milling and asphalt layers. Provide the following information in the plans:

(1) Details showing how the transition from normal cross slope to superelevation is to be achieved.

(2) A table that summarizes the estimated quantities for milling, overbuild, and structural courses will be necessary.

(3) Cross sections depicting superelevation correction for the following locations:

   (a) At the PC and at the PT.

   (b) Fifty feet before and after the PC and PT.

   (c) At 300-foot intervals within the curve.

For curbed roadways, superelevation correction should be provided by reconstructing or adjusting the curve to accommodate overbuild. When a correction is not possible, provide other measures appropriate to improve identified safety or operational problems.

Table 210.9.1 Superelevation Rates for e_{max} = 0.10

Superelevation Rates (e_{max} =0.10) Tabulated Values

Degree of Curve (D)	Radius R (ft.)	Design Speed (mph)								
		30	35	40	45	50	55	60	65	70
0° 15'	22,918	NC	NC	NC	NC	NC	NC	NC	NC	NC
0° 30'	11,459	NC	NC	NC	NC	NC	NC	RC	RC	RC
0° 45'	7,639	NC	NC	NC	NC	RC	RC	0.023	0.025	0.028
1° 00'	5,730	NC	NC	NC	RC	0.021	0.025	0.030	0.033	0.037
1° 15'	4,584	NC	NC	RC	0.022	0.026	0.031	0.036	0.041	0.046
1° 30'	3,820	NC	RC	0.021	0.026	0.031	0.037	0.043	0.048	0.054
	*R_{NC}									
2° 00'	2,865	RC	0.022	0.028	0.034	0.040	0.048	0.055	0.062	0.070
	*R_{RC}									
2° 30'	2,292	0.021	0.028	0.034	0.041	0.049	0.058	0.067	0.075	0.085
3° 00'	1,910	0.025	0.032	0.040	0.049	0.057	0.067	0.077	0.087	0.096
3° 30'	1,637	0.029	0.037	0.046	0.055	0.065	0.075	0.086	0.095	0.100
4° 00'	1,432	0.033	0.042	0.051	0.061	0.072	0.083	0.093	0.099	D_{max} = 3° 30'
5° 00'	1,146	0.040	0.050	0.061	0.072	0.083	0.094	0.098	D_{max} = 4° 15'	
6° 00'	955	0.046	0.058	0.070	0.082	0.092	0.099	D_{max} = 5° 15'		
7° 00'	819	0.053	0.065	0.078	0.089	0.098	D_{max} = 6° 30'			
8° 00'	716	0.058	0.071	0.084	0.095	0.100				
9° 00'	637	0.063	0.077	0.089	0.098	D_{max} = 8° 15'				
10° 00'	573	0.068	0.082	0.094	0.100					
11° 00'	521	0.072	0.086	0.097	D_{max} = 10° 15'					
12° 00'	477	0.076	0.090	0.099						
13° 00'	441	0.080	0.093	0.100						
14° 00'	409	0.083	0.096	D_{max} = 13° 15'						
15° 00'	382	0.086	0.098							
16° 00'	358	0.089	0.099							
18° 00'	318	0.093	D_{max} = 17° 45'							
20° 00'	286	0.097								
22° 00'	260	0.099								
24° 00'	239	0.100								
		D_{max} = 24° 45'								

Notes:

NC = Normal Crown (-0.02)

RC = Reverse Crown (+0.02)

R_{NC} = Minimum Radius for NC

R_{RC} = Minimum Radius for RC

(1) Rates for intermediate D's and R's are to be interpolated.

(2) Degree of Curvature (D) on high-speed curbed roadways must not exceed: 2° 30' for 50 mph and 2° 00' for 55 mph.

(3) Degree of Curvature (D) on interstates must not exceed 3° 00' for 70 mph.

*** NC/RC (- -) and RC/e (—) Break Points (Radius in feet)**

Break Points	Design Speed (mph)								
	30	35	40	45	50	55	60	65	70
R_{NC}	3349	4384	5560	6878	8337	9949	11709	13164	14714
R_{RC}	2471	3238	4110	5087	6171	7372	8686	9783	10955

Table 210.9.2 Superelevation Rates for e_{max} = 0.05

Superelevation Rates (e_{max} =0.05) Tabulated Values					
Degree of Curve (*D*)	Radius (R) (feet)	Design Speed (mph)			
		25-30	35	40	45
2° 00'	2,865	NC	NC	NC	NC
2° 15'	2,546				
2° 45'	2,083				NC
3° 00'	1,910				RC
3° 45'	1,528			NC	
4° 00'	1,432			RC	
4° 45'	1,206				
5° 00'	1,146		NC		
5° 15'	1,091		RC		
5° 30'	1,042				
5° 45'	996				
6° 00'	955				RC
6° 15'	917				0.022
6° 30'	881				0.024
6° 45'	849				0.027
7° 00'	819	NC			0.030
7° 15'	790	RC			0.033
7° 30'	764				0.037
7° 45'	739				0.041
8° 00'	716			RC	0.045
8° 15'	694			0.022	0.050
8° 30'	674			0.025	D_{max} = 8° 15'
8° 45'	655			0.027	
9° 00'	637			0.030	
9° 30'	603			0.034	
10° 00'	573			0.040	
10° 30'	546		RC	0.047	
11° 00'	521		0.023	D_{max} = 10° 45'	
11° 30'	498		0.026		
12° 00'	477		0.030		
13° 00'	441		0.036		
14° 00'	409	RC	0.045		
15° 00'	382	0.023	D_{max} = 14° 15'		
16° 00'	358	0.027			
17° 00'	337	0.032			
18° 00'	318	0.038			
19° 00'	302	0.043			
20° 00'	286	0.050			
		D_{max} = 20° 00'			

Notes:
(1) NC = Normal Crown (-0.02), RC = Reverse Crown (+0.02)
(2) Rates for intermediate D's and R's are to be interpolated.
(3) Design Speeds of 25 mph are to be designed as 30 mph.

Table 210.9.3 Superelevation Transition Slope Rates

# Lanes One Direction	Superelevation Transition Slope Rates						
	e_{max} = 0.10				e_{max} = 0.05		
	Design Speed (mph)				Design Speed (mph)		
	25-40	45-50	55-60	65-70	25-35	40	45
1-Lane & 2-Lane	1:175	1:200	1:225	1:250	1:100	1:125	1:150
3-Lane	---	1:160	1:180	1:200			
4-Lane or more	---	1:150	1:170	1:190			

Notes:

e_{max} = 0.10:

(1) The length of superelevation transition is to be determined by the relative slope rate between the travel way edge of pavement and the profile grade, except that the minimum length of transition is 100 feet.

(2) For additional information on transitions, see the ***Standard Plans***, ***Index 000-510***.

e_{max} = 0.05:

(1) The length of superelevation transition is to be determined by the relative slope rate between the travel way edge of pavement and the profile grade, except that the minimum length of transition is 50 feet for Design Speeds of 25-35 mph and 75 feet for Design Speeds of 40-45 mph.

(2) A slope rate of 1:125 may be used for Design Speeds of 45 mph under restricted conditions.

(3) For additional information on transitions, see the ***Standard Plans***, ***Index 000-511***.

210.10 Vertical Alignment

The profile grade line defines the vertical alignment for roadway and bridge construction. The profile grade line is a series of tangents connected by vertical curves. For undivided highways, the profile grade line is typically located at the horizontal centerline of the roadway. For divided highways, a profile grade line should be established for each direction of travel.

Vertical alignments must meet criteria in the ***FDM*** to assure proper transitions, sight distances, and clearances.

210.10.1 Grades

The slope or grade of each tangent is expressed in percent rise (+) or fall (-); e.g., +2.000% or -2.000%. The maximum grades that may be used in establishing the vertical alignment are given in ***Table 210.10.1***.

Table 210.10.1 Maximum Grades

Context Classification	Maximum Grades (percent)								
	Design Speed (mph)								
	25-30	35	40	45	50	55	60	65	70
C1 Natural C2 Rural	N/A	N/A	N/A	N/A	4	4	3	3	3
C2T Rural Town C3 Suburban C4 Urban General	8	7	7	6	6	5	N/A	N/A	N/A
C5 Urban Center C6 Urban Core	8	8	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

(1) Maximum grade used should not exceed 4% when truck volume ≥ 10% for all context classifications.

(2) For RRR projects, when existing grades do not meet the above requirements but meet the standards in effect at the time of construction, the existing grades may remain.

(3) N/A indicates this combination of Design Speed and context classification is outside the intended design range and should be avoided. See ***Table 201.5.1*** for context classifications and Design Speed ranges.

The point where tangents intersect is known as the vertical point of intersection (VPI). When two tangent grades intersect and no vertical curve is provided, the "kink" is known as the point of intersect (PI). The maximum change in grade (i.e., algebraic change) without a vertical curve is provided in ***Table 210.10.2***.

Table 210.10.2 Maximum Change in Grade without Vertical Curve

Maximum Change In Grade Without Vertical Curve (percent)								
Design Speed (mph)								
25-30	35	40	45	50	55	60	65	70
1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20

210.10.1.1 Curbed Roadway

The minimum distance between VPIs on curbed roadways is 250 feet. The minimum grade on curbed roadways is 0.30%.

210.10.2 Vertical Curves

A vertical curve must be provided when the change in grade of two intersecting tangent grades exceed the values shown in ***Table 210.10.2***. A vertical curve is identified by a curve length (L) which is equal to the product of the K value (K) and the algebraic difference in grades (A).

Table 210.10.3 provides minimum K-Values and ***Table 210.10.4*** provides minimum vertical curve lengths.

Table 210.10.3 K Values for Vertical Curves

	Minimum K Values For Curves									
	Design Speed (mph)									
	25	30	35	40	45	50	55	60	65	70
Sag	26	37	49	64	79	96	115	136	157	181
Crest (new const.)	19	31	47	70	98	136	185	245	313	401
Crest (RRR Criteria)	12	19	29	44	61	84	114	151	193	247

Notes:

Length, L = KA

Where: K = Rate of vertical curvature

L = Length of vertical curve, (feet)

A = Algebraic difference in grades, (percent)

(1) New Construction K values are based on an eye height of 3.5 feet and an object height of 6 inches. RRR Criteria K values are based on an eye height of 3.5 feet and an object height of 2 feet.

(2) The minimum curve length must not be less than values shown in ***Table 210.10.4***.

Table 210.10.4 Minimum Vertical Curve Lengths

	Minimum Curve Length (feet)									
	Design Speed (mph)									
	25	30	35	40	45	50	55	60	65	70
Sag	75	90	105	120	135	200	250	300	350	400
Crest						300	350	400	450	500

210.10.2.1 RRR Criteria for Vertical Curves

Table 210.10.3 provides RRR Criteria K values to be used to check the sufficiency of existing crest vertical curves. ***2001 AASHTO Green Book*** revised its K values to reflect a 2-foot object height; FDOT has not adopted this change for new construction but these K values can be used to check existing curves. An existing crest vertical curve that does not meet the minimum RRR Criteria K value requires a Design Exception or Design Variation to remain.

When crash data indicates that an evaluation is required, consider the following:

(1) The nature of potential hazards hidden by a hill crest.

(2) The location of the hazard in relation to the portion of the highway where sight distance falls below new construction criteria.

(3) Effectiveness of other options such as relocating or correcting the hazard.

(4) Providing warning signs.

Sag vertical curves do not typically pose stopping sight distance problems. A sag vertical curve that does not meet the minimum K value in ***Table 210.10.3*** and does not have a crash history does not require a Design Exception or Design Variation to remain.

210.10.3 Vertical Clearances

Consider the following vertical clearance requirements when developing the vertical alignment:

(1) Minimum clearances for bridge structures are given in ***FDM 260.6*** *and* ***FDM 260.8***.

(2) Minimum clearance from the bottom of the roadway base course to the Base Clearance Water Elevation is 3 feet, except as noted below. These exceptions will require a reduction in the design resilient modulus in accordance with the ***Flexible Pavement Design Manual***. Coordinate with the Pavement Design Engineer for the following facilities:

  (a) 2-lane roadways in context classifications C1, C2, C2T and C3 and all ramps may be reduced to a 2-foot clearance.

  (b) Low points on ramps at crossroads may be reduced to a 1-foot clearance.

  (c) All other facilities in context classifications C4 through C6 may be reduced to a 1-foot clearance.

(3) The relationship between the pavement elevation and the Design Flood Elevation is discussed in ***Section 4.4 (3)*** of the ***FDOT Drainage Manual (Topic No. 625-040-002)***.

(4) ***Drainage Manual, Appendix C*** lists minimum cover and maximum fill heights for all types of culverts.

(5) For utility clearances, refer to the ***Utility Accommodation Manual***.

(6) The required clearance for new overhead sign structures is 17.5 feet. This clearance is the least distance measured between the lowest point on the sign structure and the traffic lane or shoulder directly below the sign structure. For any construction affecting existing overhead sign clearances, the minimum vertical clearance is 17 feet.

(7) The required clearance for new walk-in Dynamic Message Sign (DMS) structures is 19.5 feet. This clearance is the least distance measured between the lowest point on the DMS structure and the traffic lane or shoulder directly below the DMS structure. For any construction affecting existing DMS, the minimum vertical clearance is 19 feet.

(8) The required clearance for new signals on span wires, mast arms, or other structures is 17.5 feet. This clearance is the least distance measured between the lowest point on the signal structure and the traffic lane or shoulder directly below the signal structure. For any construction affecting existing signal clearances, FDOT minimum vertical clearance is 17 feet. Vertical clearances between 15 feet and 17 feet require a Design Variation. Signal clearances less than 15 feet are not allowed.

210.10.4 RRR Criteria for Vertical Alignment

Vertical alignment must be reviewed together with the horizontal alignment to assure that the necessary balance of standards is realized and that the combination is both safe and pleasing.

The alignment should be reviewed to see if the following principles are satisfied by the existing vertical alignment:

(1) The stopping sight distance provided meets or exceeds the values in ***Table 210.11.1***.

(2) Grades do not significantly affect truck operations.

(3) There are no hidden dips which could obscure traffic or hazards.

(4) Steep grades and sharp vertical curves do not exist at or near an intersection.

(5) Sufficient grades and, when necessary, special gutter grades exist to adequately drain urban projects.

(6) Adequate sight distance exists for traffic signals (e.g., beyond overpasses, etc.).

When any of the above conditions do not exist, evaluate for hazardous conditions and determine if corrective measures are warranted.

210.11 Sight Distance

The ***AASHTO Green Book*** has a thorough discussion on sight distance. Consider the following aspects of sight distances:

(1) Stopping Sight Distance: Sight distances needed for stopping, which are applicable on all highways

(2) Intersection Sight Distance: Sight distances needed by a motorist to see approaching vehicles before their line of sight is blocked by an obstruction near the intersection.

(3) Passing Sight Distance: Sight distances needed for the passing of overtaken vehicles, applicable only on two-lane highways

(4) Decision Sight Distance: Sight distances needed for decisions at complex locations (e.g., merging tapers, ramps, weaving sections)

210.11.1 Stopping Sight Distance

Stopping sight distance is defined as the distance needed for drivers to see an object on the roadway ahead and bring their vehicles to a safe stop before colliding with the object. The distances are derived for various Design Speeds based on assumptions for driver reaction time, the braking ability of most vehicles under wet pavement conditions, and the friction provided by most pavement surfaces.

Stopping sight distance is influenced by both vertical and horizontal alignment. A roadway designed to criteria employs a horizontal alignment, vertical alignment, and a cross section that provides at least the minimum stopping sight distance through the entire facility.

Minimum stopping sight distances are provided in ***Table 210.11.1***. ~~Values shown in this table are based on an~~ Stopping sight distance eye height ~~of~~ is 3.5 feet and ~~an~~ object heights are the following: ~~of~~

- 6 inches for new construction~~.~~

- 2 feet for RRR

Minimum stopping sight distances greater than shown in ***Table 210.11.1*** should be considered when drivers require additional time to make decisions.

Table 210.11.1 Minimum Stopping Sight Distance

Grade (percent)		Minimum Stopping Sight Distance (feet)									
		Design Speed (mph)									
		25	30	35	40	45	50	55	60	65	70
Downgrade	≤ 2	155	200	250	305	360	425	495	570	645	730
	3	158	205	257	315	378	446	520	598	682	771
	4	160	208	261	320	385	454	530	610	696	788
	5	162	211	266	326	392	464	541	623	712	806
	6	165	215	271	333	400	474	553	638	728	825
	7	167	218	276	339	408	484	565	652	746	845
	8	170	222	281	346	417	495	579	669	765	867
	9	173	227	287	354	427	507	593	686	785	891
Upgrade	≤ 2	155	200	250	305	360	425	495	570	645	730
	3	147	190	237	289	344	405	469	538	612	690
	4	146	188	234	285	339	399	462	530	602	678
	5	144	186	231	281	335	393	456	522	593	668
	6	143	184	229	278	331	388	450	515	584	658
	7	142	182	226	275	327	383	443	508	576	648
	8	141	180	224	272	323	379	438	501	568	639
	9	139	179	222	269	320	375	433	495	561	631

210.11.2 Intersections

Information and requirements on sight distance at intersections is contained in ***FDM 212***.

210.11.3 Passing Sight Distance

Passing sight distance is the minimum distance that would enable a vehicle to pass another vehicle without interfering with oncoming vehicles traveling at the Design Speed. The minimum passing sight distance is sufficient only for the passing of a single or isolated vehicle.

Minimum passing sight distances for 2-lane, 2-way roadways are provided in ***Table 210.11.2***. Values shown in this table are based on an eye height of 3.5 feet and an object height of 3.5 feet.

Table 210.11.2 Minimum Passing Sight Distance

	Minimum Passing Sight Distance For 2-Lane, 2-Way Roadways (feet)									
	Design Speed (mph)									
	25	30	35	40	45	50	55	60	65	70
New Const.	900	1090	1280	1470	1625	1835	1985	2135	2285	2480
RRR	450	500	550	600	700	800	900	1000	1100	1200

The ***2011 AASHTO Green Book*** revised its passing sight distance values, and FDOT has not adopted this change for new construction. The new construction passing sight distance values in ***Table 210.11.2*** should be used to check the vertical and horizontal geometry on new alignments to provide as many passing zones as possible.

The values shown in the ***Manual on Uniform Traffic Studies (MUTS)*** are used as the warrants for placing no-passing zone pavement markings for all projects. The RRR values in ***Table 210.11.2*** should be used to verify existing pavement markings, in accordance with the No Passing Zone Study procedure included in the ***MUTS***.

210.11.4 Decision Sight Distance

AASHTO Green Book, ***Chapter 3*** provides a detailed discussion on decision sight distance.

212 Intersections

212.1 General

This chapter provides design criteria and guidance for the geometric layout of at-grade conventional intersections. Conventional intersections include 3-leg (T), 4-leg, and multi-leg (5 or more legs).

Multi-leg conventional intersections should be avoided. Alternatives to existing multi-leg intersections include:

(1) Converting to a roundabout.

(2) Converting one or more legs to a one-way operation.

(3) Reconfiguring or realigning the intersection to create separate intersections, each with no more than four legs.

See ***FDM 201*** for design vehicle selection and design speed requirements.

See ***FDM 210*** for lane width, median width, island dimensions, and deflection angle requirements.

See ***FDM 222*** for requirements concerning pedestrian facilities and ***FDM 223*** for bicycle facilities.

212.1.1 Alternative Intersections

Alternative intersection design is a key component of upgrading our transportation facilities and improving the mobility and safety of all road users. These innovative designs are becoming more common as increasing traffic demand exceeds the limitations of traditional intersection solutions.

Alternative intersections offer the potential to improve safety and reduce delay at lower cost and with fewer impacts than traditional solutions such as adding lanes or grade separation. Three of the more common alternative intersection types are:

- Displaced Left-Turn (a.k.a. Continuous Flow Intersection)
- Restricted Crossing U-Turn (RCUT)
- Median U-Turn (MUT)

The FHWA has published comprehensive informational guides for alternative intersections which include guidance on how to plan, design, construct, and operate them. The following links provide access to these guides: ***FHWA Alternative Designs*** and ***Alternative Intersections/Interchanges: Informational Report (AIIR).***

These types of alternate intersection designs should be coordinated with the Central Office Roadway Design Office.

212.1.2 Intersection Control Evaluation

Intersection Control Evaluation (ICE) is a process to determine the most effective intersection configuration for a specified project. Through ICE, multiple alternative and conventional intersection configurations are compared to one another based on safety, operations, cost, and environmental impacts. The ICE procedure provides a transparent and consistent approach to intersection alternatives selection and provides documentation to support decisions made.

ICE policy and procedure is published on the FDOT Traffic Engineering and Operations Office website at the following Link: ***Manual on Intersection Control Evaluation***.

212.2 Intersection Control

Conventional intersections utilize one of four control types; yield, stop, all-way stop and signal.

212.2.1 Yield Control

Certain channelized movements at intersections and interchanges, and all approaches to roundabouts are often yield controlled. Refer to the ***Manual on Uniform Traffic Control Devices (MUTCD)*** for information on the locations where yield control traffic control devices may be appropriate.

212.2.2 Stop Control

Stop-controlled intersections have one or more legs of the intersection controlled by a "STOP" sign (R1-1).

Intersections with stop control are a common, low-cost control, which require the traffic on the minor roadway to stop before entering the major roadway. It is used where application of the normal R/W rule is not appropriate for certain approaches at the intersection.

To meet the requirements for the assigned access classification, or where U-turn opportunities exist within a corridor, consider limiting stop-controlled minor roads or driveways to “right-in, right-out” only.

212.2.3 All-Way Stop Control

For an all-way stop intersection, traffic approaching it from all directions is required to stop before proceeding through the intersection. An all-way stop may have multiple approaches and is typically marked with supplemental signing stating the number of approaches.

All-way stop control is most effective at the intersection of low-speed 2-lane roadways not exceeding 1,400 vehicles during the peak hour. All-way stop control should not be used on multilane highways. Guidance for consideration of the application of all-way stop control is provided in the ***MUTCD***.

All-way stop control may be used as an interim measure when a traffic signal or roundabout is warranted, but the installation is delayed.

212.2.4 Signal Control

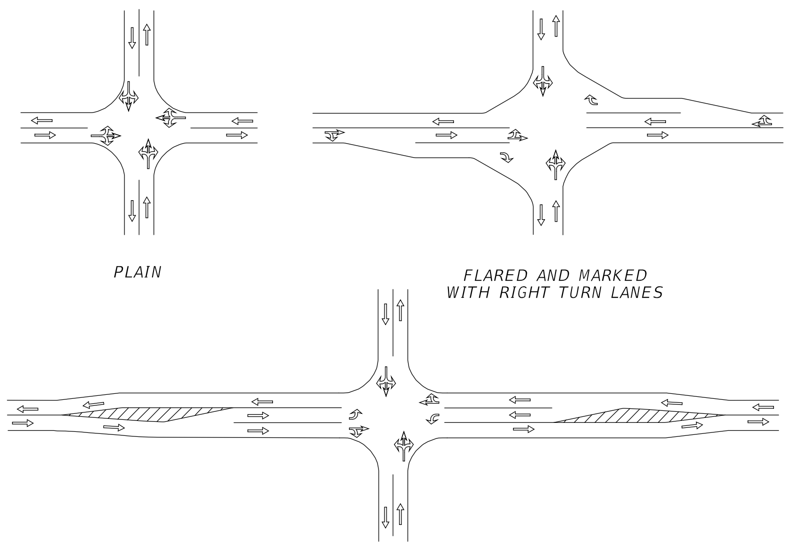
Signalization provides an orderly and predictable movement of motorized and non-motorized traffic throughout the highway transportation system. It also provides guidance and warnings to ensure the safe and informed operation of the traffic stream.

Refer to ***FDM 232*** for design criteria for signalization.

212.3 Intersection Types

Conventional intersection configurations include flared and channelized intersections (divided and undivided). Flared intersections are illustrated in ***Figure 212.3.1*** and channelized intersections in ***Figure 212.3.2.*** See ***FDM 210.3*** for median and island requirements.

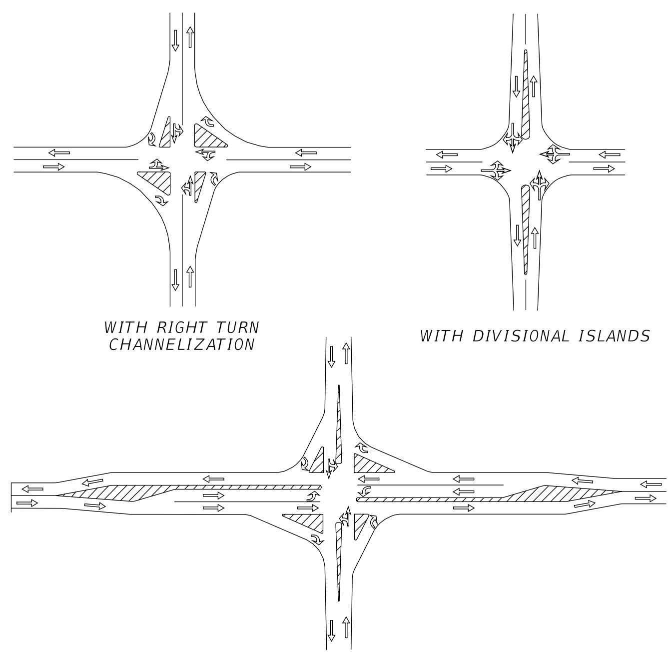
Figure 212.3.1 Flared Intersections



FLARED AND MARKED WITH
LEFT TURN LANES

Ref: Figure 9-4, 2018 AASHTO Green Book

Figure 212.3.2 Channelized Intersections



WITH RIGHT TURN CHANNELIZATION,
DIVISIONAL ISLANDS, AND LEFT
TURN LANES

Ref: Figure 9-8, 2018 AASHTO Green Book

212.4 Intersection Functional Area

The functional area of an intersection extends in both directions including auxiliary lanes and their associated channelization. This is illustrated in ***Figures 212.4.1*** and ***212.4.2***.

The functional area on the approach to an intersection or driveway consists of three basic elements:

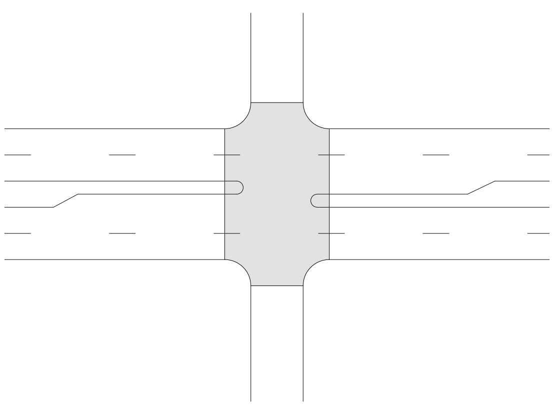
(1) Perception-reaction-decision distance

(2) Maneuver distance

(3) Queue-storage distance (see ***FDM 212.14.2***)

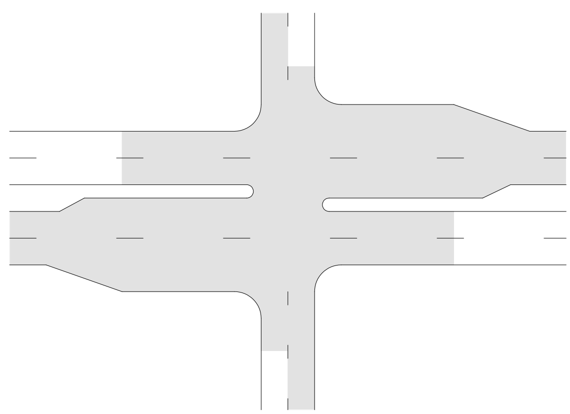
These elements are shown in ***Figure 212.4.3***. The maneuver distance includes the length needed for both braking and lane-changing when there is a left or right turning lane. In the absence of turn lanes, the maneuver distance is the distance to brake to a comfortable stop. The storage length includes the most distant extent of any intersection-related queue expected to occur during the design period.

Figure 212.4.1
Physical Definition



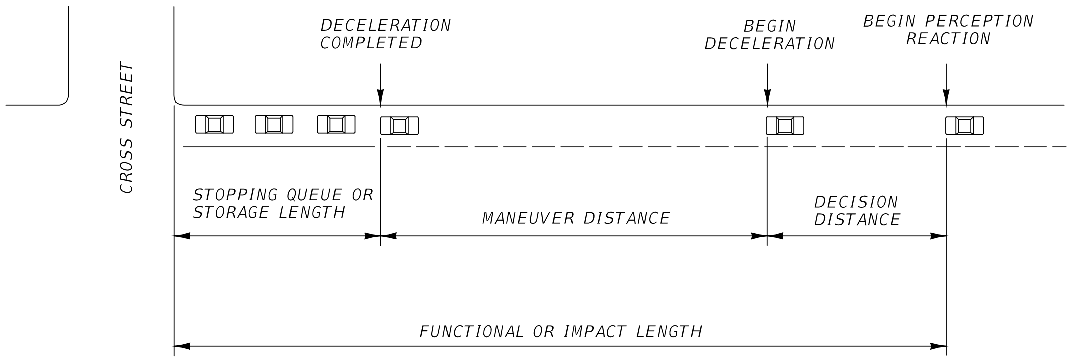
Ref: Figure 9-2, 2018 AASHTO Green Book

Figure 212.4.2
Functional Definition



Ref: Figure 9-2, 2018 AASHTO Green Book

Figure 212.4.3 Elements of the Functional Area



Ref: Figure 9-3, 2018 AASHTO Green Book

See ***FDM 127.2 (15)*** for limitations on aesthetic applications within intersection functional areas.

212.5 Intersection Angle

The intersection angle between two roadways has a significant influence on the safety and operation of an intersection. Intersection angles are to be as close to 90 degrees as practical. Intersection angles less than 75 degrees should be avoided for the following reasons:

(1) Heavy skew angles increase the intersection crossing length, exposing vehicles, pedestrians, and cyclists to conflicting traffic streams for longer periods of time. This is of particular concern at stop-controlled approaches on high-speed facilities.

(2) The road user's sight angle to the crossing leg becomes restricted due to the skew, making it difficult to see conflicting vehicles and to perceive safe crossing gaps.

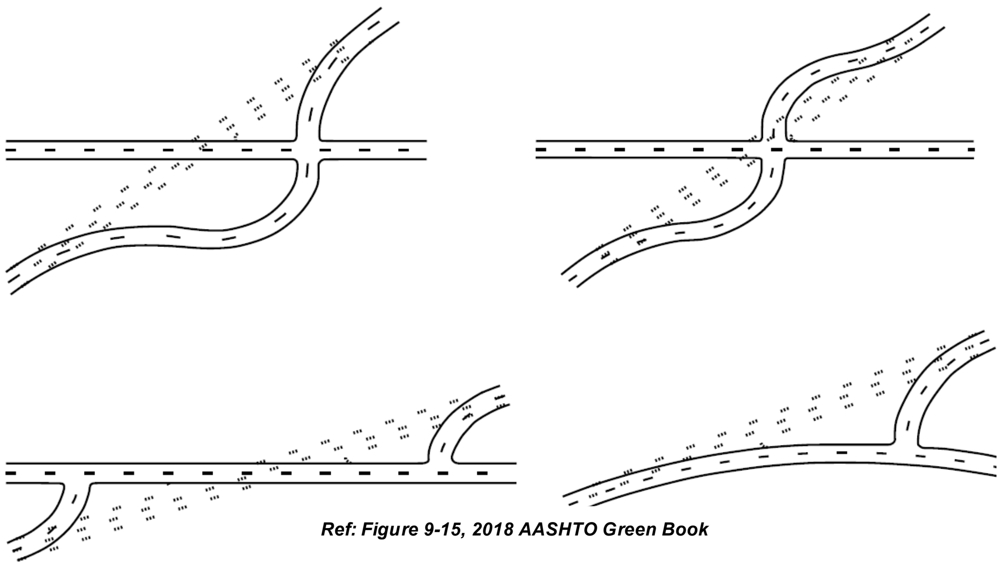
(3) Turning movements are difficult because of the skew. Additional pavement may be necessary to accommodate the turning of large trucks.

(4) Turning movements or positioning may be confusing and require additional channelization.

(5) Increased open pavement areas of highly skewed intersections increase construction and maintenance costs.

Evaluate intersections with severe skew angles and crash histories for geometric improvements as shown in ***Figure 212.5.1***. A high incidence of right-angle crashes is an indicator that improvements may be justified.

Figure 212.5.1 Intersection Reconfigurations



Ref: Figure 9-15, 2018 AASHTO Green Book

212.6 Lane Tapers

Standard taper lengths for auxiliary lanes are given in ***FDM 212.14***. Taper length is based on the following equations:

(1) Merging Taper (L):

(a) For design speeds ≤ 40 mph: $L = (W*S^2)/60$

(b) For design speeds ≥ 45 mph: $L = W*S$

Where: L = Taper length (feet)
W = Width of offset (feet)
S = Design speed (mph)

(2) Shifting Taper is equal to Merging Taper (L) / 2.

Minimum deceleration lengths are illustrated in ***Exhibit 212-1***. Additional information on lane transitions (add or drop) is provided in ***Exhibits 212-2*** and ***212-3***.

Exhibit 212-1: Median Turn Lanes Minimum Deceleration Lengths

Exhibit 212-2: Lane Transitions: 4-Lane Roadways

Exhibit 212-3: Lane Transitions: 2-Lane Roadways

212.7 Lane Shifts

Lane shifts through intersections should meet the requirements for non-merging conditions. Pavement markings should be used through the intersection to provide positive guidance to the motorist. The shifting taper length is controlled by the size of the intersection and the deflection angle. Although deflections through intersections are discouraged, there may be conditions where they are necessary.

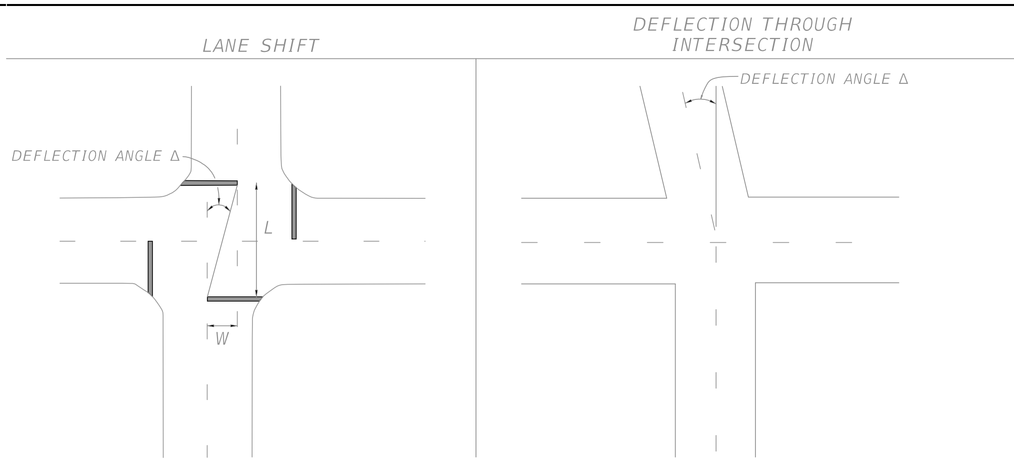
The maximum deflection angles at intersections to be used in establishing the horizontal alignment are given in ***Table 212.7.1***.

Table 212.7.1 Maximum Deflection Angle Through Intersection

Maximum Deflection Angle Through Intersection (DM)					
Design Speed (mph)					
≤ 20	25	30	35	40	45
16° 00'	11° 00'	8° 00'	6° 00'	5° 00'	3° 00'

Notes:

Deflection angle used is not to cause a lane shift (W) of more than 6 feet from stop bar to stop bar.



212.8 Profile Grades

The profile grade line defines the vertical alignment for construction. The grade line of the mainline road is typically carried through the intersection and the minor crossroad (or cross street) is adjusted to it. This design involves a transition in the crown of the crossroad to an inclined cross section at its junction with the mainline road, as illustrated in ***Figure 212.8.1***.

The break in the crossroad profile at the center of the intersection should be accomplished with a vertical curve.

Vertical alignments at or near intersections should provide traffic lanes that are:

(1) Clearly visible and understandable to drivers for any desired direction of travel,

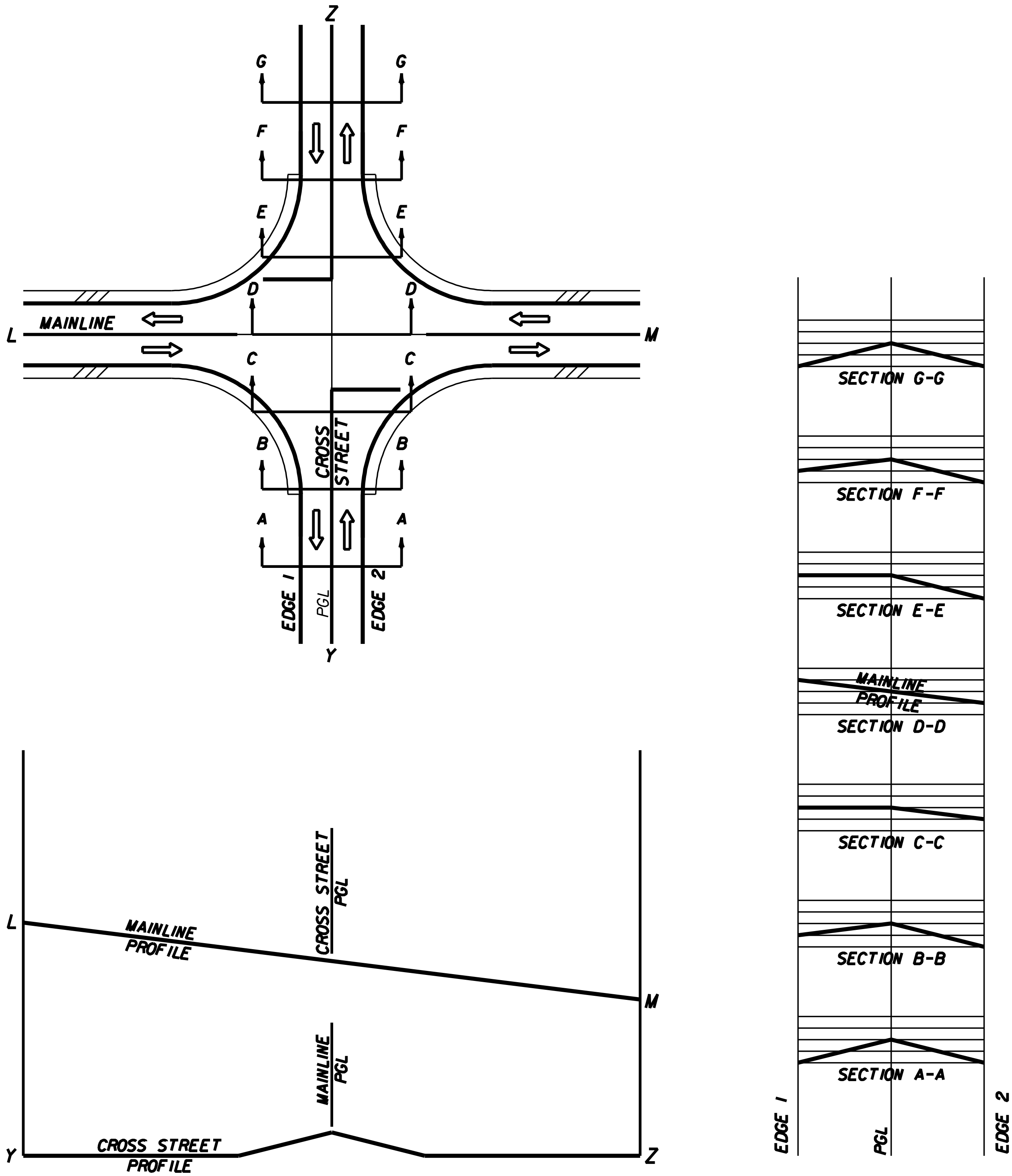
(2) Free from the sudden appearance of potential conflicts, and

(3) Consistent in design with the portions of the highway just traveled.

Steep grades at intersections may increase or decrease stopping or acceleration distance. Avoid grades in excess of 3% on intersecting roads in the vicinity of the intersection. Where conditions make such designs impractical, grades should not exceed 6%.

Provide adequate sight distance along both intersecting roads and across their included corners, even where one or both intersecting roads are on vertical curves. The gradients of intersecting roads should be as flat as practical on those sections that are to be used for the queuing of stopped vehicles.

Figure 212.8.1 Cross Street Intersection Transition



212.8.1 Special Profiles

Special profiles for certain roadway elements may be necessary to ensure a safe, efficient, well-drained and smooth roadway system. Elements that may require special profiles include pavement edges or gutter flow lines at street intersections, profile grade lines, intersection plateaus, curb returns, and special superelevation details. Special profiles are developed at close intervals and large scale to clearly identify all construction details of these elements.

212.8.2 Plateauing

In some instances, it is desirable for the crossroad to receive the same profile considerations as the mainline road. To provide this "equal treatment" with respect to profile, a technique commonly known as intersection plateauing is applied. Plateauing refers to flattening of the intersection and the transition of both roadway profiles and cross slopes on the intersection approaches.

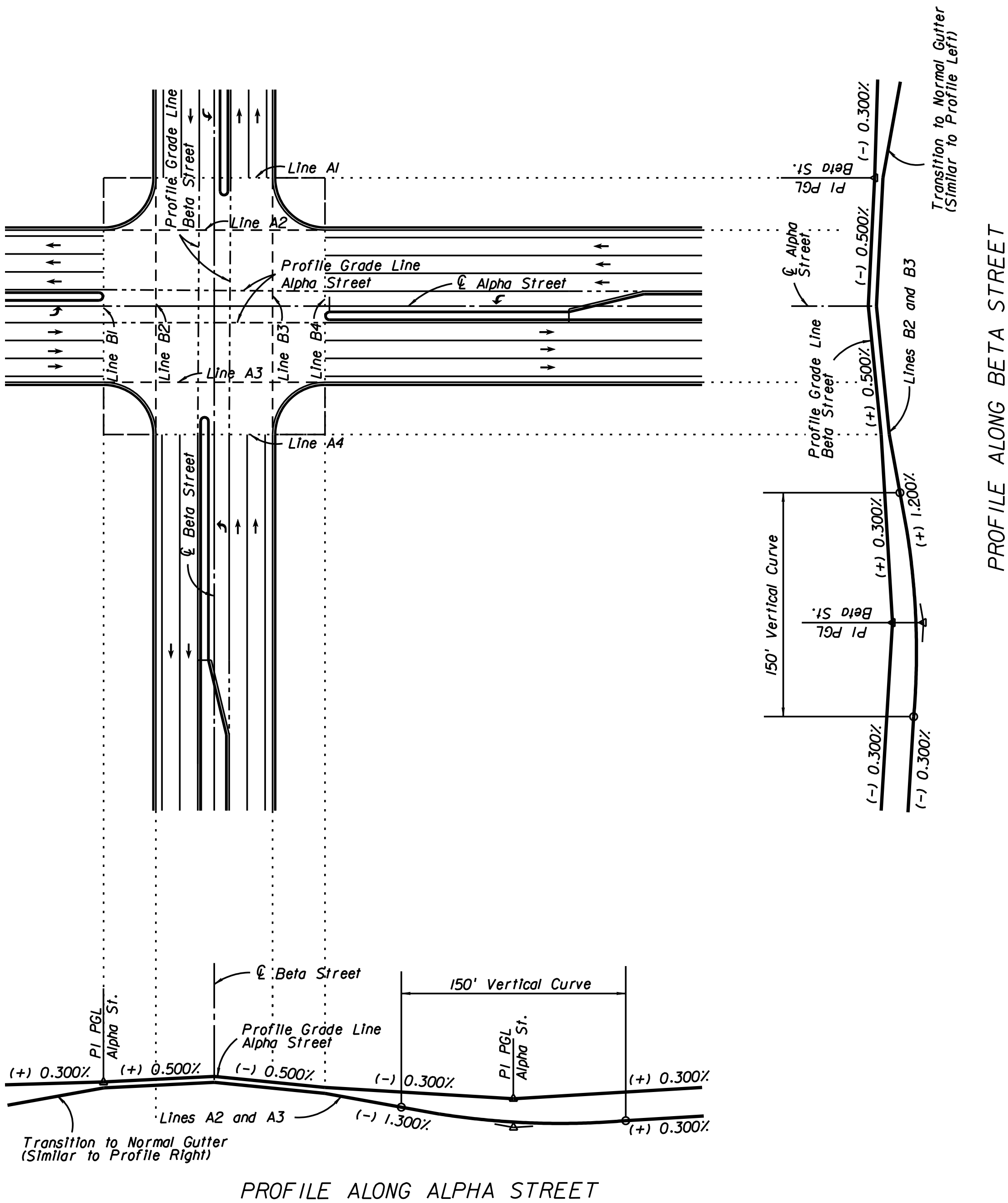
Provide a profile combination that provides a smooth transition and adequate drainage when applying intersection plateauing. Transition slope rates are to meet the values provided in ***Table 212.8.1***; however, the minimum length of cross slope transition is 50 feet for design speeds less than or equal to 35 mph and 75 feet for design speeds of 40 mph or greater.

An example of a plateaued intersection design is illustrated in ***Figure 212.8.2***.

Table 212.8.1 Slope Rates for Intersection Approaches

Design Speed (mph)	Slope Ratio
25-35	1:100
40	1:125
45-50	1:150
55-60	1:170
65-70	1:190

Figure 212.8.2 Example of Plateaued Intersection



212.9 Median Openings

Locate and design median openings to meet traffic requirements in accordance with the access management plan for the facility. See ***FDM 201.4*** for more information on access management plans and decision-making.

See ***FDM 210.3*** for additional requirements for medians at intersections**.**

The following conditions may require additional median width:

- accommodations for trees (provide space above and below ground for growth)
- offset turn lanes
- directional median openings
- dual and triple left-turn lanes

The overall length of a full median opening is typically the same width as the intersecting road (including shoulders) which is sufficient to accommodate the swept path of left-turning vehicles. Median functions and minimum widths are provided in ***Table 212.9.1***.

For un-signalized intersections, median openings should not be longer than the required length to avoid multiple vehicles attempting to stop within the opening.

Table 212.9.1 Minimum Median Width

Median Function	Minimum Width (feet)
Separation of opposing traffic	4
Provision for pedestrian refuge	6
Provision for storage of left-turning vehicles	See ***Table 210.3.1***
Provision for protection of vehicles crossing through lanes	22
Provision for U-turns, left-turn lane to outside lanes	30
Provision for dual left-turn lanes and U-turns	42

The control radius refers to a radius that must be considered in establishing the location of median or traffic separator ends on divided highways and the stop bar on undivided highways. Provide this radius for left-turn movements when appropriate.

Design guidance on minimum edge-of-traveled-way design for various design vehicles is provided in ***FDM 212.12.1***.

For the central part of the turn, the use of compound curves is not necessary and the use of simple curves is satisfactory. ***Table 212.9.2*** provides control radii for minimum-speed turns (10 to 15 mph) that can be used for establishing the location of the median ends.

Table 212.9.2 Control Radii for Minimum Speed Turns

Design Vehicles Accommodated	Control Radius (feet)			
	50 (40 min)	60 (50 min)	75	130
Predominant	P	SU-30	SU-40, WB-40	WB-62FL
Occasional	SU-30	SU-40, WB-40	WB-62	WB-67

212.9.1 U-Turns

Median width should accommodate passenger vehicle (P) left-turn and U-turn maneuvers. If adequate median width does not exist for accommodating U-turns, then consider adding extra pavement width such as a taper or additional shoulder width. See ***FDM 210.3*** for information on median width criteria.

In cases where U-turn traffic volumes are high, consider the use of jug handles, loop designs, or indirect left-turn designs.

212.10 Stopping Sight Distance

See ***FDM 210.11.1*** for stopping sight distance requirements.

212.11 Clear Sight Triangles

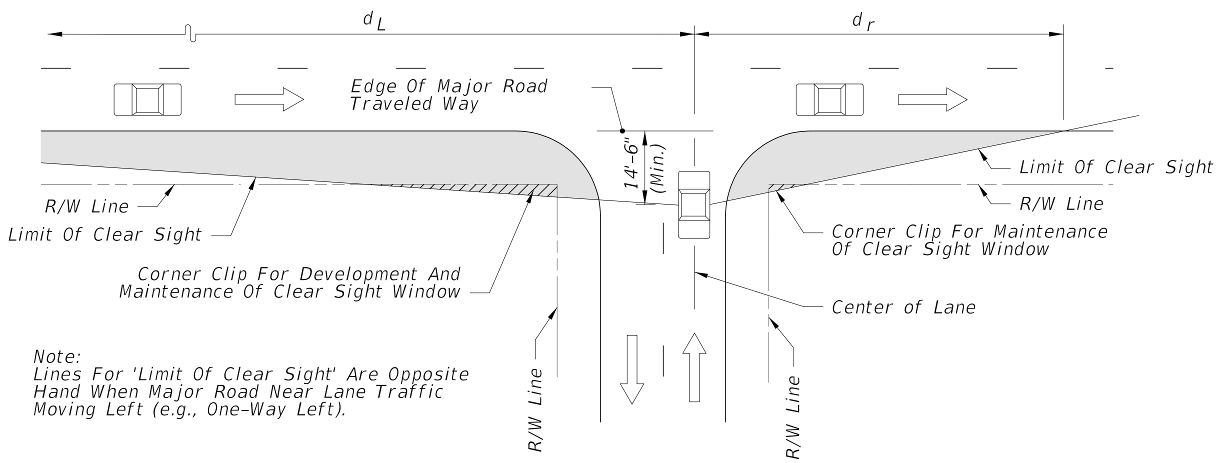
Establish clear sight triangles to assure that drivers are provided a sufficient view of the intersecting highway to identify gaps in traffic and decide when it is safe to proceed. Document the analysis of sight distance for all intersections.

Clear sight triangles are the areas along intersection approach legs and across their common corners that should be clear of visual hindrances. The dimensions of clear sight triangles are based on design speed, design vehicle, and the type of traffic control used at the intersection.

212.11.1 Stop Control (AASHTO Case B)

Figure 212.11.1 illustrates clear sight triangles for intersections and driveways.

Figure 212.11.1 Clear Sight Triangles



The minimum driver-eye setback of 14.5 feet from the edge of the traveled way may be adjusted on any intersection leg only when justified by a documented, site-specific field study of vehicle stopping position and driver-eye position.

Exhibits 212-4 through ***212-7*** provide intersection sight distances for stop-controlled intersections. The tables in the exhibits provide sight distance values for Passenger vehicles, Single Unit (SU) Trucks, and Combination vehicles for design speeds ranging from 25 mph to 70 mph. Intersection sight distance based on Passenger vehicles is suitable for most intersections; however, consider the values for SU Vehicles or Combination vehicles for intersections with high truck volumes.

The following guidance applies to ***Exhibits 212-4*** through ***212-7***:

(1) Limitations

(a) The exhibits apply to intersections in all context classifications with stop control or flashing beacon control.

(b) The exhibits apply only to intersections with intersecting angles between 60°and 120°, and where vertical and horizontal curves are not present.

(2) Dimensions

(a) Sight distance (d) is measured from the center of the entrance lane of the crossroad to the center of the near approach lane (right or left) of the highway.

(b) Distances 'd_L' and 'd_r' are measured from the centerline of the entrance lane of the crossroad to a point on the edge of the near side outer traffic lane on the highway.

(c) Distance 'd_m' is measured from the centerline of the entrance lane of the crossroad to a point on the median clear zone limit or horizontal clearance limit for the far side road of the highway.

(3) Vertical limits

(a) Provide a clear sight window throughout the limits of all intersection sight triangles.

(b) Provide a clear line of sight between vehicles at intersection stop locations and vehicles on the highway throughout the limits of all intersection sight triangles.

(c) The reference datum between roadways is 3'-6" above respective pavements since observations are made in both directions along the line of sight.

Exhibit 212-4: Intersection Sight Distance: 2-Lane Undivided

Exhibit 212-5: Intersection Sight Distance: 4-Lane Undivided

Exhibit 212-6: Intersection Sight Distance: 4-Lane Divided

Exhibit 212-7: Intersection Sight Distance: 6-Lane Divided

212.11.2 All-Way Stop Control (AASHTO Case E)

Provide clear sight lines on each of the approach legs for all-way stop controlled intersections.

212.11.3 Signal Control (AASHTO Case D)

For signalized intersections incorporate the following:

(1) Develop sight distances based on AASHTO 'Case D-Intersections with Signal Control'.

(2) The first vehicle stopped on any approach leg is visible to the driver of the first vehicle stopped on each of the other approach legs.

(3) For permissive left-turns, provide sufficient sight distance for left-turning vehicles to select gaps in oncoming traffic and complete the left-turns.

(4) If a traffic signal is to be placed on two-way flashing operation (i.e., flashing yellow on the major road approaches and flashing red on the minor road approaches) under off-peak or nighttime conditions, provide the appropriate departure sight triangles for AASHTO Case B (Stop Control on the Minor Road).

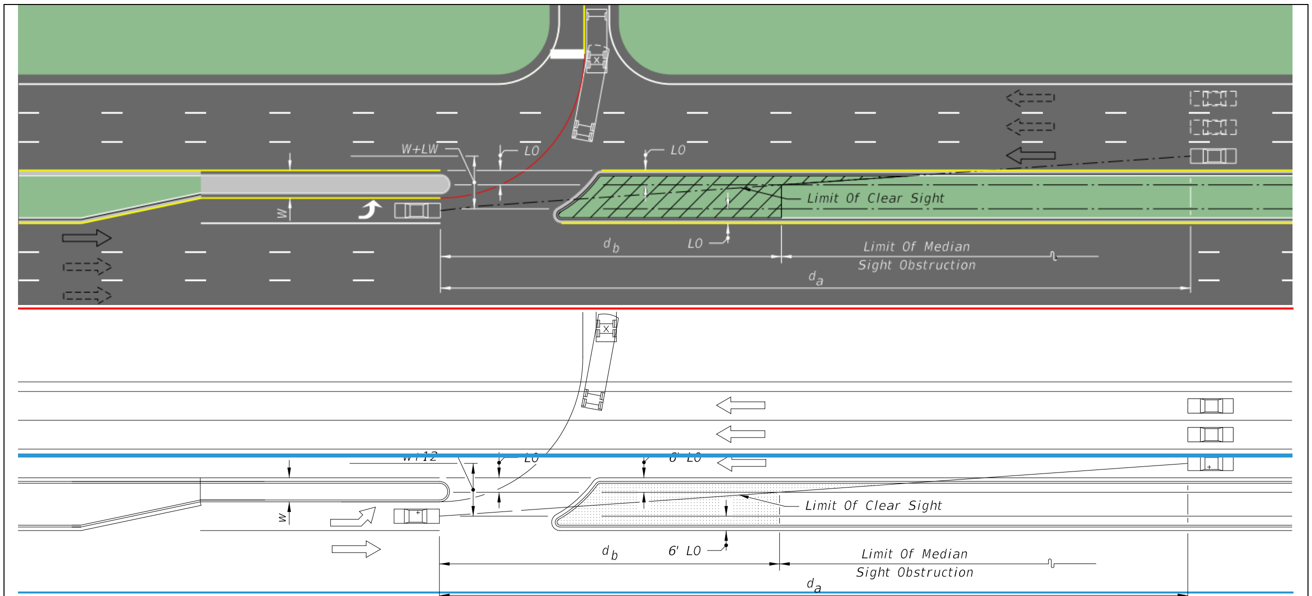
(5) If right-turns on red are permitted from any approach leg, then provide the appropriate departure sight triangle to the left for AASHTO Case B above.

212.11.4 Left-Turn from Highway (AASHTO Case F)

Provide sufficient sight distance to accommodate a left-turn maneuver for locations where left turns across opposing traffic are permitted. ***Table 212.11.1*** provides clear sight distance values for left-turn from highway.

For additional information on determining the sight distance, refer to Chapter 9 of AASHTO's ***A Policy on Geometric Design of Highways and Streets***.

Table 212.11.1 Sight Distance for Left-Turn from Highway



Design Speed (mph)	d_a (feet)								
	1 Lane Crossed			2 Lane Crossed			3 Lane Crossed		
	P	SU	Comb.	P	SU	Comb.	P	SU	Comb.
25	205	240	280	225	265	305	240	290	330
30	245	290	330	265	320	365	290	350	395
35	285	335	385	310	370	425	335	410	460
40	325	385	440	355	425	485	385	465	525
45	365	430	495	400	475	545	430	525	590

d_b (feet) Equations					
10 Foot Lane Lateral Offset (feet)		11 Foot Lane Lateral Offset (feet)		12 Foot Lane Lateral Offset (feet)	
1.5	4	1.5	4	1.5	4
$d_a\left(\frac{W+2}{W+10}\right)$	$d_a\left(\frac{W-0.5}{W+10}\right)$	$d_a\left(\frac{W+2.5}{W+11}\right)$	$d_a\left(\frac{W}{W+11}\right)$	$d_a\left(\frac{W+3}{W+12}\right)$	$d_a\left(\frac{W+0.5}{W+12}\right)$

Notes:

(1) Use the appropriate d_b equation to calculate the required value based on the lane width (LW) and lateral offset (LO).~~Provide a lateral offset (LO) of 6' as shown in the diagram above. d_b may be determined by the equation $d_b = d_a (w/(w+12))$.~~ See **FDM 215.2.4** for lateral offset requirements. The d_b value can be interpolated for roadways with left turn lane widths different from travel lane widths (e.g., 11-foot travel lane and a 10-foot left turn lane interpolate d_b from the 10-foot and 11-foot lane calculations). For roadways with non-restricted conditions, d_a and d_b should be based on the geometry for the left-turn storage and on clear zone widths.

(2) For wide medians where the turning vehicle can approach the through lane at or near 90°, use d values from tables in ***Exhibits 212-6*** and ***212-7***. The clear sight line origin is assumed to be 14.5 feet from the edge of the near travel lane.

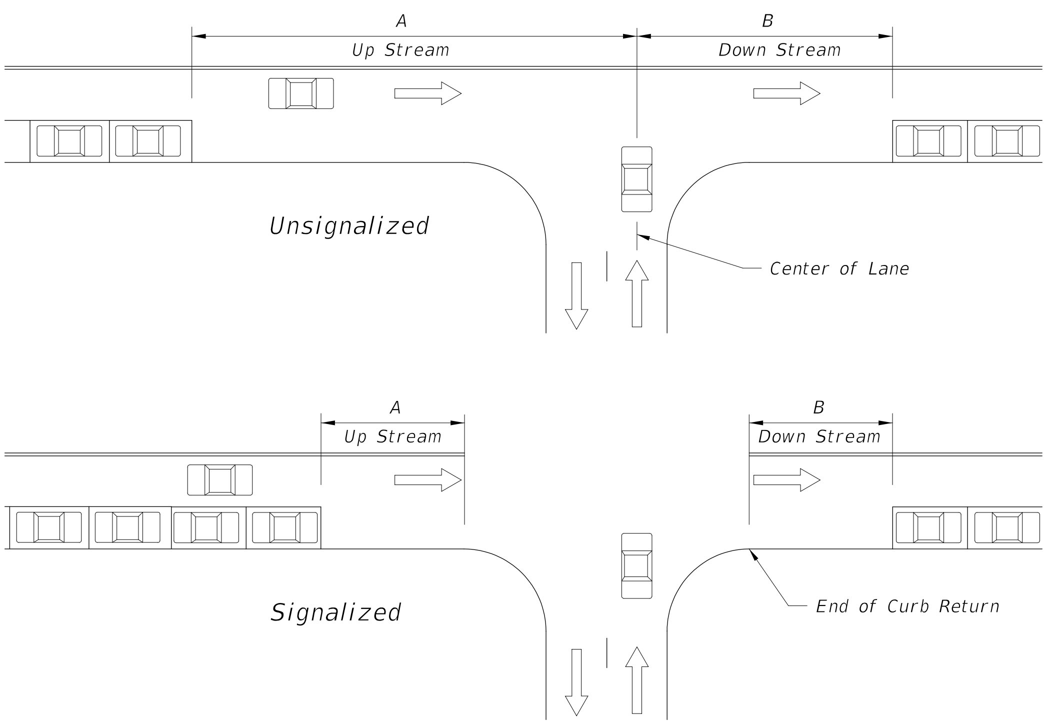
212.11.5 On-Street Parking

Table 212.11.2 provides parking restrictions for intersections, including mid-block crossings and roundabout approaches. For additional information, see the following:

- ***FDM 210.2.3*** for additional information concerning on-street parking.
- ***FDM 222.2.6*** for information concerning curb extensions (bulb-outs).
- ***Chapter 316, Florida Statutes*** (***F.S.***) for laws governing parking spaces.

Table 212.11.2 Parking Restrictions for Driveways and Intersections

Control Type	Posted Speed (mph)	A - Up Stream (ft)	B – Down Stream (ft)	
			2-Lane	4-Lane or more
Unsignalized	< 35	90	60	45
	35	105	70	50
Signalized	< 35	30	30	30
	35	50	50	50



Notes:

(1) For entrances to one-way streets, the downstream restriction (B) may be reduced to 20 feet.

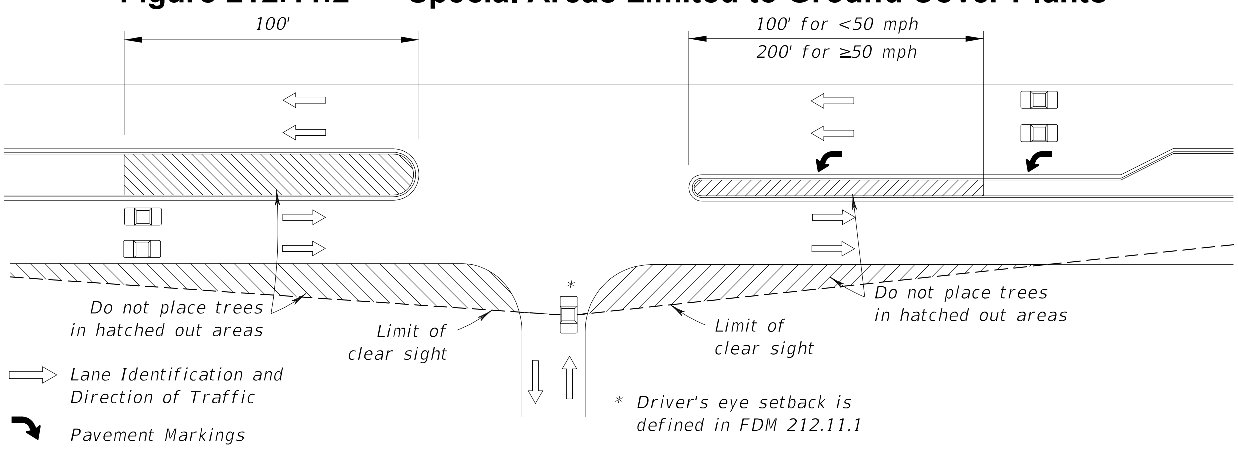
(2) Do not place parking within 20 feet of a marked crosswalk.

212.11.6 Trees and Vegetation

Intersections should be designed to accommodate the placement of trees and other desired vegetation (e.g., ground cover plants, trunked plants) in C2T, C3C, C4, C5, and C6 context classifications while still maintaining clear sight triangles. Ground cover plants are naturally low-growing plants with a maximum mature height of ≤ 18 inches. Trunked plants are those with a mature trunk diameter of 4 inches or less (measured 6 inches above the ground).

Maintain clear sight triangles for all approaches. Do not place trees within the hatched-out areas as shown in ***Figure 212.11.2***. The hatched-out areas are for ground cover plants only. Coordinate with the Project Landscape Architect for the placement of vegetation and the necessary space above and below ground for tree growth that will maintain clear sight triangles.

Figure 212.11.2 Special Areas Limited to Ground Cover Plants



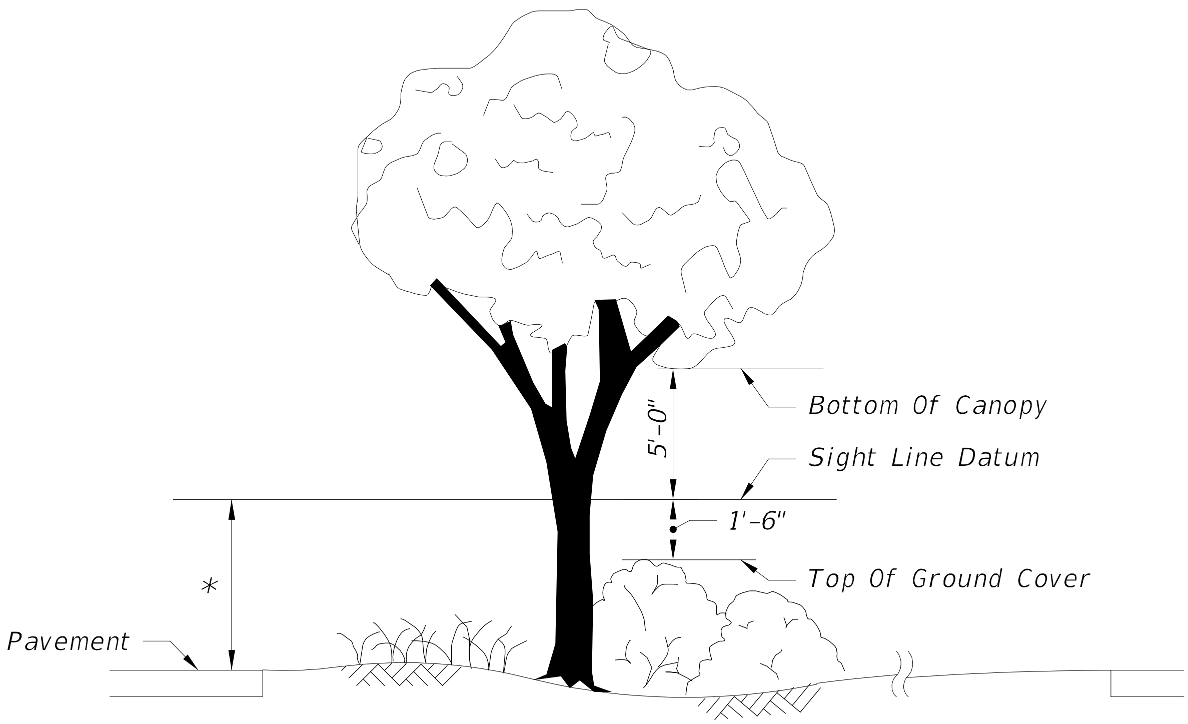
Where left-turns from the major road are permitted, do not locate trees within the distance d_b shown in ***Table 212.11.1*** (see ***FDM 212.11.4***) and not less than the distances shown in ***Figure 212.11.2*** and the spacings in ***Table 212.11.3*** as applicable.

212.11.6.1 Clear Sight Window Concept

The clear sight window concept may provide opportunities for vegetation in medians inside the limits of intersection sight triangles. This concept is illustrated in ***Figure 212.11.3.*** This detail provides the required vertical clear sight limits with respect to the sight line datum. Do not place trees within the hatched-out areas as shown in ***Figure***

212.11.2 (even if using the clear sight window concept). The hatched-out areas are for ground cover plants only. Trees may be placed in the median where there is no hatching.

Figure 212.11.3 Window Detail



* Since observations are made in both directions, the line-of-sight datum between roadways is 3.5 feet above both pavements.

The horizontal limits of the window are defined by clear sight triangles. Within the limits of clear sight triangles, the following restrictions apply:

- The canopy of trees and trunked plants must be at least 5 feet above the sight line datum.
- The top of the ground cover plants must be at least 1.5 feet below the sight line datum.

See ***FDM 270*** for additional information about plant selection and placement. Enforcing these limits provides a clear line of sight for approaches to an intersection.

When trees are located in the median of a divided roadway and fall within the limits of a clear sight triangle, conform to ***Table 212.11.3*** for tree size and spacing. Spacing values for trees with diameters of 11 inches or less were derived assuming a maximum 6-foot-wide shadow band on a vehicle at the stop bar location when viewed by a mainline driver beginning at sight distance ‘d’. This is illustrated in ***Figure 212.11.4***. Spacing values for trees with diameters greater than 11 inches and less than or equal to 18 inches were derived assuming a 2 second full view of the vehicle at the stop bar when viewed by the mainline driver beginning at sight distance ‘d’. (See ***Figure 212.11.5***).

Table 212.11.3 Minimum Tree Spacing

Design Speed (mph)	Minimum Tree Spacing (Center-to-Center of Trunk) (feet)	
	4” < Tree Diameter ≤ 11”	11” < Tree Diameter ≤ 18”
25	20	75
30	25	90
35	30	105
40	35	120
45	40	135
50	50	150
55	55	165
60	60	180

Notes:

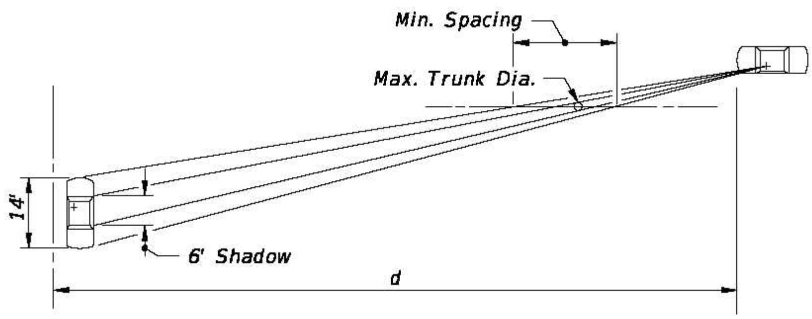
(1) Size and spacing are based on the following conditions:

- (a) A single line of trees in the median parallel to but not necessarily collinear with the centerline.
- (b) A straight approaching mainline and intersection angle between 60° and 120°.
- (c) Space trees with 4” < Dia. ≤ 11” intermixed with trees with 11” < Dia. ≤ 18” based on trees with 11” < Dia. ≤ 18”.

(2) Detail tree size, spacing, and location in the plans for any other conditions.

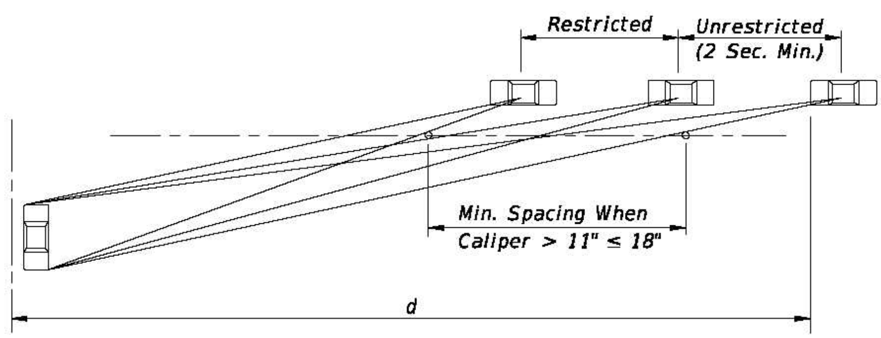
(3) Trunked plants may be placed on 20-foot centers.

Figure 212.11.4 Shadow Diagram



SHADOW DIAGRAM
TREE SPACING (DIA. 11" OR LESS)

Figure 212.11.5 Perception Diagram



PERCEPTION DIAGRAM
TREE SPACING (DIA. BETWEEN 11" AND 18")

212.12 Turning Roadways

Turning roadways are typically designed for use by right-turning traffic at intersections. There are three types of right-turning roadways:

- edge-of-traveled-way design
- design with a corner triangular island
- free-flow design using a simple radius or compound radii

The turning radii and the pavement cross slopes for free-flow right-turns are functions of design speed and design vehicle.

212.12.1 Edge-of-Traveled-Way Design

When the selected design vehicle is to be accommodated within minimum space, corner radii should be based on the required turning path.

Table 212.12.1 provides simple curve radii with and without tapers. ***Table 212.12.2*** provides symmetric and asymmetric three-centered compound curve radii for a range of design vehicles. These values provide the minimum turning paths attainable at design speeds of 10 mph and less.

Figure 212.12.1 demonstrates the angle of turn for use in these tables.

The minimum edge-of-traveled-way values provided in these tables are based on the assumption that the vehicle is properly positioned within the traffic lane at the beginning and end of the turn (2 feet from the edge-of-traveled-way on the tangents approaching and leaving the intersection curve). Such designs follow closely the inner wheel path of the selected design vehicle, with a clearance of 2 feet or more throughout most of the turn, and with a clearance at no point less than 9 inches. Differences in the inner paths of vehicles turning left and right are not sufficient to be significant in design. For this reason, these edge designs also apply to left-turn maneuvers, such as a left-turn by a vehicle leaving a divided highway at a very low speed.

Figure 212.12.1 Turn Angle for Turning Roadway Designs

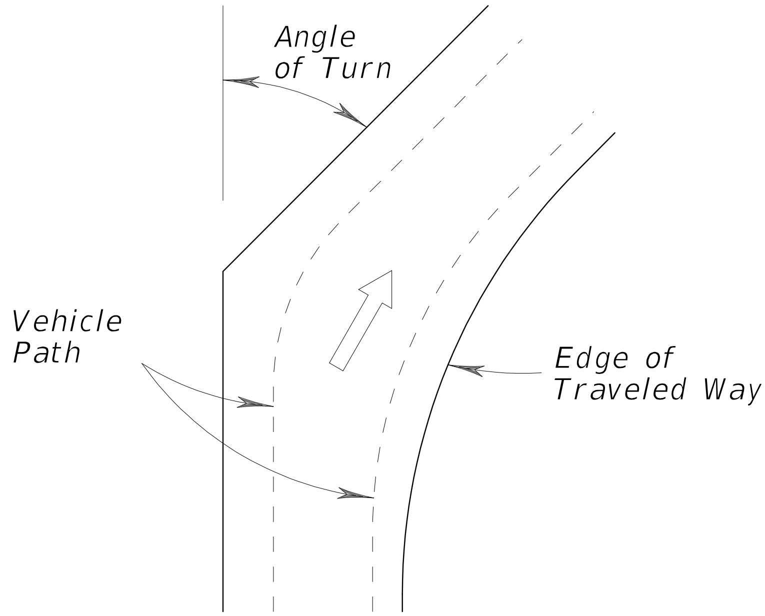


Table 212.12.1 Edge-of-Traveled-Way, Simple Curve Radii

Angle of Turn (degrees)	Design Vehicle	Simple Curve Radius (feet)	Simple Curve Radius with Taper		
			Radius (feet)	Offset (feet)	Taper H:V
30	P	60	----	----	----
	SU-30	100	----	----	----
	SU-40	140	----	----	----
	WB-40	150	----	----	----
	WB-62	360	220	3.0	15:1
	WB-62FL	380	220	3.0	15:1
	WB-67	380	220	3.0	15:1
	WB-92D	365	190	3.0	15:1
	WB-100T	260	125	3.0	15:1
	WB-109D	475	260	3.5	20:1
45	P	50	----	----	----
	SU-30	75	----	----	----
	SU-40	115	----	----	----
	WB-40	120	----	----	----
	WB-62	230	145	4.0	15:1
	WB-62FL	250	145	4.5	15:1
	WB-67	250	145	4.5	15:1
	WB-92D	270	145	4.0	15:1
	WB-100T	200	115	2.5	15:1
	WB-109D	----	200	4.5	20:1
60	P	40	----	----	----
	SU-30	60	----	----	----
	SU-40	100	----	----	----
	WB-40	90	----	----	----
	WB-62	170	140	4.0	15:1
	WB-62FL	200	140	4.5	15:1
	WB-67	200	140	4.5	15:1
	WB-92B	230	120	5.0	15:1
	WB-100T	150	95	2.5	15:1
	WB-109D	----	180	4.5	20:1

Table 212.12.1 Edge-of-Traveled-Way, Simple Curve Radii, cont.

Angle of Turn (degrees)	Design Vehicle	Simple Curve Radius (feet)	Simple Curve Radius with Taper		
			Radius (feet)	Offset (feet)	Taper H:V
75	P	35	25	2.0	10:1
	SU-30	55	45	2.0	10:1
	SU-40	90	60	2.0	10:1
	WB-40	----	60	2.0	15:1
	WB-62	----	145	4.0	20:1
	WB-62FL	----	145	4.0	20:1
	WB-67	----	145	4.5	20:1
	WB-92D	----	110	5.0	15:1
	WB-100T	----	85	3.0	15:1
	WB-109D	----	140	5.5	20:1
90	P	30	20	2.5	10:1
	SU-30	50	40	2.0	10:1
	SU-40	80	45	4.0	10:1
	WB-40	----	45	4.0	10:1
	WB-62	----	120	4.5	30:1
	WB-62FL	----	125	4.5	30:1
	WB-67	----	125	4.5	30:1
	WB-92D	----	95	6.0	10:1
	WB-100T	----	85	2.5	15:1
	WB-109D	----	115	2.9	15:1
105	P	----	20	2.5	8:1
	SU-30	----	35	3.0	10:1
	SU-40	----	45	4.0	10:1
	WB-40	----	40	4.0	10:1
	WB-62	----	115	3.0	15:1
	WB-62FL	----	115	3.0	15:1
	WB-67	----	115	3.0	15:1
	WB-92B	----	80	8.0	10:1
	WB-100T	----	75	3.0	15:1
	WB-109D	----	90	9.2	20:1

Table 212.12.1 Edge-of-Traveled-Way, Simple Curve Radii, cont.

Angle of Turn (degrees)	Design Vehicle	Simple Curve Radius (feet)	Simple Curve Radius with Taper		
			Radius (feet)	Offset (feet)	Taper H:V
120	P	----	20	2.0	10:1
	SU-30	----	30	3.0	10:1
	SU-40	----	35	6.0	8:1
	WB-40	----	35	5.0	8:1
	WB-62	----	100	5.0	15:1
	WB-62FL	----	105	5.2	15:1
	WB-67	----	105	5.2	15:1
	WB-92D	----	80	7.0	10:1
	WB-100T	----	65	3.5	15:1
	WB-109D	----	85	9.2	20:1
135	P	----	20	1.5	10:1
	SU-30	----	30	4.0	10:1
	SU-40	----	40	4.0	8:1
	WB-40	----	30	8.0	15:1
	WB-62	----	80	5.0	20:1
	WB-62FL	----	85	5.2	20:1
	WB-67	----	85	5.2	20:1
	WB-92D	----	75	7.3	10:1
	WB-100T	----	65	5.5	15:1
	WB-109D	----	85	8.5	20:1
150	P	----	18	2.0	10:1
	SU-30	----	30	4.0	8:1
	SU-40	----	35	7.0	8:1
	WB-40	----	30	6.0	8:1
	WB-62	----	60	10.0	10:1
	WB-62FL	----	65	10.2	10:1
	WB-67	----	65	10.2	10:1
	WB-92B	----	65	11.0	10:1
	WB-100T	----	65	7.3	10:1
	WB-109D	----	65	15.1	10:1

Table 212.12.1 Edge-of-Traveled-Way, Simple Curve Radii, cont.

Angle of Turn (degrees)	Design Vehicle	Simple Curve Radius (feet)	Simple Curve Radius with Taper		
			Radius (feet)	Offset (feet)	Taper H:V
180	P	----	15	0.5	20:1
	SU-30	----	30	1.5	10:1
	SU-40	----	35	6.4	10:1
	WB-40	----	20	9.5	5:1
	WB-62	----	55	10.0	15:1
	WB-62FL	----	55	13.8	10:1
	WB-67	----	55	13.8	10:1
	WB-92D	----	55	16.8	10:1
	WB-100T	----	55	10.2	10:1
	WB-109D	----	55	20.0	10:1

Table 212.12.2 Edge-of-Traveled-Way, 3-Centered Compound Curves

Angle of Turn (degrees)	Design Vehicle	3-Centered Compound Curve			
		Curve Radii (ft)	Symmetric Offset (ft)	Curve Radii (ft)	Asymmetric (ft)
30	P	----	----	----	----
	SU-30	----	----	----	----
	SU-40	----	----	----	----
	WB-40	----	----	----	----
	WB-62	----	----	----	----
	WB-62FL	460-175-460	4.0	300-175-550	2.0-4.5
	WB-67	460-175-460	4.0	300-175-550	2.0-4.5
	WB-92D	550-155-550	4.0	200-150-500	2.0-6.0
	WB-100T	220-80-220	4.5	200-80-300	2.5-5.0
	WB-109D	550-250-550	5.0	250-200-650	1.5-7.0

Table 212.12.2 Edge-of-Traveled-Way, 3-Centered Compound Curves, cont.

Angle of Turn (degrees)	Design Vehicle	3-Centered Compound Curve			
		Curve Radii (ft)	Symmetric Offset (ft)	Curve Radii (ft)	Asymmetric (ft)
45	P	----	----	----	----
	SU-30	----	----	----	----
	SU-40	----	----	----	----
	WB-40	----	----	----	----
	WB-62	460-240-460	2.0	120-140-500	3.0-8.5
	WB-62FL	460-175-460	4.0	250-125-600	1.0-6.0
	WB-67	460-175-460	4.0	250-125-600	1.0-6.0
	WB-92D	525-155-525	5.0	200-140-500	1.5-6.0
	WB-100T	250-80-250	4.5	200-80-300	2.5-5.5
	WB-109D	550-200-550	5.0	200-170-650	1.5-7.0
60	P	----	----	----	----
	SU-30	----	----	----	----
	SU-40	----	----	----	----
	WB-40	----	----	----	----
	WB-62	400-100-400	15.0	110-100-220	10.0-12.5
	WB-62FL	400-100-400	8.0	250-125-600	1.0-6.0
	WB-67	400-100-400	8.0	250-125-600	1.0-6.0
	WB-92D	480-110-480	6.0	150-110-500	3.0-9.0
	WB-100T	250-80-250	4.5	200-80-300	2.0-5.5
	WB-109D	650-150-650	5.5	200-140-600	1.5-8.0
75	P	100-25-100	2.0	----	----
	SU-30	120-45-120	2.0	----	----
	SU-40	200-35-200	5.0	60-45-200	1.0-4.5
	WB-40	120-45-120	5.0	120-45-195	2.0-6.5
	WB-62	440-75-440	15.0	140-100-540	5.0-12.0
	WB-62FL	420-75-420	10.0	200-80-600	1.0-10.0
	WB-67	420-75-420	10.0	200-80-600	1.0-10.0
	WB-92B	500-95-500	7.0	150-100-500	1.0-8.0
	WB-100T	250-80-250	4.5	100-80-300	1.5-5.0
	WB-109D	700-125-700	6.5	150-110-550	1.5-11.5

Table 212.12.2 Edge-of-Traveled-Way, 3-Centered Compound Curves, cont.

Angle of Turn (degrees)	Design Vehicle	3-Centered Compound Curve			
		Curve Radii (ft)	Symmetric Offset (ft)	Curve Radii (ft)	Asymmetric (ft)
90	P	100-20-100	2.5	----	----
	SU-30	120-40-120	2.0	----	----
	SU-40	200-30-200	7.0	60-45-200	1.0-4.5
	WB-40	120-40-120	5.0	120-40-200	2.0-6.5
	WB-62	400-70-400	10.0	160-70-360	6.0-10.0
	WB-62FL	440-65-440	10.0	200-70-600	1.0-11.0
	WB-67	440-65-440	10.0	200-70-600	1.0-11.0
	WB-92D	470-75-470	10.0	150-90-500	1.5-8.5
	WB-100T	250-70-250	4.5	200-70-300	1.0-5.0
	WB-109D	700-110-700	6.5	100-95-550	2.0-11.5
105	P	100-20-100	2.5	----	----
	SU-30	100-35-100	3.0	----	----
	SU-40	200-35-200	6.0	60-40-190	1.5-6.0
	WB-40	100-35-100	5.0	100-55-200	2.0-8.0
	WB-62	520-50-520	15.0	360-75-600	4.0-10.5
	WB-62FL	500-50-500	13.0	200-65-600	1.0-11.0
	WB-67	500-50-500	13.0	200-65-600	1.0-11.0
	WB-92D	500-80-500	8.0	150-80-500	2.0-10.0
	WB-100T	250-60-250	5.0	100-60-300	1.5-6.0
	WB-109D	700-95-700	8.0	150-80-500	3.0-15.0
120	P	100-20-100	2.0	----	----
	SU-30	100-30-100	3.0	----	----
	SU-40	200-35-200	6.0	60-40-190	1.5-5.0
	WB-40	120-30-120	6.0	100-30-180	2.0-9.0
	WB-62	520-70-520	10.0	80-55-520	24.0-17.0
	WB-62FL	550-45-550	15.0	200-60-600	2.0-12.5
	WB-67	550-45-550	15.0	200-60-600	2.0-12.5
	WB-92D	500-70-500	10.0	150-70-450	3.0-10.5
	WB-100T	250-60-250	5.0	100-60-300	1.5-6.0
	WB-109D	700-85-700	9.0	150-70-500	7.0-17.4

Table 212.12.2 Edge-of-Traveled-Way, 3-Centered Compound Curves, cont.

Angle of Turn (degrees)	Design Vehicle	3-Centered Compound Curve			
		Curve Radii (ft)	Symmetric Offset (ft)	Curve Radii (ft)	Asymmetric (ft)
135	P	100-20-100	1.5	----	----
	SU-30	100-30-100	4.0	----	----
	SU-40	200-40-200	4.0	60-40-180	1.5-5.0
	WB-40	120-30-120	6.5	100-25-180	3.0-13.0
	WB-62	600-60-600	12.0	100-60-640	14.0-7.0
	WB-62FL	550-45-550	16.0	200-60-600	2.0-12.5
	WB-67	550-45-550	16.0	200-60-600	2.0-12.5
	WB-92D	450-70-450	9.0	150-65-450	7.0-13.5
	WB-100T	250-60-250	5.5	100-60-300	2.5-7.0
	WB-109D	700-70-700	12.5	150-65-500	14.0-18.4
150	P	75-20-75	2.0	----	----
	SU-30	100-30-100	4.0	----	----
	SU-40	200-35-200	6.5	60-40-200	1.0-4.5
	WB-40	100-30-100	6.0	90-25-160	1.0-12.0
	WB-62	480-55-480	15.0	140-60-560	8.0-10.0
	WB-62FL	550-45-550	19.0	200-55-600	7.0-16.4
	WB-67	550-45-550	19.0	200-55-600	7.0-16.4
	WB-92D	350-60-350	15.0	120-65-450	6.0-13.0
	WB-100T	250-60-250	7.0	100-60-300	5.0-8.0
	WB-109D	700-65-700	15.0	200-65-500	9.0-18.4
180	P	50-15-50	0.5	----	----
	SU-30	100-30-100	1.5	----	----
	SU-40	150-35-150	6.2	50-35-130	5.5-7.0
	WB-40	100-20-100	9.5	85-20-150	6.0-13.0
	WB-62	800-45-800	20.0	100-55-900	15.0-15.0
	WB-62FL	600-45-600	20.5	100-55-400	6.0-15.0
	WB-67	600-45-600	20.5	100-55-400	6.0-15.0
	WB-92B	400-55-400	16.8	120-60-400	9.0-14.5
	WB-100T	250-55-250	9.5	100-55-300	8.5-10.5
	WB-109D	700-55-700	20.0	200-60-500	10.0-21.0

For curbed intersections, the effective turning radius must be considered in addition to the actual curb radius. As shown in ***Figure 212.12.2***, where a parking lane (or bike lane) is present, the vehicle turn is offset from the edge of the roadway by the width of the parking lane or bike lane, creating an "effective turning radius" that is larger than the physical curb radius. Where there is no parking lane or bike lane, the corner radius and effective turning radius are the same. To minimize pedestrian crossing distance, designers should provide the shortest curb radius possible or provide bulbouts within the effective turning radius area. The corner radii should follow the guidance in ***Table 212.12.3***, and accommodate the following:

- The control vehicle, design vehicle, and design speed for each street
- Available R/W
- Angle of turn between intersection legs
- Presence of on-street parking or a bike lane
- The width and number of lanes on the intersecting street

Figure 212.12.2 Actual Curb Radius Vs Effective Radius

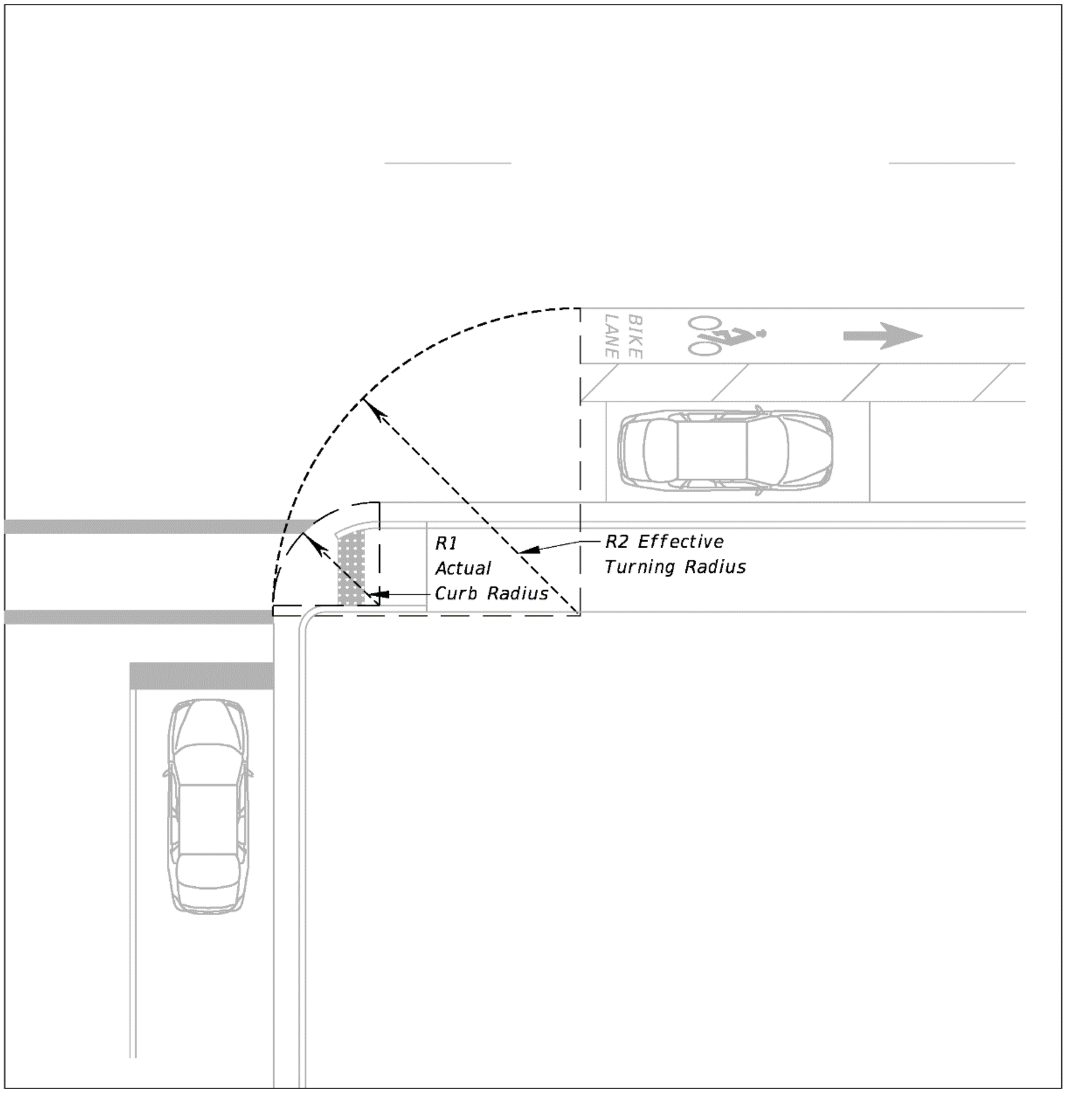


Table 212.12.3 Recommended Corner Radii

R1 Actual Curb Radius (feet)	R2 Effective Turning Radius (feet)	Operational Characteristics
5-30	**25 - 30**	P vehicles and SU vehicles with minor lane encroachment
5-40	**40**	P vehicles, SU vehicles, and WB-40 vehicles with minor encroachment
5-50	**50**	All vehicles up to WB-40

Notes:

(1) Table 212.12.3 assumes perpendicular intersections. For skewed intersections, establish radius using AutoTurn or turning templates.

(2) Confirm the actual curb radius using AutoTurn or turn templates.

Guidelines for corner radii in C4, C5, and C6 context classifications without on-street parking or a bike lane are as follows:

(1) Radii of 15 to 25 feet are adequate for passenger vehicles. These radii are suitable for minor cross streets where there is little occasion for trucks to turn and at major intersections where there are parking lanes;

(2) Radii of 25 feet or more should be provided at minor cross streets on new construction or reconstruction projects;

(3) Radii of 30 feet or more should be provided at minor cross streets where practical so that an occasional truck can turn without too much encroachment;

(4) Radii of 40 feet or more or preferably three-centered curves or simple curves with tapers to fit the paths of large truck combinations, should be provided where such combinations or buses turn frequently. Where speed reductions would cause problems, larger radii should be considered; and,

(5) Curb radii should be coordinated with crosswalk distances or special designs should be used to make crosswalks efficient for all pedestrians. Where larger radii are used, an intermediate refuge or median island is desirable or crosswalks may need to be offset so that crosswalk distances are not excessive. See ***FDM 210.3*** for additional information on islands.

212.12.2 Turning Roadways with Corner Islands

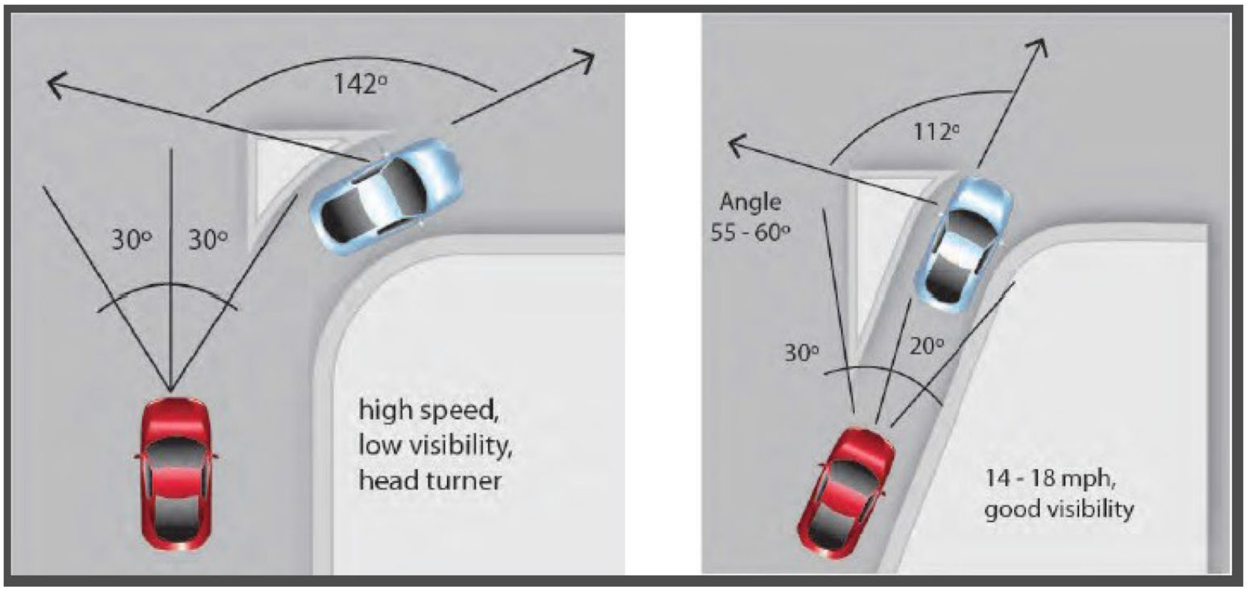
Consider providing a corner island at an intersection where paved areas are excessively large or do not establish proper channelization of traffic. Corner islands can provide delineation for through and turning traffic. In addition, corner islands shorten crosswalks and give pedestrians and bicyclists a refuge area. See ***FDM 210.3.2*** for island requirements.

Channelized right-turn lanes can be designed with a flat or near perpendicular angle of entry to the cross street (see ***Figure 212.12.3***). The flat angle of entry is most appropriate for higher-speed turning movements with no pedestrian accommodations. Large turning radii and angles of entry into the cross street allow higher turning speeds, reduced traffic delays, and the turning movement of large trucks. The higher speeds, angle of entry and large radii adversely impact pedestrian safety at the crosswalk.

The near perpendicular angle of entry is preferred where pedestrian facilities are provided. Tight turning radii and angles of entry into the cross street accommodate the following:

- Slower turning speeds,
- Reduced cross walk length,
- Improved pedestrian visibility,
- Improved sight distance,
- Decreased angle of driver head turning,
- Reduced right-of-way impacts.

Figure 212.12.3 Channelized Right Turn Lanes



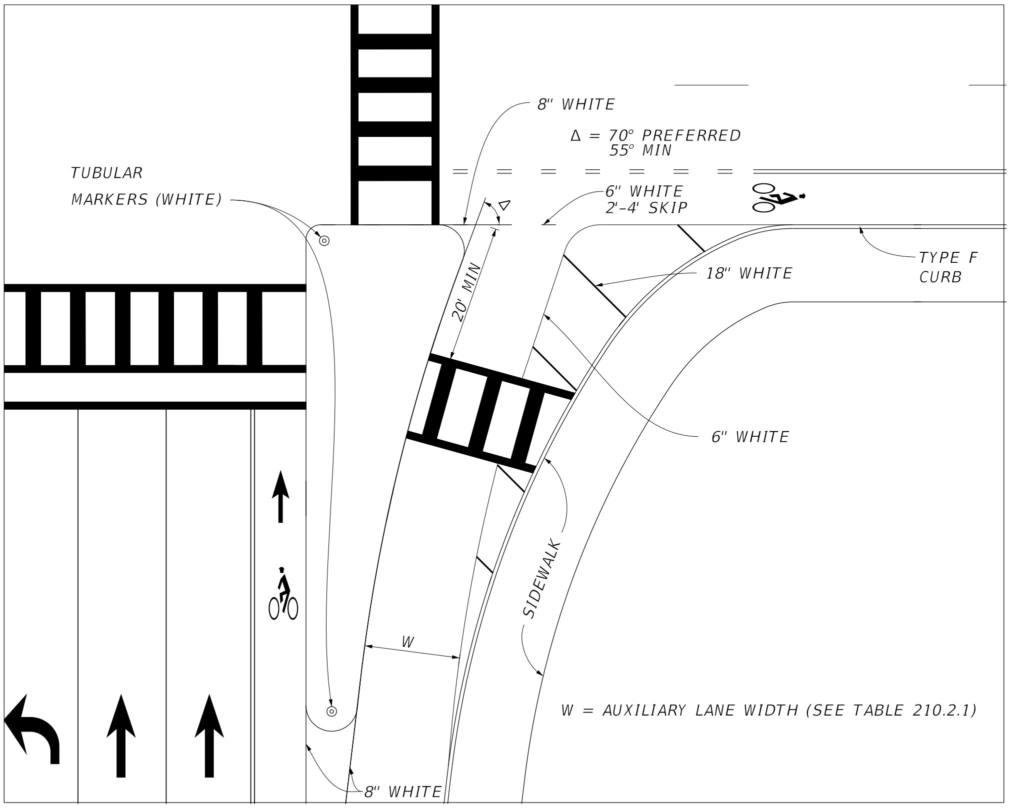
Ref: Figure 9-19, 2018 AASHTO *Green Book*

Consider the near perpendicular right-turn lane design in ***Figure 212.12.4*** when the following conditions are met:

- Context Classifications C2T, C3, C4, C5 and C6
- Low-speed roadway (design speeds of 45 mph and less)
- Pedestrian traffic is expected
- No acceleration lane is provided

This design includes the previously-mentioned benefits to passenger cars and pedestrians with striping and a scalene triangle shaped corner island. An approaching deceleration lane is preferred to provide vehicles additional time to stop for crossing pedestrians. The crosswalk is set back 20 feet minimum from the end of the island to allow room for a passenger car to wait for a gap in traffic without blocking the crosswalk. As shown in ***Figure 212.12.4***, the outside curb radii can be designed to accommodate over-tracking of large vehicles such as single-unit trucks, transit, or Florida Interstate Semi-trailers (WB-62FL).

Figure 212.12.4 Near Perpendicular Right-Turn Lane



212.12.3 Mountable Truck Aprons

Truck aprons are used to manage the turning movements of vehicles where pedestrian or bicycle facilities are present. A truck apron is a mountable portion of an intersection designed to:

- Manage the turning speed of passenger vehicles
- Accommodate the turning movements of large trucks
- Minimize instances of off-tracking over street corners when making turns
- Reduce risks to bicyclists and pedestrians.

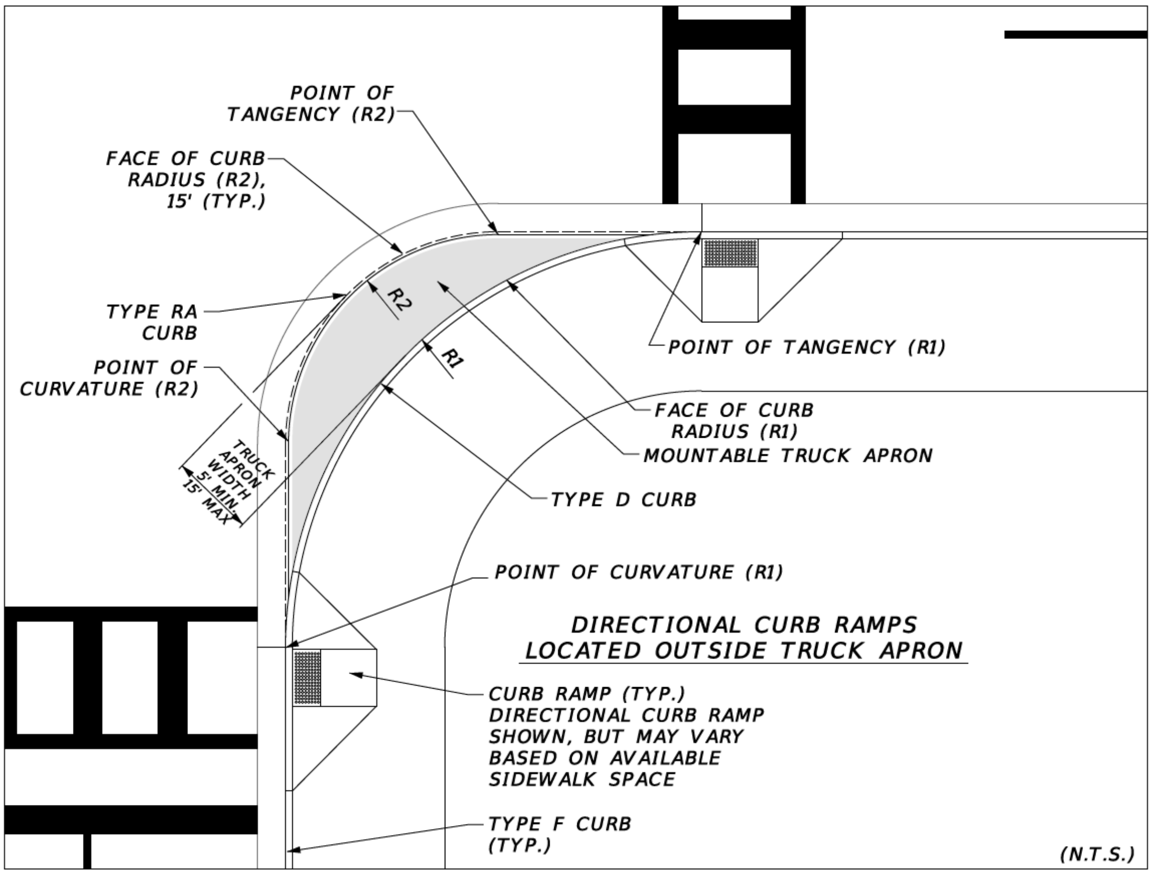
Design a mountable truck apron by either of these methods:

- Attach to a full height curb and allow water to flow along the apron's outer edge.
- Separate from the full height curb to allow water to flow along the curb's edge.

See ***Figure 212.12.5*** for additional details.

Locate all traffic equipment, bicycle features, and pedestrian features (e.g., detectable warning surfaces, bicycle stop bars, curb ramps, etc.) behind the mountable surface area. The design of a mountable truck apron at intersections should incorporate Type RA curbs. See ***FDM 213.3.8*** for additional truck apron requirements. Cross slopes shown in ***Figure 213.3.2*** may be adjusted based on intersection site conditions.

Figure 212.12.5 Mountable Truck Apron



212.12.4 Free-Flow Design

Provide superelevation on free-flow turning roadways. An important part of the design on some intersections is the design of a free-flow alignment for turns. Ease and smoothness of operation can result when the free-flow turning roadway is designed with compound curves preceded by a deceleration lane. Turning radii and pavement cross slope for free-flow right-turns at speeds greater than 10 mph are a function of the design speed and design vehicle. In general, the design speed of the turning roadway should be equal to or within 10 to 20 mph less than the through roadway design speed.

It is desirable to provide as much superelevation as practical on intersection curves, particularly where the intersection curve is sharp and on a downgrade. However, the short curvature and short lengths of turning roadways often prevents the development of a desirable rate of superelevation. ***Table 212.12.4*** provides the minimum superelevation rates in relation to design speed. The wide variation in likely speeds on intersection curves precludes the need for precision, so only the minimum superelevation rate is given for each design speed and intersection curve radius.

Table 212.12.4 Superelevation Rates for Turning Roadways

	Design Speed (mph)							
	10	15	20	25	30	35	40	45
Minimum Superelevation Rate	NC	NC	0.02	0.04	0.06	0.08	0.09	0.10
Minimum Radius (feet)	25	50	90	150	230	310	430	540

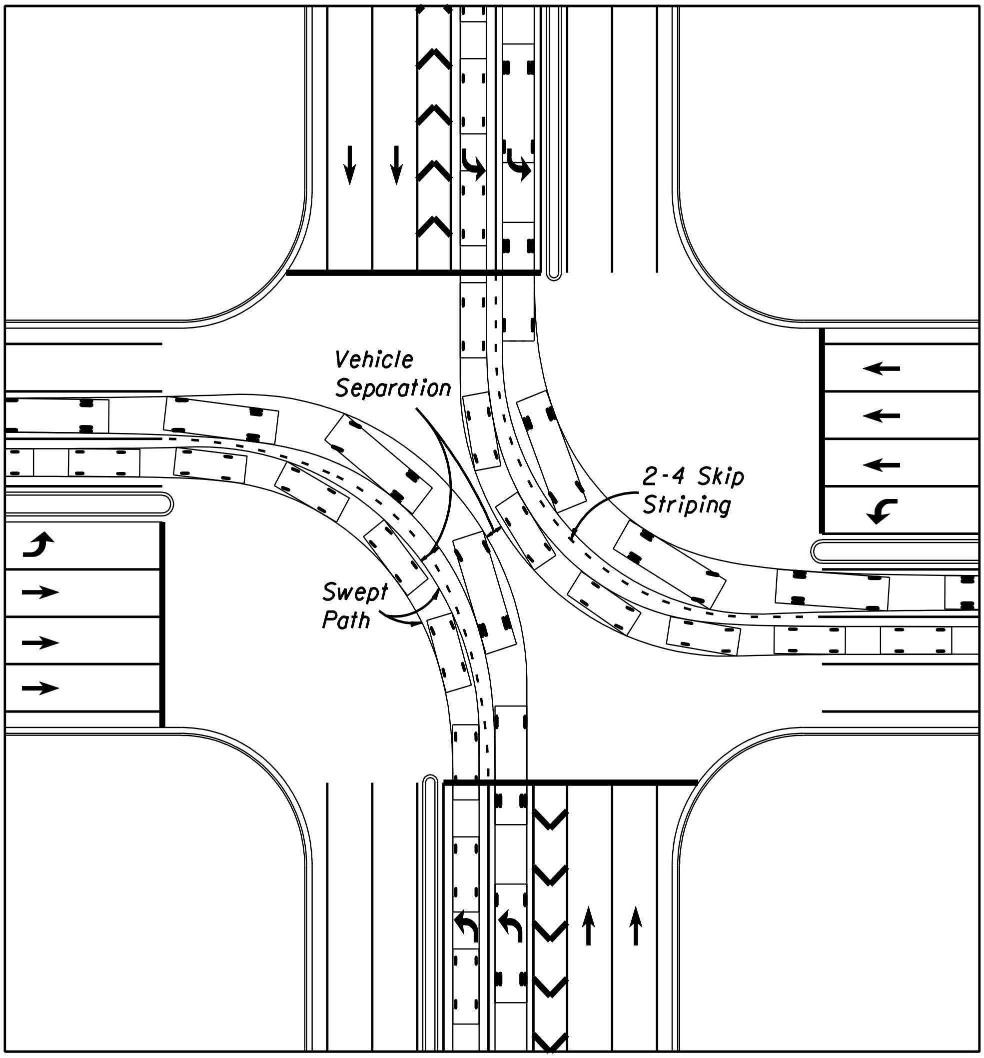
See ***FDM 210.9*** for additional superelevation criteria.

212.12.5 Dual and Triple Left-Turns

Double and triple turn lanes require turning radii that will accommodate the selected design vehicles turning simultaneously. The radius of curvature in combination with the track width of the design vehicles will establish the required width within the turn. Lane lines (i.e., guidelines) and width requirements should be determined by plotting the swept paths of the selected design vehicles. For preliminary layout of intersection geometry, use the swept path of the design vehicle on the inside turning lane to locate the median nose and crosswalk on the crossing street (at the receiving point of the left-turn).

The design of dual turns should accommodate a SU-40 vehicle and a P vehicle turning simultaneously, as illustrated in ***Figure 212.12.6***.

Figure 212.12.6 P and SU Design Vehicles Turning Simultaneously



The design of triple left-turns should accommodate a WB-62FL (outside lane), a SU-40 (center or inside lane), and a P vehicle (center or inside lane) turning simultaneously.

Establish the control radius for the inside turning lane based on the guidance in ***FDM 212.14.5*** and ***Table 212.9.2***. Establish the inside edge of the outer lane by providing a minimum 4-foot separation between swept paths of the selected design vehicles traveling in the same direction. Except for turns with large radii, the inside edge of the outer lane will not be concentric with the selected control radius. The radius for the inside edge of the outer turn lane should be determined by analysis of the plotted swept path of the design vehicles.

Provide at least 8 feet of separation between vehicles traveling in opposing directions. The separation may be less than 8 feet when:

(1) Turning paths are highly visible and speeds are low, or

(2) Signal left-turn phases are not concurrent for the opposing directions.

212.13 Islands

See ***FDM 210.3*** for island criteria.

212.14 Auxiliary Lanes

The primary function of auxiliary lanes at intersections is to accommodate speed changes, storage and maneuvering of turning traffic. The length of the auxiliary lane is the sum of the deceleration length, queue length and approach end taper. Pavement marking requirements for auxiliary lanes are included in ***Standard Plans, Index 711-001***.

212.14.1 Deceleration Length

The required total deceleration length is that needed for a safe and comfortable stop from the design speed of the highway. See ***Exhibit 212-1*** for minimum deceleration lengths (including taper) for left-turn lanes.

Right-turn lane tapers and lengths are identical to left-turn lanes under stop control conditions. Right-turn lane tapers and lengths are site-specific for free-flow or yield conditions.

212.14.2 Queue Length

The queue length provided should be based on a traffic study.

For low-volume intersections where a traffic study is not justified, a minimum 50-foot queue length (2 vehicles) should be provided for C1, C2, and C3R context classifications. A minimum 100-foot queue length (4 vehicles) should be provided in C2T, C3C, C4, C5, and C6 context classifications. Locations with over 10% truck traffic should accommodate at least one car and one truck.

For queue lengths at signalized intersections, refer to ***FDM 232.2***.

212.14.3 Approach End Taper

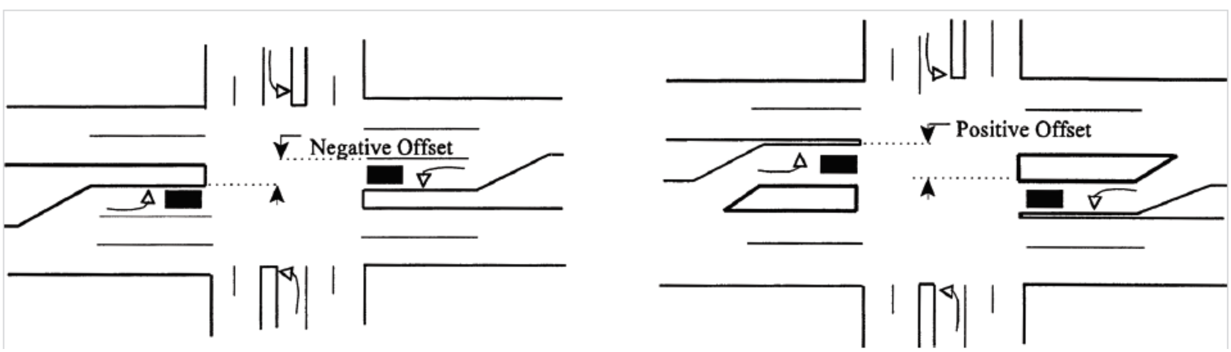
The length of approach end tapers is 50 feet for a single turn lane and 100 feet for two or more turn lane, as shown ***Exhibit 212-1***. These taper lengths apply to all design speeds.

212.14.4 Offset Left-Turn Lanes

The alignment of opposing left-turn lanes and the horizontal and vertical curvature on the approaches are the principal geometric design elements that determine how much sight distance is available to a left-turning driver. Vehicles queuing in opposing left-turn lanes restrict each other's view of oncoming traffic in the through lanes. The level of restricted view depends on the alignment of opposing left-turn lanes with respect to each other and the type of vehicles in the opposing queue.

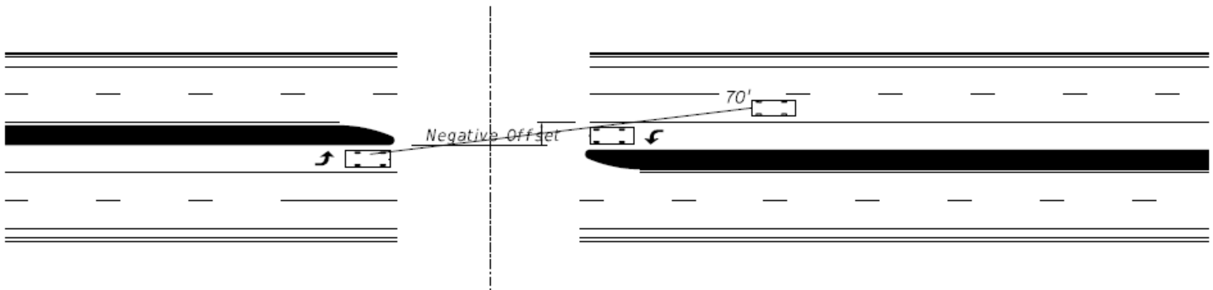
The offset distance is defined as the distance between the left edge of the turn lane and the right edge of the opposing turn lane. If the offset distance is to the left of the turn lane, it is considered a negative offset; and if it is to the right of the turn lane, it is considered a positive offset, as illustrated in ***Figure 212.14.1***.

Figure 212.14.1 Negative and Positive Offset Left Turns



The conventional method of designing left-turn lanes is to place the left-turn lanes adjacent to the through lanes. This design creates a negative offset which restricts the sight distance of the left-turning driver's view of oncoming traffic when another vehicle is in the opposing turn lane. ***Figure 212.14.2*** indicates the negative offset when the conventional design is used.

Figure 212.14.2 Opposing Left Turns (22' Median with Negative 10' Offset)

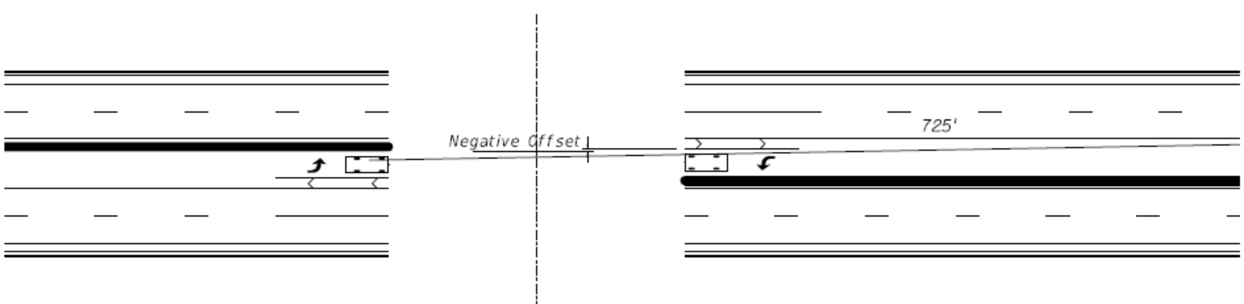


On curbed roadway designs, offset left-turn lanes should be used with median widths greater than 18 feet. A 4-foot traffic separator should be used when possible to channelize the left-turn and provide separation from opposing traffic.

Consider offset left-turn lanes at C1, C2, and C3R context classification intersections with high turning movements. For median widths of 30 feet or less, use a parallel offset left-turn lane. Stripe the area between the offset left-turn lane and the through traffic lane where vehicles are moving in the same direction. For medians wider than 30 feet, consider a tapered offset left-turn lane. An offset left is illustrated in ***Figure 212.14.3***.

2018 AASHTO Green Book Figure 9-41 illustrates the design of parallel and tapered left-turn lanes.

Figure 212.14.3 Typical Opposing Left-Turns (22-Foot Median with Negative 1-Foot Offset)



At locations where the full offset distances cannot be obtained, it is recommended that the minimum offset distances shown in ***Table 212.14.1*** be provided to achieve minimum required sight distances according to design speed. It is recommended that the "Opposing Truck" values be used where the opposing left-turn traffic includes a moderate to heavy volume of large trucks.

Table 212.14.1 Minimum Offset Distances for Left-Turn Lanes

Design Speed (mph)	Minimum Offset (feet)	
	Opposing Car	Opposing Truck
≤ 30	1.0	3.0
35	1.5	3.5
40 - 45	2.0	4.0
50 - 55	2.5	4.5
60 - 65	3.0	4.5
70	3.0	5.0

212.14.5 Directional Median Openings

Directional (channelized) median openings are designed to accommodate left-turn movements from the through roadway and prevent or discourage left-turn and crossing movements by traffic from a side road or driveway. Directional median openings are to be provided in accordance with the access management plan for the roadway.

The design of a directional median opening must accommodate the swept path of the predominant design vehicle. Channelization may be achieved using a combination of traffic separators, islands, and tubular markers. See ***FDM 210*** for additional information on islands. See ***Standard Plans***, ***Index 520-020*** for standard details for 4 feet, 6 feet and 8.5 feet wide traffic separators. See ***FDM 230.2.7*** for additional information on tubular markers.

Typical layouts for directional median openings for high-speed roadways with 40-feet-wide medians are provided in ***Exhibits 212-8***, ***212-9*** and ***212-10***. Type E curb and raised islands in conjunction with the minimum offsets shown in these figures may be used on high-speed roadways for directional median openings.

Exhibit 212-8: Directional Median Opening: SU & WB-40 Parallel

Exhibit 212-9: Directional Median Opening: WB-62 Parallel

Exhibit 212-10: Directional Median Opening: SU & WB-40 Tapered

233 Intelligent Transportation Systems (ITS)

233.1 General

Intelligent Transportation Systems (ITS) criteria provided in this chapter applies to the placement and installation of ITS devices and systems along Florida's roadways including Limited Access (LA) facilities, arterials, and express lanes.

The design and layout of ITS facilities should complement the basic highway design and comply with current versions of the following:

- ***Standard Specifications***
- ***Standard Plans***
- ***Traffic Engineering Manual (TEM)***
- ***Structures Manual***
- ***Highway Beautification Policy***
- ***Manual on Uniform Traffic Studies (MUTS)***
- ***AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals***
- ***Manual on Uniform Traffic Control Devices (MUTCD)***
- ***Intelligent Transportation System Integration Guide Book***
- ***National Electric Code (NEC)***
- ***National Fire Protection Association (NFPA)***
- ***Title 23 Code of Federal Regulation (CFR), Part 940***
- ***Title 47 CFR, Part 90***
- ***Title 47 CFR, Part 95L***

Additional information related to the design of ITS facilities is found in the following locations of the ***FDM***:

- ***FDM 215*** – lateral offset requirements for poles, sign structures, field cabinets, and communication hubs for deployments. Deployment refers to existing and new ITS facilities and infrastructure.
- ***FDM 221*** – utility coordination
- ***FDM 261*** – structural support requirements

- ***FDM 942*** – ITS Plans content and requirements

The Statewide Systems Engineering Management Plan and various systems engineering templates (e.g., Concept of Operations) are found on the following web site:

https://www.fdot.gov/traffic/ITS/Projects_Deploy/SEMP.shtm

233.1.1 Railroad-Highway Grade Crossing Near or Within Project Limits

Federal-aid projects with a railroad-highway grade crossing near or within the project limits should refer to ***FDM 220.2.4***.

233.1.2 Attachments to Barriers

Refer to ***FDM 215*** for information regarding proposed attachments to bridge traffic railings, concrete median barrier walls, concrete shoulder barrier walls or the evaluation of existing attachments.

233.1.3 ITS Device Approval and Compatibility

ITS devices are traffic control devices that follow approval requirements discussed in ***FDM 232.1.3***.

Incorporate features and functions that allow interoperability with other ITS deployments throughout the region and state including existing Transportation Management Center (TMC) hardware and software. Examples of design characteristics that promote interoperability include:

- Systems and products based on open architectures and standards.
- Systems and products that are scalable and nonproprietary.
- Compatibility with the Department's SunGuide® Software directly or via support of one or more of its related Interface Control Documents (ICD).
- Compatibility with the local agency central system software, as applicable.
- Systems on the Department's Approved Products List (***APL***), Innovative Products List (***IPL***), or proprietary products. Refer to ***FDM 110.4.1*** for more information on proprietary products.
- Compatibility with existing or legacy systems and networks.

- Develop technical special provisions (TSPs) or modified special provisions (MSPs) in accordance with the Department's ***Specification Handbook***.

233.2 ITS Design Criteria

ITS devices and systems gather, analyze, and distribute real-time information to improve the safety, efficiency, mobility, security, and integration of transportation systems. Various ITS technologies have strengths and limitations for collecting, analyzing, and disseminating information. Select ITS devices for the appropriate application.

Many ITS devices require specific placement and configuration requirements for the equipment to perform properly. Consider the following for the design of these devices:

Life cycle expectancy for continued operations and maintenance.

Value engineering for installation and maintenance of the design.

Environmental impacts.

Technologies for commercial vehicle operations.

Technologies for connected vehicles.

Accommodations for future expansion.

Utility and landscaping impacts.

233.2.1 Title 23 CFR, Part 940

ITS projects must comply with the requirements specified in the ***Guidelines for the Implementation of Part 940 in Florida*** (Topic No. 750-040-003). This is to ensure compliance with ***Code of Federal Regulations (CFR) Chapter 23 Part 940 Section 940.11*** and Department requirements.

233.2.2 Maintenance Considerations

Consider the following for maintenance access:

- Provide a minimum 4-foot clear area around the ITS pole for maintenance of the camera lowering device.
- Avoid ITS equipment near areas susceptible to vegetation overgrowth, swales, or wetlands.
- Avoid installing equipment in medians.

- Provide a leveling platform and railing system (handrail) to protect from any drop-off hazards and/or slopes steeper than 1:2.
- Place ITS equipment behind existing or proposed guardrails, as required in ***FDM 215.2.4***.
- Provide space to pull over on the shoulder to access the equipment.

233.3 ITS Power Design

ITS systems typically operate on 120 volts alternating current (AC) from the commercial utility service provider. Some systems operate using a low voltage (60 volts or less) direct current (DC) power source, facilitating battery and solar power options. Do not use 600-volt step-up electrical systems. Do not exceed 480 volts for ITS systems. Consider the following for power designs:

- Existing and future loads.
- Expected power consumption duty cycle.
- The time during which the system must operate.

Include a Remote Power Management Unit (RPMU) within each ITS field cabinet.

233.3.1 Power Source Design and Placement

Power service availability is an essential element to ITS design. The power service location is the demarcation point between the Department and the commercial utility service provider. In many cases, the power service is a new power service pole located immediately inside the R/W.

Identify the location of power service and design the power service cable routing from the power service to the field device cabinet. Include the device stations and offsets for proposed power service locations in the plans.

Power service locations are typically located within a half-mile of the ITS devices served. Consult with the commercial utility service provider to select optimal power service locations for power service routing greater than a half-mile.

Identify underground and above-ground obstacles (e.g., buried utilities, structure foundations, retaining walls, guardrail) between proposed ITS devices and the power services. These obstacles may affect the location of proposed ITS devices, the choice of power service points, or the routing for the power service conductors.

233.3.2 Local Backup and Alternative Power Sources

Provide Uninterruptible Power Supply (UPS) to prevent failure of normal operations for mission critical systems. Mission critical systems are systems that are critical to the daily operation of the Transportation Management Center (TMC) (e.g., master hubs, certain local hubs, detectors, cameras, signs, tolling systems, express lanes) as defined by the District ITS/Transportation Systems Management & Operations (TSM&O) Engineer.

Solar or wind power sources may be an option for some ITS applications. Consider the geographical and topographic features that affect sunlight or wind exposure, size of site, and protection from maintenance operations (e.g., mowing).

An electrical distribution system may be necessary in rural areas where commercial electric service is not readily available. Design the electrical distribution system in accordance with ***NEC*** requirements. Consider voltage and amperage needs of the equipment along the distribution system. Different combinations of voltage, conductor size, step-up, step-down, and isolation transformers may be used to design a system that is cost effective to construct and maintain. Coordinate with the District ITS/TSM&O Engineer to determine additional electrical capacity needs.

233.3.3 Application for Electric Service

Proposed service points for new power service installations require approval by the commercial utility service provider. This approval should be coordinated with the Department and the commercial utility service provider early in the design process.

The approval of proposed service points for new power service installations includes the following steps:

(1) Determine the following:

- (a) Availability of service at any location.
- (b) Commercial utility service provider’s standard type of service for the load to be served.
- (c) Designated point of delivery (prior to confirmation with the commercial utility service).

(2) Request that the proposed service points be verified and approved by the commercial utility service provider.

(3) (Optional) Hold a coordination meeting in the field with the commercial utility service provider representative.

(4) (Optional) Designer to obtain a written agreement with the commercial utility service provider for agreed upon service locations.

In most locations, the secondary distribution system provides service(s) at standard voltages.

233.3.4 Power Design Requirements

Key design steps for an ITS device deployment electric power system are:

(1) Determine the total power requirement based on anticipated peak equipment loads determined in accordance with ***FDM 233.3.5***.

(2) Select a suitable power source based on availability.

(3) Determine transformer requirements (step-down, step-up, or isolation), where applicable. The need for transformers may be based on voltage and power loss calculations.

(4) Balance the device electrical loads to achieve a uniform and efficient power distribution design.

(5) Separate power service meter to be provided for ITS infrastructure

Locate a power disconnect switch within a convenient distance from the device service enclosure. For example, the power to operate a Dynamic Message Sign (DMS) may be fed from a nearby DMS service enclosure, and a power disconnect switch is typically installed outside of the service enclosure. Step-up and step-down transformers must include a minimum of two 2.5% full capacity below normal taps and two 2.5% above normal taps on the primary side.

233.3.5 Power Load Requirements

The total power requirement for any deployed device or deployment site is the sum of the power requirements of the following:

- Heating Ventilation and Air Conditioning (HVAC).
- Cabinet components (lights, fans, UPS).
- Devices not powered through the UPS.
- Convenience outlets.
- Future device loads.

Assume all equipment is in continuous operation. Provide 20% spare load capacity in every ITS field cabinet (excluding DMS loads). In addition, provide for a 15A load at 120V at the end of every circuit.

233.3.6 Voltage Drop

Perform voltage drop calculations for ITS devices with the following considerations:

- Ability of the ITS device to operate above or below the nominal voltage.
- Distance from the power source to the ITS device.

Voltage drop mitigation strategies may include use of larger power conductors or higher service voltage.

Meet ***NEC*** code for ITS equipment electrical designs, including voltage drop calculations, load requirements, electrical device sizing (e.g., switches, isolators, bus bars, surge protective devices), and grounding.

233.3.7 Installation of Power Cable

Install power cables in separate conduits and pull boxes from communications cables. Design for the maximum duct fill ratio in accordance with ***NEC, Chapter 9***.

233.3.8 Grounding and Lightning Protection

Include provisions for grounding and lightning protection. Examples of techniques for grounding and lightning protection include the following:

- Proper bonding and installation of grounding rods and grounding conductors.
- Air terminals.
- Surge Protective Devices (SPDs).

Standard Plans, Index 700-090 contains additional information on grounding and lightning protection for DMS signs.

Existing geological and other physical characteristics (e.g., rock formations, underground utilities, gravel deposits, soil types, and resistivity, groundwater) affect the design or layout of grounding systems. Include in the plans relevant subsurface data at the proposed installation locations (e.g., soil resistivity measurements).

Place the grounding arrays such that grounding paths from the down cable to the primary electrode are as straight as possible. Provide details in the plans related to grounding and cable routing for each device.

Determine grounding and SPD placement and overall system design based on project-specific needs and the following:

- Follow ***NFPA 780 (Standard for the Installation of Lightning Protection Systems)***, ***Underwriters Laboratories*** (***UL***) ***UL-1449***, and the ***NEC***.
- Place SPD equipment so that grounding connections are as short and straight as possible.
- Avoid bending conductor routes.
- Provide physical separation between low-voltage and high-voltage signal paths.
- Avoid routing unprotected wires or grounding wires parallel or adjacent to the protected wiring.

233.3.9 Emergency Generator Power Systems (Generators)

Generators provide temporary power when commercial AC power is interrupted. Their use is associated with mission critical ITS applications (as described in ***FDM 233.3.2***).

Permanent generators are required for applications that cannot tolerate a short duration outage. Supplement with a UPS or battery system to provide continuous power service during the start-up cycle of the generator.

Include a connection and proper receptacles to accommodate a portable generator for applications that can tolerate a short duration outage of a few hours.

233.3.9.1 Generator Design Requirements

Sizing a generator depends on design load (including future device loading) and power factor. Consider run time requirements and future load expansion in the generator design. Identify and design specific critical load circuits to be powered by the generator when commercial power fails.

Use Liquefied Petroleum Gas (LPG) as the fuel type for permanent generator designs. The preferred storage technique for LPG is in-ground (buried) tank. Obtain approval from the District ITS/TSM&O Engineer to use fuel alternatives. Design permanent generators to provide a minimum of 48-hours of run time at full (rated) load. Meet the minimum requirements in ***NFPA 58 (Liquefied Petroleum Gas Code)*** for generator designs.

For permanent generators, provide a generator pad with a minimum clearance of 30 inches around the generator and fuel tank. Provide pad design details with adequate information such as reinforcing, concrete class type/strength, and installation notes.

Install a manual transfer switch for all generator installations and also include an automatic transfer switch for permanent generator installations. The automatic transfer switch must provide emergency power in less than 15 seconds and permit full manual override control for testing and maintenance.

Install a remote monitor and control appliance for permanent generators. Connect to a network management system to monitor the status of permanent generators and allow remote operations and testing capabilities. Coordinate with the District ITS/TSM&O Engineer for connections to a network management system.

233.3.10 DC Power Plant (48 Volt)

DC power plants protect ITS devices from potential disruptions, such as high-switching voltages, transients, lightning strikes, harmonic distortion, and interference from other equipment.

Include DC power plants where ITS applications require isolation from the AC power grid utility service provider. Connect the DC power plant to the facility grounding system.

233.3.10.1 Battery Types

Use Valve Regulated Lead-Acid (VRLA) batteries for mission critical ITS applications (as described in ***FDM 233.3.2***).

Consider a large form factor lithium battery (e.g., Lithium Iron Phosphate) if a site has a unique battery size limitation.

Provide proper ventilation for specified battery system.

Do not use flooded type lead-acid batteries.

233.3.10.2 Battery Sizing

Size battery systems to support all the following:

- Present design load plus load expansion safety margin (typically 25%).
- Anticipated future load expansion.
- Minimum run time requirements of the DC power plant load.

Evaluate the present design load for the maximum instantaneous DC current requirements and the average DC current requirements.

Size VRLA battery systems such that the battery cells do not discharge below 50% of their rated capacity.

233.3.10.3 Battery Interconnects

Provide a circuit breaker disconnect and a low voltage disconnect for battery systems.

233.3.10.4 Battery Charging Systems

Match the battery charging system to the battery type and size to avoid unnecessary damage to battery cells. Battery charging systems may include multiple rectifiers for load sharing and redundancy.

233.3.10.5 Battery Monitoring System

Provide a battery monitoring system to monitor the condition of each battery or cell. Specify a monitoring system that identifies a thermal runaway event in the battery system and provides information to the charging system. This allows the charging system to lower the rectifier float voltage to limit the current or shutdown the battery system. Connect the battery monitoring system to the network to permit remote reporting.

233.3.10.6 DC Power Plant Load Distribution

Equip DC power load circuits with circuit breaker panels or fuses. Circuit breakers and fuses may be inherent to the DC power plant or part of a stand-alone fused alarm panel to distribute the DC power to load circuits. The panels may be networked to permit remote monitoring.

233.3.10.7 DC Power Plant Wiring

Specify stranded insulated wire with sufficient gauge to carry the required current in the DC power plant. Specify red insulation for source wiring (e.g., -48 VDC) and black insulation for the return (0 V).

233.3.10.8 Battery Installation

Large DC power plants and battery systems installed on flooring may require a structural analysis to determine the load bearing capacity. Coordinate with the FDOT Project Manager to determine if structural analysis is required.

Design for the weight of large DC power plants and batteries to be evenly distributed to minimize surface or floor load.

233.4 ITS Support Infrastructure

ITS support infrastructure includes:

- Conduits infrastructure
- Pull, slice, and junction boxes
- Utility designation (e.g., power, communications)
- Fiber optic network cables and connections
- Poles and structures
- Camera lowering devices

Coordinate the grading of all foundations to ensure elevation of cabinet bases are above grade. Consider the following:

- Sight obstructions with landscaping and other structures
- Temporary Traffic Control functionality
- Drainage or flooding concerns
- Constructability
- Access for future maintenance

233.4.1 Conduit Infrastructure

Specify the conduit color, inner duct type, size, and quantity of the conduit system in the Plans. Coordinate with the District ITS/TSM&O Engineer to ensure conduit colors and sizes synchronize with existing conduit subsystem. Obtain approval from the District ITS/TSM&O Engineer and District Structures Engineer to utilize bridge-mounted or barrier-wall-embedded conduit for fiber/electric service wires.

Design the conduit system in accordance with the following:

- Conduit runs are to be as straight as possible
- Joints and bends in the conduit system are to meet minimum bending radius of the fiber optic cable as defined in ***Standard Specifications***, ***Section 633***
- Place conduit along the edge of R/W as much as possible to avoid future widening conflicts
- Avoid placing conduits:
  - Within terrain steeper than 1:4 slope
  - Near endangered species habitats, chronic wet areas, landscaping, drainage features, and existing or proposed roadside features (e.g., guardrail)
  - Near underground utilities and lighting conductors
  - Behind noise walls
- Provide maintenance access to the conduit and pull or splice boxes
- Minimize the number of directional borings. If there are two directional bore sections, less than 100 feet apart, then consider using a continuous directional bore.
- Minimize road crossings. When road or ramp crossing is necessary, locate and route the conduit crossing in a manner that minimizes the length to cross the road. Place conduit perpendicular (shortest distance) to the roadway or ramp to the greatest extent practicable.
- Include only one fiber cable in each fiber optic backbone conduit. Do not collocate fiber cables inside the same backbone conduit. Obtain approval from the District ITS/TSM&O Engineer to place multiple fiber optic cables in conduits with lateral fiber optic cable drops. Ensure conduits meet NEC conduit fill ratio requirements.

Provide callouts and notes in the plans indicating existing conduit infrastructure that will be removed or abandoned in the project. Note existing underground conduit identified in the plans for removal as incidental to clearing and grubbing.

If existing conduit is to be abandoned and remain in place, include fiber optic cable removal in plans, so that it is apparent that the conduit has been abandoned.

233.4.2 Pull, Splice, and Junction Boxes

Provide access points using pull, splice, or junction boxes. Minimum requirements for placement of access points are as follows:

- Provide at-grade access to fiber optic cables housed within conduit systems.
- Provide assist points to aid in fiber optic cable installation.
- Provide protection for the fiber optic cable.
- Provide space for storing cable slack/coils and splice enclosures.
- Provide space for entry, routing, and slack fiber storage for pull boxes and splice boxes. Fiber optic cable slack requirements are provided in ***Standard Specifications*, Section 633**.

Access points are required at the following locations:

- As provided in ***Standard Specifications*, Section 635**.
- Planned or future splice locations.
- On each side of:
    - A railroad crossing.
    - A roadway crossing, except for narrow roadways, such as ramps.

Splice boxes must be used for access points on fiber optic cable backbone routes or for device drop. Pull boxes can only be used for access points when the conduit system extends from the backbone to the ITS field devices.

Standard Plans*, Index 634-002** includes information for aerial interconnect, and ***Index 635-001 includes information for pull and splice box details.

The top of pull, splice, and junction boxes should be placed a minimum of 2 feet above the appropriate drainage feature elevation. Coordinate with the Drainage Design Engineer to confirm these structures and their associated components are placed above the appropriate elevation as follows:

- Treatment Swales – Weir Elevation
- Conveyance Ditches – Normal Depth
- Stormwater Ponds – Design Storm Peak Stage

- Floodplain Compensation or Other Systems – Seasonal High-Water Level

Provide the applicable elevation of the top of the pull, splice, and junction in the component-specific cross-sections and typical cross-sections.

233.4.3 Fiber Optic Cable Designating System

The fiber optic cable designating system provides visual indication of the underground fiber optic conduit or cable system. Provide appropriate fiber optic cable locating and marking per ***Standard Specifications*** ***633***.

233.5 Fiber Optics and Network Design

Design network facilities based on specific project needs with the following information:

- General network topology.
- Facility diagrams illustrating conduit routes.
- Network diagrams, including communication hub details.
- External network connections and demarcation points.
- Fiber block diagram to show switches, field devices, and physical network connectivity.

Include Special Provision ***SP0071101-Tolls*** in the contract documents when there are existing power or communication cables that transmit toll system information near areas where work is to be performed. Refer to the ***General Tolling Requirements (GTR)*** for specific ITS requirements related to toll facility design.

233.5.1 Fiber Optic Cable

Fiber optic cable is utilized in the Department's statewide network infrastructure to provide data and device control communications between ITS field devices, Transportation Management Centers (TMCs) and other identified stakeholder facilities.

Requirements for fiber optic cable are as follows:

- Design for single mode fiber strands.
- Define fiber optic cable backbone, drop buffer tube, and strand color requirements.

- Use 12 fibers as a minimum when lateral fiber optic cable drops to ITS field cabinets. Use 24 fibers as a minimum when lateral fiber optic cable drops to local ITS hubs with Layer 3 switches.
- Use 144 single-mode fibers as a minimum for fiber optic cable backbone in new systems.

233.5.1.1 Splices, Terminations, and Connection Hardware

Plans must provide the following:

- Splice points and splice diagrams.
- Interconnect fiber strands, origination, and destination points.
- Minimum link loss budget; including line, splice, and termination losses
- Reserve loss budget for future splicing and cable deterioration. Budget for future loss to equal one-half of the total decibels of the circuit or 10 decibels, whichever is greater.
- Splice enclosures to protect all fiber splices within splice trays. The number and size of splice trays and enclosures are based on the number of fibers involved in the splicing diagram at each splice location.
- Existing fiber optic cables and the location of the nearest full splices in the existing cables, including distance in each direction.
- Termination of fiber optic cables using a Fiber Patch Panel (FPP). Terminate single-mode fiber optic cable in the FPP or use pre-terminated FPP connectors.
- When the project work necessitates a break in the fiber cable, include provisions regarding allowable downtime. Provide any temporary splice drawings required during construction.

233.6 ITS Poles and Structures

Consider the following to locate and select ITS poles and structures:

- Existing ITS infrastructure, roadway features, device type (match existing), and environment.
- Road geometry, static signs spacing, lightning protection, underground utilities, and drainage infrastructure.
- Aesthetics, conflict avoidance, and line of sight issues.

- Soil boring information for the foundation design of the structures.
- Co-locating ITS devices to minimize the number of poles and structures.
- Pole type for each ITS device (e.g., pre-stressed concrete, steel) and structure type (e.g., cantilever, full-span, mid-span).

233.6.1 Camera Lowering Device

Provide a lowering device for pole-mounted cameras with mounting heights greater than 45 feet or where height impedes access via maintenance truck.

Design external conduit for housing the cables, mounting box hardware at the top of the structure, and component details required for installation (e.g., air terminal, guide wire) for a lowering device to be attached to an existing pole or similar structure.

Orient the lowering device to prevent an operator from standing directly beneath the equipment while it is being lowered.

233.7 ITS Enclosures

ITS enclosures include ITS field cabinets, small equipment cabinets, and equipment shelters. Each of these cabinets require an analysis for design, usage, and placement.

233.7.1 ITS Cabinets

Placement of ITS cabinets is based on the safety of the motorist, visibility of roadside devices, and safety of maintenance staff. Mount the ITS cabinets on concrete pads, structures, or poles. Do not place cabinets in flood-prone areas or wetlands. Place ground mounted DMS cabinets based on the DMS type. Cabinet mounting details are shown in ***Standard Plans*, *Index 676-010***.

Size the cabinet to accommodate equipment to be installed, ease of access, anticipated future equipment (e.g., connected vehicle roadside unit in-cabinet equipment), and proper ventilation. All cabinets within a project corridor should have a consistent layout for the interior by functionality. Orientate the cabinet such that the maintenance technician is facing oncoming traffic when accessing the cabinet. Show cabinet orientation and door swings in the plans.

Provide one power and one communication entry conduit for each cabinet, at minimum. Include additional conduit entries as required for the equipment to be housed. Include spare conduits in the cabinet for future expansion.

Provide maintenance service slabs in accordance with ***Standard Plans*, Index 676-010**.

Consider mitigation strategies to prevent drop-off hazards from maintenance service slabs. Modifications to grading surrounding the maintenance service slab is preferred to the extent practicable. The use of retaining walls and railings should be limited to safety concerns in coordination with district ITS maintenance. If a railing is used, extend the maintenance slab to provide a minimum of three feet, six inches of clear space beyond all sides of the ITS pole and cabinet constrained by the railing.

Coordinate with district ITS maintenance for deficiencies and other safety concerns at existing maintenance slab locations. If field reviews and documented safety concerns warrant refurbishment or replacement of any deficient maintenance slabs, seek approval from District ITS/TSM&O Engineer to make provisions in the plans to address the deficiencies.

233.7.2 Small Equipment Enclosures

Small equipment enclosures include structure- or pole-mounted cabinets (e.g., National Electrical Manufacturers Association (NEMA) 3R). These may be used in lieu of ITS field cabinets in locations that require minimal equipment to be housed. Small equipment enclosures may be connected to another ITS site, which houses the Ethernet switch and other ITS components. When locating the small equipment enclosure, consider the allowable power and communication loss per ***IEEE 802.3ab*** to District network speed requirements.

233.7.3 Equipment Shelter

Co-location of master hub equipment in existing FDOT-owned microwave tower buildings may be used in-lieu of new equipment shelters. Coordinate with the District ITS/TSM&O Engineer and the State Traffic Engineering and Operations Office's ITS Communications division to determine if co-location is possible.

If co-location is not possible, provide the following information in the equipment shelter details:

(1) Site layout

  (a) Shelter dimensions.

(b) Site preparation work, clearing and grubbing, fencing, and landscape.

(c) Conduit and pull box installation.

(d) Details for grounding.

(2) Shelter layout

(a) Details for electrical and lighting.

(b) HVAC systems.

(c) Back-up power systems (e.g., UPS, generator, fuel tanks).

(d) Security features (e.g., cameras, security alarms).

(e) Remote monitoring alarms.

(3) Equipment layout

(a) Overhead cable trays.

(b) Standard EIA/TIA 19-inch racks.

(c) Demarcation punch blocks.

(d) Patch panels.

(e) Equipment placement within each rack.

233.8 Communication and Networking Devices

Network devices include a variety of Internet Protocol (IP)-addressable electronic equipment. This equipment is used for the collection and dissemination of video, traffic data, and other information.

Provide communication and networking devices that conform with the following:

- Network requirements and information for communication network design.
- Compatibility with existing network equipment currently in operation.
- Minimal system downtime to facilitate immediate replacement of defective or damaged units.
- Open architecture.
- Survivability and reliability.
- Redundant path and no single point of failure.

233.8.1 Managed Field Ethernet Switch (MFES) Network

Provide MFES network to avoid the following:

- Distance limitations for common Ethernet media types.
- Interference that may be induced on copper-based interconnects.
- Data size transfer limitations based on Gigabit Interface Converter (GBIC).

In the fiber network layout, provide a leap-frog configuration to support availability and optimal data transfer. Ensure no more than one DMS and no more than six CCTV devices are included on any one leap-frog circuit. Ensure that adjacent CCTV devices are on separate circuits.

233.8.2 Device Server

Include device servers when remote field devices with serial communication interfaces require connection to an Ethernet network.

Equipment that may require the use of device servers include:

- Traffic data and vehicle detection systems.
- Road Weather Information System (RWIS).
- Low-speed data output devices.

233.8.3 Media Converter

Media converters may be used to transition between various types of interfaces.

233.8.4 Wireless Communications System

Determine the proper wireless communications system to fit the ITS application (e.g., point-to-point, point-to-multipoint). Consider reliability, security, capital, and operational expenditures, licensed versus unlicensed radio bands, and regulatory requirements for the wireless communications system selection.

Wireless systems enable data communications through radio links.

Typical applications for point-to-point wireless communications system includes:

- Remote ITS field devices or intersections that can use a wireless connection to the nearest fiber drop point.
- Across rugged terrain and bodies of water.
- The use of fiber optics is temporarily unavailable during construction; this use must be approved by the District ITS/TSM&O Engineer.
- ITS device sites where it is difficult or cost prohibitive to install fiber optic cables.

Typical applications for point-to-multipoint wireless communications system includes:

- Land Mobile Radio push-to-talk.
- Highway Advisory Radio.
- Citizens Band (CB) Radio.

The ITS Communications division maintains the Federal Communications Commission (FCC) licenses associated with ITS wireless communications and manages assignment of new licenses. Districts using wireless communications systems to support an ITS application are encouraged to contact the State Traffic Engineering and Operations Office's ITS Communications division.

Specify each component in the wireless communications system including antennas, radios, transmission lines, and connectors. Provide installation details, location, and placement of the system components. Design cable management details. Consider the length between transmit and receive equipment to attain optimum communications signal.

Design line-of-sight, throughput, frequency, availability, power levels, and path calculations for the communications design plans as follows:

- Design the communication path so that two-thirds of the Fresnel Zone is clear of any obstructions (e.g., surrounding terrain, trees, signs, buildings).
- Set throughput capacity for each radio link to transmit two times more data than the maximum data throughput.
- Analyze multipath challenges over large water bodies and within urban street canyons (created by large buildings).
- Analyze spectrum interference in the vicinity.

Wireless communications shall not be used for communication to Express Lane ITS devices.

233.8.5 Layer 3 Switch

Within the ITS network, the Layer 3 switch provides connectivity at transmission rates of 1 or 10 Gigabit per second to and from adjacent Layer 3 switches.

The Layer 3 switch includes Layer 2 capabilities, including Quality of Service (QoS), Internet Group Management Protocol (IGMP), rate limiting, security filtering, and general management. The Layer 3 switch is fully compatible and interoperable with the ITS trunk Ethernet network interface.

The Layer 3 switch is a port based VLAN, supporting VLAN tagging, meeting the requirements of IEEE 802.1Q standard.

The selection of a Layer 3 switch involves variables suited for the proper environment. Items such as dual power supplies, dual supervisor units, Layer 3 protocols, and voltage requirements are considered during the switch selection process. Items such as number and type of ports are design specific. An MSP and custom pay-item are needed for all projects requiring a Layer 3 switch.

See **Form 233-A** (located in **FDM 103**) for desired Layer 3 switches.

233.9 Traffic Data and Vehicle Detection Systems

Include the location and placement of system components and provide installation details for the cables. Design the cabling installation details.

Consider capabilities and functional limitations at each location to attain the required levels of detection accuracy as specified in ***Standard Specifications***, ***Section 660***.

Show detector types and locations on the plans to obtain traffic data such as speed, occupancy, and volume. Detector placement must conform to the following requirements:

- Cover all lanes in both directions (as a group or individually).
- Space one-third to one-half mile in urban areas (context classifications C4, C5 and C6).
- Space one mile in suburban areas (context classifications C3R and C3C).
- Space one to two-mile in rural areas (context classifications C1, C2, and C2T).
- Space one-fourth to one-third mile on express lanes.
- Place at major interchanges exit and entrance ramps.

- Place at intersection to detect vehicle presence at the stop bar, when required.

233.9.1 Loop Detectors

Do not use loop detectors on concrete pavement or on corridors with large traffic volumes of heavy vehicles. Consider using them at locations with low volumes of traffic.

233.9.2 Video Vehicle Detection Systems (VVDS)

Design considerations for VVDS include:

- Upstream versus downstream view orientation.
- Shoulder coverage to detect stalled vehicles.
- Detection zone layout to cover near and far zones.
- Roadway geometry and line of sight.
- Requirement to view VVDS images from the Transportation Management Center (TMC).
- High-contrast or low-light conditions that might interfere with VVDS data reliability.
- Maintenance requirements and impact of high winds on detector alignment and calibration.

233.9.3 Microwave Vehicle Detection Systems (MVDS)

Design considerations for MVDS include:

- Cover all lanes in both directions of travel.
- Provide offset mounting on structures.
- Avoid aiming toward steel structures.
- Align detector perpendicular to the roadway.
- Provide access for maintenance and calibration.
- Use Power over Ethernet when connecting to an ITS Field Cabinet within 330 feet.

On limited-access facilities, place MVDS devices at a maximum of 1-mile intervals for C1 and C2 context classifications and half-mile intervals for other context classifications. Additionally, place MVDS devices at all limited-access facility exit ramp locations or as directed by the District ITS/TSM&O Engineer.

Install MVDS at CCTV camera locations, if possible, to minimize costs. Install MVDS so that it does not interfere with the lowering of CCTV. Do not use roadway lighting poles or sign structures for the installation of CCTV cameras or MVDS.

233.9.4 Wireless Magnetometer Detection Systems (WMDS)

Design considerations for WMDS include:

- Determine the number and spacing of sensors based on detection requirements, e.g., three magnetometers may be required for truck parking.
- Align sensors such that they are placed in the direction of traffic flow or parking space.
- Provide access for installation, maintenance, and calibration.

233.9.5 Automatic Vehicle Identification (AVI) Systems

Design considerations for AVI systems include:

- Follow manufacturer's requirements for AVI sensor placement, mounting height, offset, and line of sight.
- Follow location and spacing based on District objectives for the AVI system. Potential locations include mid-blocks, major intersections, and locations prior to or after interchanges.

233.10 Closed-Circuit Television Systems

Closed-circuit television (CCTV) systems consist of roadside cameras, communication devices, as well as camera control and video display equipment. CCTV is located at one or more remote monitoring locations that allow surveillance of roadway and traffic conditions for traffic and incident management. Cameras are also required for visual confirmation of dynamic message signs and ramp signal operation, as well as security purposes.

Locate and place cameras to provide continuous view of general toll lanes, managed lanes, and limited-access roadways within the project corridor.

Design and placement considerations for CCTV cameras include:

- Continuous view of arterial roadways as directed by the Department.

- Coverage of roadway features including lanes, shoulders, ramps, ramp terminals, and designated emergency stopping, and crash investigation sites beyond the traveled way.
- Coverage of the master hubs, ITS cabinets, generators, and walk-in DMS. Ensure the CCTVs can view corresponding DMS clearly.
- Place cameras at interchanges to view arterial traffic.
- Place cameras for DMS verification no further than 1,000 feet from the face of the DMS with a clear line of sight within the horizontal and vertical viewing cone.
- Dedicated express lane cameras for verification must be capable of pan, tilt, and zoom (PTZ) for every DMS.
- Accommodate service and maintenance access with minimal impact to traffic.
- Utilize crash data analysis to place cameras at high-crash locations.
- Place the camera at a location with minimal vegetation obstruction within half-mile on each side.
- Identify locations for vegetation removal in the plans or propose closer spacing upon approval from the District ITS/TSM&O Engineer and District Landscape Architect.
- Locate the camera in accordance with minimum lateral offset requirements in ***FDM 215***, or place behind existing guardrail and barrier walls. Avoid introducing new guardrail and barrier walls.
- Specify camera mounting height in the plans based on specific project needs. Mount cameras a minimum of 45 feet above the highest crown elevation of the mainline roadway on limited-access facilities. Consider the following in determining the mounting height:
    - Required viewing distance.
    - Roadway geometry and lane configuration.
    - Roadway functional classification (e.g., arterial, collector, limited access facility).
    - Environmental factors (e.g., glare from the horizon, headlight glare).
    - Vertical clearance.
    - Co-location with the other ITS devices.
    - Existing and anticipated vegetation.
- Do not place cameras on lighting structures.

- Avoid placing camera poles in the bottom of ditches or in locations that would prevent maintenance.
- Consider camera life-cycle cost, including maintenance costs.
- Consider CCTV performance and bandwidth requirements, control type, use of temporary cameras, and camera housing.

Design camera housings, enclosures, lowering devices, and mounts in accordance with the ***Standard Specifications***.

Refer to ***Standard Plans**, **Index 649-020*** or ***Index 641-020*** for CCTV camera pole and foundation details. Refer to Department's ***Standard Specifications***,(Division II and III) Section 649 for Steel Pole and Section 641 for Concrete CCTV Pole.

233.11 Motorist Information Systems

Motorist Information Systems include DMS, Highway Advisory Radio (HAR), electronic display signs, and Citizens Band (CB) Radio.

233.11.1 Dynamic Message Sign (DMS)

Select the appropriate DMS type based on specific project needs. Position the DMS to be legible from the roadway based on the display characteristics of DMS technology (e.g., the vertical and horizontal viewing angles of LED displays).

Determine DMS placement based on the following requirements:

- Compatible with the message library proposed for use on the project, including text and graphics.
- Utilize DMS capable of displaying minimum character heights and line spacing per ~~the~~ ***MUTCD***~~, Section~~ Chapter 2L~~.04~~.
- Place in advance of high crash locations and traffic bottlenecks.
- Place where sufficient space is available between the edge of travel lanes and the R/W limits, while meeting the minimum lateral offset requirements in ***FDM 215***
- Place where no conflict with underground or overhead utilities exists.
- Accommodate access for service and maintenance.
- Place along key commuter or evacuation corridors.

- Place on Interstate and Freeway facilities in advance of interchanges that offer alternate routes, and meet the requirements of ***MUTCD***, ~~Section~~ Chapter 2L and the following:
    - Place in advance of 1-mile exit signing.
    - Provide a minimum 800-foot spacing between existing and planned overhead static and other signs, per the ***MUTCD***. Provide increased spacing when conditions allow.
    - Install walk-in DMS on support structures without static signage.
    - In advance of interchanges where interstates meet to allow for advance messaging of traffic conditions on both roadways. Consider locations that are two exits before major interchanges as well as immediately prior to the interchange.
    - Mount embedded DMS over or under the static sign panel or use a static sign cut-out.
- Place on arterials prior to major intersections and interchanges:
    - Approximately 1/4 to 1/2 mile in advance of major intersections or interchanges.
    - At least 600 feet from adjacent signalized intersections.
    - Where the DMS is continuously visible to motorists for 600 to 800 feet, depending on the design speed of the roadway.
    - Where no existing or planned guide signs exist within the 600-foot minimum visibility distance.
    - With minimum interference from lighting, adjacent driveways, side streets, or commercial signage.
    - Where no historical neighborhoods exist.

233.11.1.1 Express Lanes DMS

Express lanes DMS must be full-color or full-matrix DMS and conform to the following application criteria:

Table 233.11.1 DMS Characters

DMS Type		Minimum Character Size (inches)	Minimum Number of Characters Per Line	Maximum Resolution (millimeter pixel pitch)
Lane Status	LA Facility	18	18	20
	Arterial	12		
Toll Amount	LA Facility	18	7	
	Arterial	12		

233.11.2 Highway Advisory Radio (HAR)

A highway advisory radio (HAR) system is an advisory tool that informs the public of traffic- and safety-related issues. HAR systems may be installed or upgraded with the approval from the Chief Engineer. See Engineering and Operations Memorandum ***16-03***.

Include the equipment necessary for the operator to record verbal messages from onsite or remote locations, and to continually broadcast live, prerecorded, or synthesized messages from roadside transmission sites. Also, include highway signs with remotely operated flashing beacons to notify motorists of HAR broadcasts.

Refer to FCC regulations ***Title 47 CFR, Part 90.242*** for additional design requirements on travelers' information stations. Additional information on licensing issues, frequency allocation, and other specifics may be obtained by contacting the State Traffic Engineering and Operations Office's ITS Communications division.

Determine placement of a HAR installation based on specific project needs, as well as the following requirements:

- Transmission of message that can be received by motorists traveling through the broadcast zone.
- Placement on Interstate and Freeway facilities prior to interchanges that offer alternate routes.
- Placement in advance of high crash locations and traffic bottlenecks.
- Placement that accommodates access for service and maintenance.
- Placement along key commuter or evacuation corridors.

- Placement of flashing beacon signs within the HAR coverage area prior to exit signs or DMS associated with an interchange.
- Wood poles are often recommended by HAR manufacturers for antenna mounting to reduce interference that may occur with conductive poles. Install the antenna in accordance with the manufacturer's recommendations and in compliance with FCC requirements.

233.11.3 Electronic Display Signs

Place Variable Speed Limit (VSL) signs and Lane Control Signals (LCS) in accordance with:

- Locations per District requirements.
- Sign spacing per ***MUTCD*** requirements.

Specify field cabinet, support structure, power supply, and communications to support VSL and LCS installation.

233.11.4 Citizens Band (CB) Radio

The Department deploys CB radios to advise motorists (particularly commercial freight vehicles) about travel conditions and emergencies. The CB radio service operations and electronic equipment are regulated by the FCC in ***Title 47 CFR, Part 95, Subpart D***.

Operation of a remotely located CB radio station from a facility (e.g., a Transportation Management Center (TMC) where the operator is not co-located with the CB radio) requires a written waiver of the FCC rules. Contact State Traffic Engineering and Operations Office's ITS Communications division to obtain the required FCC waiver needed to remotely operate a CB radio.

233.12 Additional ITS Devices

This section includes information on other ITS devices that are TSM&O tools.

233.12.1 Road Weather Information System (RWIS)

RWIS consists of Environmental Sensor Station that incorporates multiple or single environmental sensor(s) (e.g., wind speed sensors, visibility sensors, pavement sensors) that are attached to one pole. Location of Environmental Sensor Stations should consider the following:

- Place in locations where weather observations will be the most representative of the roadway segment of interest.
- Select locations to avoid the following:
  - Effects of passing traffic (e.g., heat, wind, splash).
  - Standing water.
  - Locations where billboards, surrounding trees, or other vegetation would affect the weather measurements.

For more information on appropriate location of ESS and additional design requirements, refer to the ***FHWA's Road Weather Information System (RWIS) Environmental Sensor Station Siting Guidelines*, *Publication No. FHWA-HOP-05-026***.

Identify the appropriate communication platform for the RWIS application (e.g., copper, fiber, wireless).

Licensing for using satellite-based communications is required, and it must be coordinated by the Department with the National Oceanic and Atmospheric Administration (NOAA). Coordinate the use of satellite-based systems with the State Traffic Engineering and Operations Office's ITS Communications division.

233.12.2 Ramp Metering Signals

A ramp metering signal controls the number of vehicles entering a limited-access facility to maintain steady traffic flow. Consider the following when designing ramp metering signals:

- ***MUTCD*** signalization requirements for ramp signals (e.g., design of the signal system, number of signal heads, placement beside or over the ramp).
- Distance from the stop bar to the acceleration lane to allow vehicles starting from the signal to reach highway speeds and merge safely.
- Distance from signal stop bar to the cross-street intersection to allow adequate vehicle storage at the signal.
- Add two-lane storage upstream of stop bar from cross street to store additional vehicles and not spill over cross street if ramp meter is proposed on a single lane ramp and traffic analysis warrants the need.
- Placement of stop bar and queue length detection.

- Placement of detectors to support local or central ramp signal control algorithm in use by the District.
- Signing to support signal operation.

233.12.3 Connected Vehicle Infrastructure

Connected Vehicle (CV) technologies are equipment, applications, or systems that use vehicle-to-everything (V2X) communications to address safety, system efficiency, or mobility.

CV technology leverages direct radio communication in the 5.9GHz public safety spectrum (i.e., LTE-V2X and PC5) or networked communications (LTE and 5G) between roadside equipment and vehicles via on-board units (OBUs), smartphone applications, or a combination of both.

While multiple communication methods are incorporated into the Department's approach to CV deployments, direct communication utilizing roadside units (RSUs) and projects involving the deployment of roadside equipment are methods that will require plans development, and thus are included in this section.

Use the following documents and guidance when designing CV infrastructure:

- ***FDOT Developmental Specification, Dev681CVRSE and Dev995CVRSE*** for Connected Vehicle Roadside Equipment.
- ***FDOT Security Credential Management System (SCMS)*** work process for providing guidance to the contractors and device providers.
- The ***CAV Guidance Document*** obtained from the District TSM&O Section.
- Coordinate with the District TSM&O Section for any specific guidance and requirements for the contractors or device providers.

Best Practices for projects comprising CV technologies include:

- Co-locate RSUs with new or existing ITS or signal infrastructure.
- Ensure aspects such as CV device signal strength, coverage, or occlusions, that may block or degrade signal strength are taken into consideration during design.
- Ensure the RSUs and OBUs are enrolled into the statewide SCMS. Manufacturers are required to enroll and provision devices within the FDOT SCMS before they are shipped for installation.

- Engage stakeholders in the design analysis stage if the project involves a local maintaining agency.
- Coordinate network changes and firewall updates that may be needed with the District TSM&O team and local maintaining agencies in the early stages of work.

233.12.3.1 Applications and Systems Engineering

Connected Vehicle is a broad technology that utilizes applications for specific functions.

Coordinate with the District TSM&O Section for guidance on the need for Systems Engineering documentation and what to document. Develop Systems Engineering documentation reflecting existing applications and their functionality. Consider all aspects of the system when determining needs, including the following:

- network connectivity
- security
- OBU availability
- compatibility with legacy hardware and software
- stakeholder agreements
- data storage and retention to meet the objectives of the project

Confirm the true capabilities and reliability of devices and applications prior to incorporating them into the plans.

Update Project and Regional ITS Architecture (RITSA) to reflect new and existing data flows.

Update the Concept of Operations to document high-level needs, feasibility, changes in operations, and responsible parties. Ensure these needs have a clear responsible party. Document data types involved in the project, data collection process, storage, and processing in alignment with the FDOT's ***Vehicle-to-Everything Data Exchange Platform (V2X DEP)***.

Develop other Systems Engineering documents, as needed.

233.12.3.2 Network

Coordinate and document end-to-end network connectivity during the design process. Coordination may require a meeting with the signal and ITS staff of the signal maintaining agency. Secure agreements with respect to system deployment and integration to ensure constructability and testing requirements can be met in a timely manner.

233.12.3.3 Security Credential Management System

The Department has a statewide Security Credential Management System (SCMS). All CV devices, RSUs and OBUs, require enrollment in the statewide system. Ensure the technical requirements include the device manufacturers to enroll the CV devices before installation.

For future enrollment of CV devices, ensure project requirements include terms for the contractors or device manufacturers to provide the required information to the District TSM&O Program Engineer for approval.

233.12.3.4 Map Data (MAP) Development

Many CV applications require a MAP message to function. Designers should be familiar with the MAP development process, including use of the USDOT Connected Vehicles Tool Library. FDOT specifications require that manufacturers preconfigure RSUs with MAP files prior to deployment. However, designers may be requested to assist with post design services that require knowledge of MAP development and verification.

233.12.3.5 Federal Communications Commission Licensing

An RSU is a radio transceiver that operates in the licensed 5.9GHz public safety radio spectrum and is mounted on roadside infrastructure.

RSU locations within Florida must be registered to operate under the existing FDOT statewide license (Call Sign WQBS407) within the Federal Communications Commission's (FCC) Universal Licensing System.

An OBU is a mobile transceiver that is mounted in or on a vehicle and operates on the same frequencies as RSUs. OBUs are required to be licensed by their manufacturer.

The FCC has assigned the portion of the 5.9GHz spectrum from 5.895 – 5.925 GHz for exchanging messages between RSUs and OBUs.

Information required for registering RSU sites must be provided to the State Traffic Engineering and Operations Office using an electronic data collection form that is available upon request from the District TSM&O Section. Ideally, the required information should be provided to the Department approximately 3 months before RSUs are placed into operation to allow ample time for the Department and the FCC to complete their respective site registration processes.

RSU antennas should be mounted at a height of 20-26 feet. Mounting heights at or below 26 feet allow RSUs to operate at full power and still comply with FCC rules regarding maximum equivalent isotropic radiated power (EIRP). If antennas are mounted above 26 feet, then the RSU output power must be reduced to comply with FCC rules regarding maximum EIRP. The RSU antenna height shall not exceed 49 feet under any circumstance per FCC rules.

233.12.3.6 Compatibility with Legacy Systems

Capture all needed infrastructure, licensing, and configuration changes needed to accomplish the deployment and applications of the project.

CV technology deployment can include existing ITS infrastructure upgrades or addition of new infrastructure.

Examples of infrastructure upgrade and the reasons for these upgrades are:

- Traffic signal cabinet upgrade to allow space for cabinet deployed equipment.
- Traffic signal controller hardware or license or firmware upgrade to allow for communication between the controller and other CV infrastructure for data exchange relating to Signal Phasing and Timing (SPaT) and other CV messages.
- Communication infrastructure additions and upgrades to allow network connectivity to controlling software and data repository.

233.12.3.7 Supporting Technology

CV technology continues to expand nationwide. While equipping vehicles and vulnerable road users with 5.9GHz transceivers has not yet occurred at scale, other supporting technology can be used to produce proxy messages on their behalf.

Utilize detection systems in conjunction with CV devices to indicate position, heading, and speed of unequipped motorists and vulnerable road users based on detection and tracking by roadside sensors (e.g., using video analytics or LiDAR sensor data) to meet project objectives. Coordinate with the District TSM&O Section if additional sensors are needed.

Include additional roadside computing equipment as required on a project-by-project basis. Some applications and projects may require additional roadside equipment, such as an industrial computer for CV applications, due to limitations of RSU processing power or other project-specific conditions (e.g., limitations of legacy signal controllers or other devices).

233.12.3.8 Operations and Maintenance

Ensure operations, maintenance and any software licensure management responsibilities are captured in agreements during the design process.

Consider maintenance access when placing devices.

~~233.12.3 Connected Vehicle Infrastructure~~

~~Connected Vehicle (CV) is an emerging TSM&O strategy that generally falls into three application categories:~~

- ~~Vehicle-to-Infrastructure (V2I).~~
- ~~Vehicle-to-Vehicle (V2V).~~
- ~~Vehicle-to-Others (V2X).~~

~~The V2X components include pedestrians, bicyclists, personal mobile devices, aftermarket safety devices (ASDs), and any other Internet of Things (IoT). The common communications source uses 5.9 GHz Dedicated Short-Range Communication (DSRC) or cellular communications to and from Roadside Units (RSUs) and On-board Units (OBUs).~~

~~Use the following national standards when designing CV infrastructure:~~

- ~~United States Department of Transportation (USDOT) ***DSRC RSU Specifications***.~~
- ~~Society of Automotive Engineers (SAE) ***DSRC Message Set Dictionary***, including Basic Safety Messages (BSMs) and Traveler Information Messages (TIMs).~~
- ~~USDOT ***Mapping Tool*** or LiDAR for intersection mapping.~~

- ~~USDOT Architecture Reference for Cooperative and Intelligent Transportation (***ARC-IT***).~~
- ~~FCC, ***Title 47 CFR***, Parts 90 and 95L.~~
- ~~USDOT Security Credential Management System (***SCMS***).~~
- ~~Communications requirements for Internet Protocol version 6 (***IPv6***).~~

~~Consider the following for the RSU device placement:~~

- ~~Co-location of devices with new or existing ITS or signal infrastructure.~~
- ~~Availability of inside cabinet space for RSU-associated equipment.~~
- ~~Antenna placement location.~~
- ~~Wireless coverage.~~

~~Provide the RSU locations to the State Traffic Engineering and Operations Office's ITS Communications division and the District ITS/TSM&O Engineer to file for FCC licenses for all DSRC RSUs. FCC licenses must be granted before a station transmits on any channel.~~

233.13 Maintenance of ITS Devices and Communications

Coordinate with the District ITS/TSM&O Engineer to determine if maintenance of ITS devices and communications during a construction project is required. Considerations for uninterrupted ITS devices and communications include the following:

- Install new ITS communications network before removing the existing network.
- Use of temporary fiber that is placed outside the limits of construction.
- Use of temporary aerial fiber or wireless communications.
- Use of other public or private communications.
- Make every effort to maintain existing ITS devices and field equipment. If ITS device locations are impacted by planned construction, include temporary ITS devices.

The maintenance of ITS devices and communications plan must be approved by the District ITS/TSM&O Engineer.