Chapter 4 Cross Section Elements

4.1 General

The main elements that make up the cross section of a highway or street are the roadway and the border area. The roadway is for vehicular use and consists of the traveled way, shoulders (paved and unpaved), on-street parking, and bike lanes. The border area is the area between the roadway and the right of way line and consists of fill slopes, ditches, sidewalks, multi-use paths, and berms. Border areas can also accommodate utilities landscaping features, and stormwater control measures.

Refer to GB Chapter 4 Section 4.1 for additional guidance.

4.2 Traveled Way

Traveled way is defined as the portion of the road that allows movement for through traffic. It does not include shoulders, curb, turn lanes, bike and pedestrian facilities, or parking lanes.

Elements that affect the design of the traveled way are surface type, cross slope, skid resistance, and hydroplaning.

Refer to RDM Part I Chapter 3 Section 3.3.3 for information on traveled way widths.

Refer to RDM Part I Chapter 7 Section 7.7 for more information on hydroplaning.

Refer to GB Chapter 4 Section 4.2 for more detail on traveled way general considerations.

Refer to GB Chapter 4 Section 4.2.3 for more detail on skid resistance.

4.3 Lane Widths

Lane width influences operational characteristics, level of service, driver comfort, and likelihood of crashes of a roadway.

- On local roads, use lane widths of 10 to 11 feet in residential areas and 12 feet in industrial areas. When right of way is limited, 9-foot lanes in residential areas and 11-foot lanes in industrial areas can be considered.
- For collectors, lane widths can range from 10 feet to 12 feet. In industrial areas, use 12-foot lanes unless right of way restrictions exist; in these cases, 11-foot lanes can be used. Turn lanes at intersections can vary from 10 to 12 feet depending on truck volumes.
- Lane widths for arterials range from 10 to 12 feet. On high speed, free flowing urban arterials, 12-foot lanes are preferred. When truck and bus traffic is low and speed is less than 35 mph, 10-foot lane widths may be used. Lane widths for divided arterials in a rural area should be 12 feet due to high speed and traffic volumes. On reconstructed arterials, 11-foot lanes are acceptable if the alignment is acceptable and has no crash history that would indicated widening is necessary.
- Provide 12-foot lanes on freeways and other high speed, high volume roadways.

A project may require lanes of unequal widths to be used. Locate the wider lane on the outside (right) to provide more space for larger vehicles that typically use the outside lane as well as provide space to share with bicycles. Locate the wider lane adjacent to the curb and gutter where curb and gutter is used.

Curb and gutter is typically used in urban settings as well as on four-lane median divided facilities to improve traffic operations and increase safety. At times, curb and gutter can be used for a multilane undivided facility or in areas to direct stormwater.

A five-lane curb and gutter section is not a preferred typical section to be used. If conditions suggest a five-lane curb and gutter section should be used, the preferred section is 64 feet face to face. Use the recommended minimum lane width of 15 feet providing a 34-foot face to face typical width for a two-lane two-way application.

Refer to RDM Part I Chapter 2 Sections 2.7.2 and 2.7.3 for additional guidance on lane widths.

Refer to RDM Part I Chapter 3 Section 3.3.3 for information on traveled way widths.

Refer to GB Chapter 4 Section 4.3 for more detail on lane width general considerations.

Refer to GB Chapters 5 through 8 and the *NCDOT Complete Streets Policy* for guidance on lane widths for specific roadway types.

4.4 Shoulders

The shoulder is a portion of the roadway adjacent to the traveled way that accommodates stopped vehicles, emergency use/vehicles, lateral support of pavement courses, and in some cases, bicyclists. Shoulders provide a vehicle recovery area that allows a driver to correct should their vehicle move outside the travel lane. The usable shoulder width refers to the width the driver can actually use when parking or making an emergency stop.

Pave shoulders the full width or partial width depending on the roadway classification, traffic volumes, and native soil types as recommended in the Pavement Design.

Consider bicyclists when designing paved shoulders on a roadway; the addition or improvement of these shoulders drastically improves the bicyclists' experience. Refer to AASHTO *Guide for the Development of Bicycle Facilities* 2012 Fourth Edition Chapter 4 Section 5 for in depth guidance.

The graded shoulder is the width from the edge of travel way to the hinge point (shoulder slope intersects the fill/ditch front slope). When guardrail is required on a project, additional shoulder width is needed for guardrail installation and clearance. At times, this added shoulder width may be continued throughout the project for uniformity. The decision to provide this wider shoulder width is based on discussions with the project team. As a cost-reduction measure, normal shoulder widths are specified where guardrail is not required and then transitioned to wider shoulders where guardrail is required. Use engineering judgement with this method by considering the length of the project and the amount of guardrail required.

Refer to GB Chapter 4 Section 4.4 for additional guidance on shoulders.

4.4.1 Shoulder Widths

4.4.1.1 Outside Shoulder Widths

Locals and Collectors

In the design of locals and collectors, use normal shoulder widths as shown in Table 4-1.

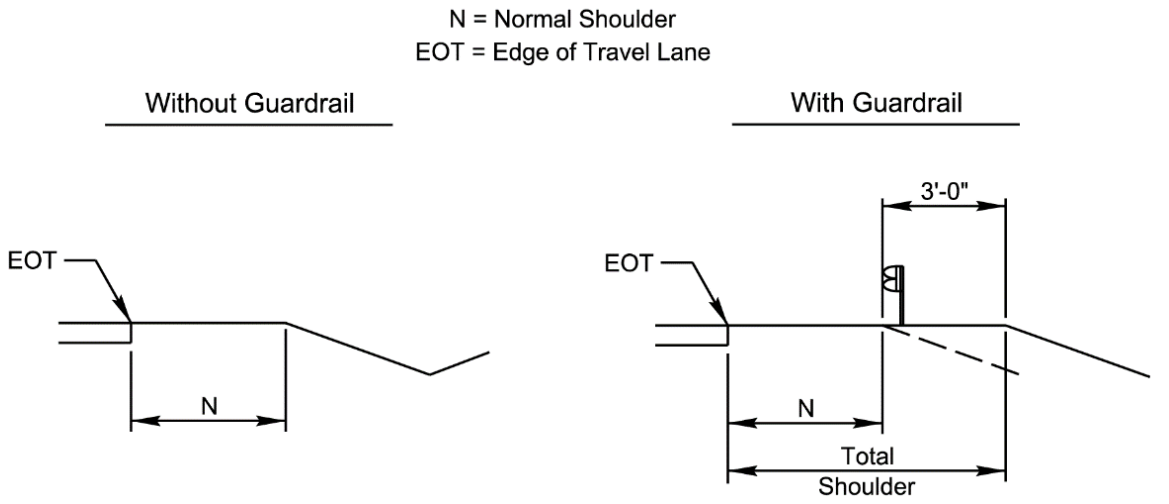
Table 4-1 Normal Shoulder Widths for Locals and Collectors

ADT	Design Year		
	Under 400	400–2000	Over 2000
Locals and Collectors	2 feet*	4 feet	6 feet

Notes:
1. *When guardrail is warranted, the minimum offset from the edge of the travel way to the face of the guardrail is 4 feet.
2. Any deviations from the values shown in this table should be discussed and approved by the project team.

When guardrail is warranted, the total shoulder width is increased by 3 feet, as shown in Figure 4-1.

Figure 4-1 Normal and Total Shoulder Width for Locals and Collectors



Arterials, Interstates, and Freeways

In the design of arterials, interstates, and freeways, use minimum normal shoulder widths, as shown in Table 4-2.

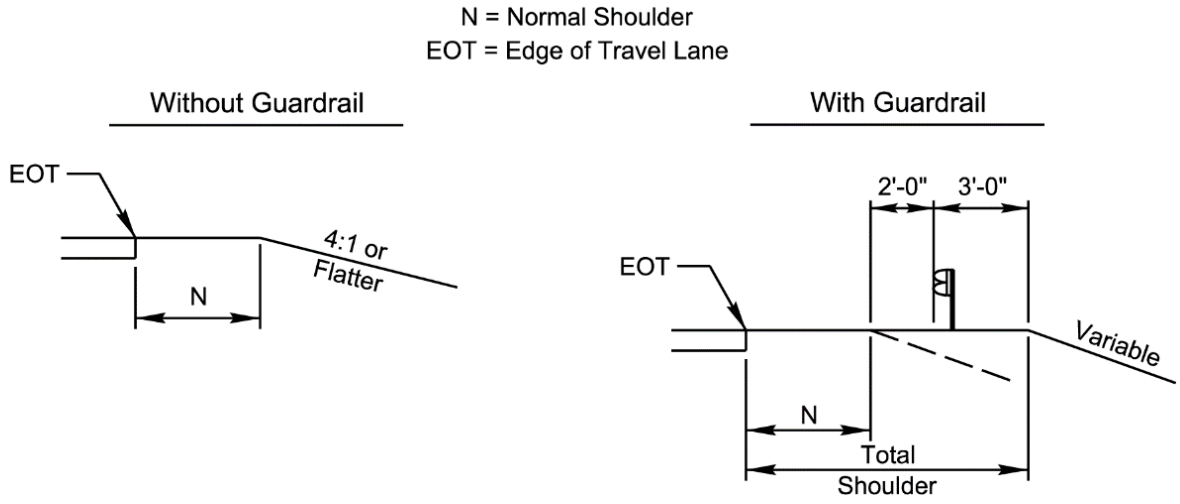
Table 4-2 Normal Shoulder Widths for Arterials, Interstates, and Freeways

ADT	DESIGN YEAR		
	Under 400	400–2000	Over 2000
Arterials	4 feet	6 feet	8 feet*

Notes:
1. *10-foot normal shoulder on freeways, expressways, and interstates; 12-foot normal shoulder on freeways and interstates when truck directional design hourly volumes (DDHV) exceed 250.
2. Any deviations from the values shown in this table should be discussed and approved by the project team.

It is desirable to provide a graded shoulder that will allow vertical elements like roadside barriers and walls to be offset a minimum of 2 feet from the outer edge of the usable shoulder. When guardrail is warranted, increase the total shoulder width by 5 feet as shown in Figure 4-2.

Figure 4-2 Normal and Total Shoulder Width for Arterials, Interstates, and Freeways



4.4.1.2 Median Shoulder Widths

On facilities with medians, use median shoulder widths as shown in Table 4-3.

Table 4-3 Median Shoulder Widths

Median Width (feet)	Median Shoulder Width (feet)
70	12
60	10
46	6
30-36	6

4.4.2 Shoulder Width on Loops

Inside shoulder – Use 2-foot 6-inch curb and gutter with 10-foot berm (right side of traffic)

Outside shoulder – Use 12-foot desirable, 10-foot minimum (left side of traffic)

4.4.3 Shoulder Width on Ramps

Inside/median shoulder – Use 12-foot desirable, 10-foot minimum (left side of traffic)

Outside shoulder – Use 14-foot desirable, 12-foot minimum (right side of traffic)

4.4.4 NCDOT Paved Shoulder Guidance

The NCDOT paved shoulder guidance (see Table 4-4) incorporates the findings of an in-depth study of construction, maintenance, safety, operational, and economic issues related directly to the usage of paved shoulders. The economics of providing a safe overall highway system were also considered in determining an appropriate level of expenditure for this design feature. This guidance is a standardized method developed specifically for the purpose of consistently providing acceptable paved shoulder designs for each roadway classification.

For design inclusive of bus priority treatments, refer to TRB Transit Cooperative Research Program *Report 151: A Guide for Implementing Bus on Shoulder (BOS) Systems*.

The Materials and Tests Unit – Pavement Design and Analysis Group determines the pavement design for the paved shoulder on a project-by-project basis. Usage of paved shoulder widths in excess of the requirements of this guidance must be approved by the project team.

Table 4-4 NCDOT Paved Shoulder Guidance

Classification	Inside / Median	Outside
Interstate and Freeways 6 or more lanes	10'	10'
Interstate and Freeways 4 lanes	4'	10'
Freeways 4 lanes ADT < 15,000	4'	4'
Median Divided Arterials and Collectors 6 or more lanes	4'	10'
Median Divided Arterials and Collectors 4 lanes ADT ≥ 40,000	4'	10'
Median Divided Arterials and Collectors 4 lanes ADT < 40,000	2'	4'
Multilane Undivided 4 or more lanes ADT ≥ 40,000	N/A	10'
Multilane Undivided 4 or more lanes ADT < 40,000	N/A	4'
Two Lane - Two Way ADT ≥ 8,000	N/A	4'
Two Lane - Two Way ADT ≥ 4,000	N/A	2'
Two Lane - Two Way ADT < 4,000	N/A	N/A
Ramps	4'	4'
Flyovers	6'	10'
Loops	N/A	4'

Notes:
1. Paved shoulder width should not exceed normal widths as defined in the RDM except at guardrail locations as shown in NCDOT Roadway Standard Drawings Std. No. 862.01.

2. Consider a 12-foot-wide paved outside shoulder for freeways and interstates having truck traffic which exceeds 250 directional design hour volume (DDHV). Consider a 12-foot-wide paved median shoulder for these facilities which have six or more lanes and truck traffic exceeding 250 DDHV.
3. Design 12-foot full depth paved shoulders for freeways and interstates that warrant 12-foot paved shoulders due to heavy truck traffic and design year average daily traffic (ADT)> 40,000. The pavement design for median and outside paved shoulders will be as directed by the Materials and Tests Unit – Pavement Design and Analysis Group.
4. Use rumble strips, pavement texturing or other approved methods for delineating mainline pavement surfaces from shoulder pavement surfaces on rural interstate and freeway shoulder surfaces.
5. Consider 10-foot paved inside shoulders for speeds ≥ 55 mph.
6. Consider additional width for outside paved shoulders on individual ramps if a history of excessive shoulder usage is apparent or expected based upon experience at similar facilities in the region. Discuss the need for additional paved shoulder width on ramps at the Field Inspection. The project team will approve any requests for additional paved shoulder widths on ramps. The pavement design for the paved shoulders will be as directed by the Materials and Tests Unit – Pavement Design and Analysis Group.
7. For auxiliary lanes, pave the full usable shoulder width if the auxiliary lane connects interchanges or is longer than 2,500 feet. The pavement design for the paved shoulders on auxiliary lanes will be as directed by the Materials and Tests Unit – Pavement Design and Analysis Group.
8. Partial depth paved shoulders can be considered as a cost reduction measure if approved by the Materials and Tests Unit – Pavement Design and Analysis Group.

When utilizing a paved shoulder, a minimum 2-foot turf shoulder is required beyond the paved shoulder limit and may affect total shoulder width. In areas where guardrail is warranted, the additional 3-foot to 5-foot shoulder widths noted above include the 2-foot minimum turf shoulder.

Refer to RDM Part I Chapter 2 Section 2.7 Figures 2-3 and 2-4 for guidance on pavement edge construction with paved shoulders.

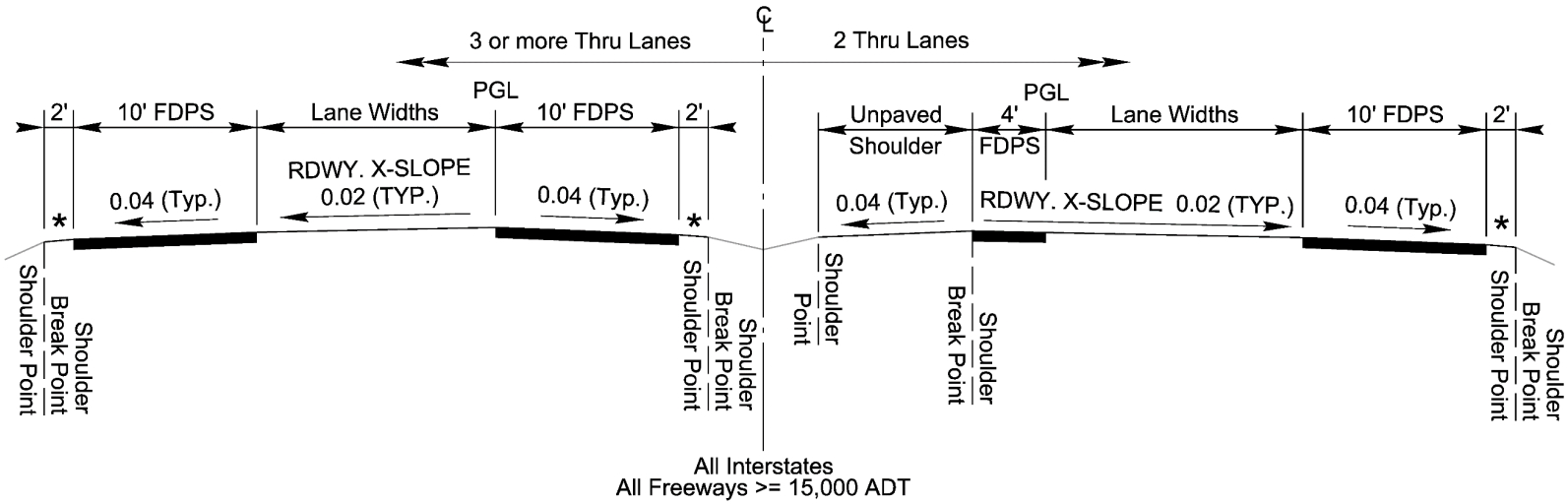
4.4.5 Shoulder Slopes

Shoulders can be paved or turf. For turf shoulders, the maximum cross slope is 8 percent. For 2-foot to 4-foot paved shoulders, the shoulder cross slope will be the same as the travel way cross slope. For paved shoulders greater than 4 feet, the cross slope will be 4 percent. The maximum rollover (algebraic difference) between the travel lane and shoulder is 6 percent.

Refer to *NCDOT Roadway Standard Drawings*, Std. Nos. 560.01 and 560.02 for shoulder slopes.

Refer to Figure 4-3 below for illustration of typical shoulder cross slopes.

Figure 4-3 Typical Shoulder Cross Slopes



* 0.08 (Typ.)

FDPS - Full Depth Paved Shoulder

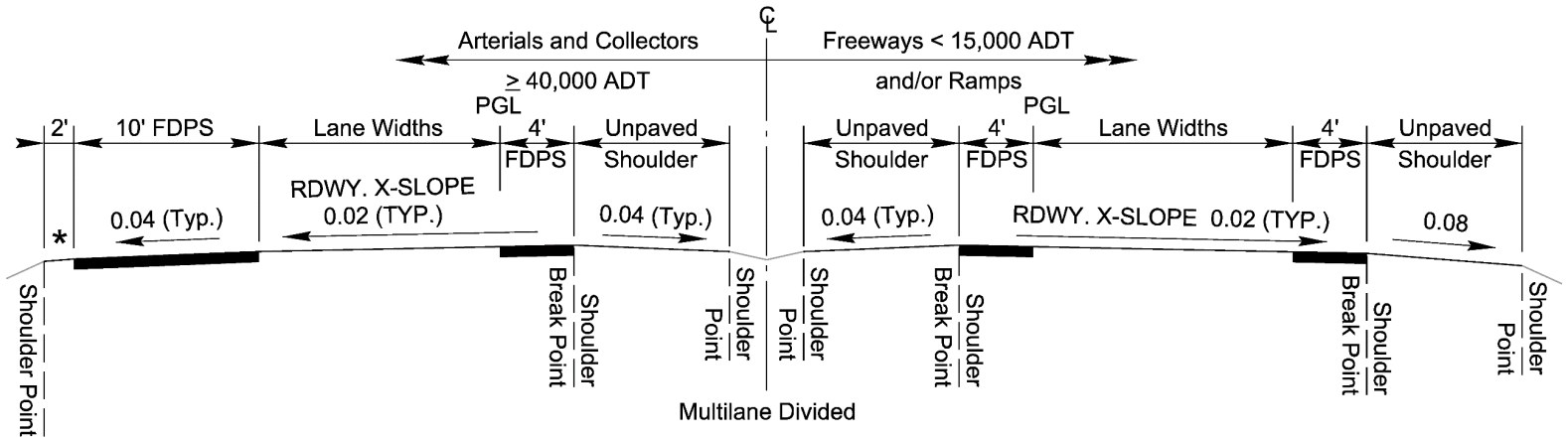
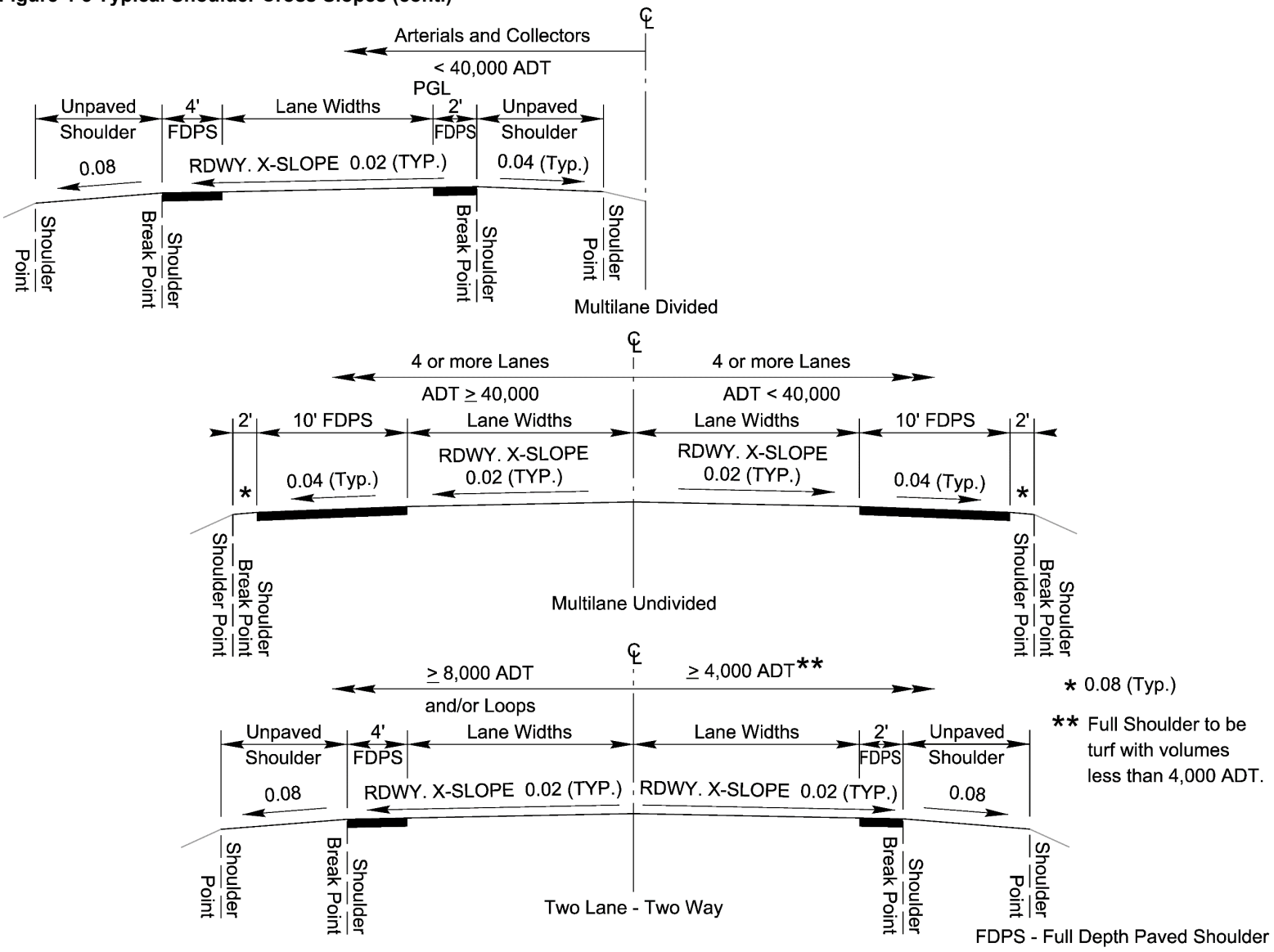


Figure 4-3 Typical Shoulder Cross Slopes (cont.)



4.4.6 Sideslopes

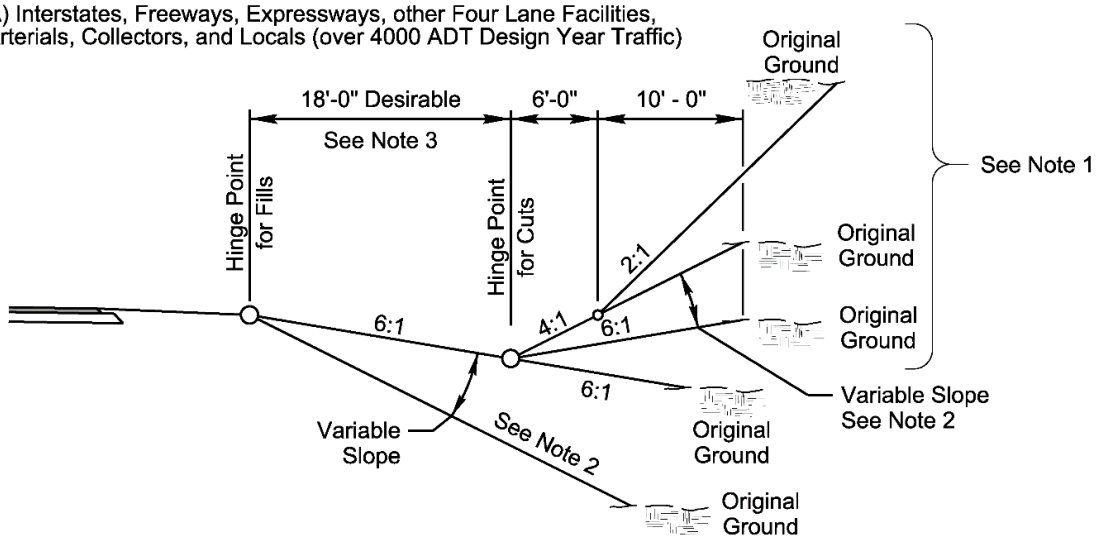
The front slope (foreslope) is the slope from the far edge of shoulder to the ditch point. Design front ditch slopes in accordance with Figure 4-4.

The back slope is the slope from the ditch bottom to existing ground and is also known as cut slope. The back slope may be a fixed slope or a hinge point slope. When fixed back slopes are used, design in accordance with the figure below. On minor or local roads, use one set of fixed slopes in cuts and fills for the length of the project.

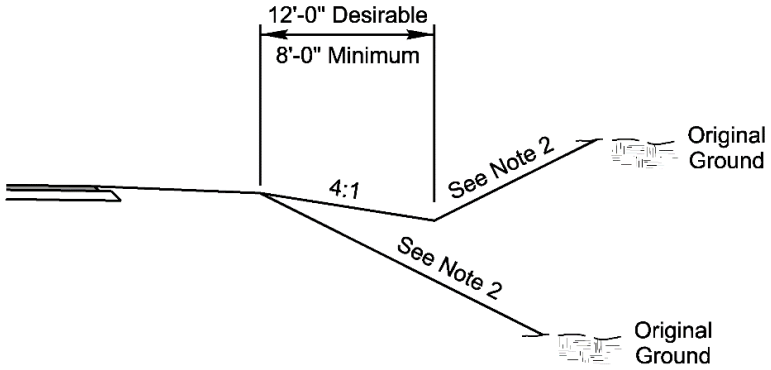
Coordinate with the hydraulics engineer to determine the appropriate ditch side slopes based on capacity calculated in the hydraulic/hydrologic analysis.

Figure 4-4 Criteria for Roadway Typical Section and Slopes

(A) Interstates, Freeways, Expressways, other Four Lane Facilities, Arterials, Collectors, and Locals (over 4000 ADT Design Year Traffic)



(B) Collectors and Locals (4000 ADT or less Design Year Traffic)



Notes:

1. Utilize 6:1 backslope if you can tie into original ground within 16′ of Hinge Point for Cuts. If limits of 6:1 backslope exceed 16′, transition to 4:1 backslope to stay within 16′ of Hinge Point for Cuts. Otherwise, utilize 2:1 backslope once beyond 6′ of Hinge Point for Cuts.
2. The steepest practical slopes as determined by the Geotechnical Unit should be utilized. Unless otherwise noted, slopes for projects east of I-95 or in Division 4 should not be steeper than 3:1. Interstate side slopes should not be steeper than 2:1 except in rock excavation. Freeways and expressways should not be steeper than 11/2:1 to 2:1
3. 15′-0″ minimum for Interstate, freeway, expressways, and four lane. 12′-0″ minimum for arterials, collectors, and local over 4,000 ADT.
4. A guardrail study will be required for fill slopes steeper than 3:1. Refer to RDM Part I Chapter 6.
5. Two-foot minimum ditch depth is required to cover driveway pipe.

The primary advantage of hinge point slopes is to provide a variable slope that relates to the height of cut or fill. Also, with the utilization of variable slopes, the proposed improvements may be blended into the existing topography and provide a more pleasing appearance. Use hinge point slopes on all freeways, expressways, and interstates in all terrains except where special ditches are required, soil conditions dictate otherwise, or rock is encountered. Hinge point slopes are also used on arterials, collectors, and locals (more than 4,000 average daily traffic (ADT) design year).

Hinge points for interstates, freeways, and expressways provide a transition area at the beginning and end of cuts and fills. Utilize steeper fixed slopes, as determined by the soils and foundation section, through the remainder of the cut or fill.

Refer to GB Chapter 4 Section 4.8.4 for more detail on sideslopes.

4.4.7 Rumble Strips

Rumble strips are sensory warning treatments constructed along paved shoulders to alert the motorists before they leave the roadway and strike a roadside barrier or hazard. They alert drivers of drifting off the road by creating an audible and vibratory warning that their vehicle is leaving the designated travel lane and that a steering correction is required.

Rumble strips used continuously along the shoulder help deter drivers from departing the travel way. Rumble strips located along the centerline of a roadway on undivided highways help reduce head-on collisions.

It is the responsibility of the project design team, the Division, the State Roadway Design Engineer, the State Traffic Engineer, and the Chief Engineer of Operations to ensure that the following guidelines are followed and applied consistently within their respective area of operation.

In general, use rumble strips on both the median and outside shoulder at locations on interstates, freeways, and expressways. It is not necessary to use the same type of rumble strips on the median and outside shoulders. Investigate the placement of rumble strips on existing roadways to verify the shoulder width and pavement structure are sufficient. On roadway facilities designated as bike routes or where bicyclists are expected, use placement and design of rumble strips sparingly, include at least a 4-foot shoulder, and coordinate with the Integrated Mobility Division.

Refer to AASHTO *Guide for the Development of Bicycle Facilities* 2012 Fourth Edition Chapter 4 Section 4.5.2 for more detailed information on designing for rumble strips on roadways with bicycle facilities. Milled rumble strips are not recommended on structures.

4.4.7.1 Rumble Strip Placement

Asphalt Paved Shoulders

Locate rumble strips in accordance with *NCDOT Roadway Standard Drawings*, Std. No. 665.01.

Concrete Paved Shoulders:

Locate rumble strips in accordance with *NCDOT Roadway Standard Drawings*, Std. No. 720.01.

Other Roadway Facilities

Consider use of rumble strips where documented histories of lane departure type crashes exist.

For rural median divided facilities with partial control of access (where designated driveway and street access points are allowed), consider use of rumble strips on a case-by-case basis.

The roadway designer is responsible for design and placement of rumble strips on other roadway facilities:

- The width of shoulder rumble strips may vary depending on the width of the paved shoulder provided.
- The width and placement of centerline rumble strips may vary depending on lane width and pavement marking type and use.

4.4.7.2 Surface Treatment

For projects that are set up for future widening, existing rumble strips can be filled with epoxy fillers until the next scheduled pavement overlay. Existing rumble strips can also be milled before applying a new pavement surface. In cases where milled rumble strips are not practical, install raised rumble strips which include side-by-side raised pavement markers, rumble bars, or plastic inserts within thermoplastic pavement markings.

Other surface treatments may be used with the approval of the State Roadway Design Engineer and the State Traffic Engineer. The roadway designer, Transportation Mobility and Safety Unit, and the appropriate Division office will agree upon the type and extent of shoulder surface treatments, when applicable. These guidelines are not intended to restrict or prohibit the use of any alternative surface treatment when special engineering circumstances are required. When selecting the type of treatment, consider the potential use of the shoulder by traffic during future construction and maintenance operations.

These guidelines or the rumble strip standard drawings do not account for all possible applications. Therefore, it may be necessary for the roadway designer to develop special application plans or details for the application of milled-in/stamped-in or alternative longitudinal rumble strip treatments. Submit all such plans and details for review by the Transportation Mobility and Safety Unit prior to use on a project.

Refer to GB Chapter 4 Section 4.5 and FHWA site *General Information - Safety | Federal Highway Administration* for more detail on rumble strips.

Refer to *NCDOT Roadway Standard Drawings*, Std. No. 665.01 for placement of rumble strips in asphalt paved shoulders.

Refer to *NCDOT Roadway Standard Drawings*, Std. No. 720.01 for placement of rumble strips in concrete paved shoulders.

4.5 Traffic Management Plan and Work Zone Traffic Control

In the design of a project, the maintenance of traffic is an essential element in determining a method for maintaining a safe flow of traffic through a construction zone, determining the need for on-site detours, or directing traffic to alternate routes.

NCDOT TIP projects range in complexity and the maintenance of traffic plan encompassing motorists, pedestrians, and cyclists will be unique to each project. Coordinate with the Transportation Mobility and Safety Unit early in the design process. The team will evaluate the project characteristics to determine project/work zone level of significance:

- Category and project type

- Existing volumes and traffic lanes
- Total truck traffic (dual & tractor trailer semi-truck combined)
- US or NC route
- Project length
- Duration

The development for the project maintenance of traffic plan begins during PDN Project Initiation (Stage 1) and is further developed during the PDN Alignment Defined (Stage 2). The roadway designer should work closely with the Work Zone Traffic Control Project Engineer to develop the conceptual temporary traffic control plans to demonstrate how traffic (motorists, pedestrians, and cyclists) is to be safely maintained during construction based on the project characteristics list above.

Additionally, the roadway designer will coordinate with the hydraulic designer to determine the need for temporary drainage, construction phasing of hydraulic design elements and avoid critical safety issues including hydraulic spread.

The coordinated efforts noted above will result in establishing the proposed design criteria for on-site detours, temporary alignments or median crossovers. This design criteria will include, but is not limited to:

- Design speed/posted speed
- Number of lanes required
- Lane width
- Total shoulder and paved shoulder widths
- Bicycle and/or pedestrian accommodations
- Maximum rate of superelevation
- Detailed ditch information

Refer to *NCDOT Work Zone Traffic Control Design Manual* and *NCDOT Maintenance/Utility Traffic Control Guidelines* for more detail.

Refer to the 2018 *NCDOT Temporary Pedestrian Accommodations Guide* for more detail on accommodations for pedestrians and bicyclists.

4.6 Roadside Design

It is documented that a significant number of highway fatalities involved vehicles that left the roadway and collided with fixed obstacles. Trees, utility poles, and traffic barriers are the most common fixed objects struck that resulted in fatalities. There are many reasons a vehicle may leave the roadway including fatigue, distraction, speed, and weather conditions. Therefore, it is important to provide safeguards in roadside design to reduce or eliminate hazards that could cause serious injury or death should a vehicle leave the roadway. Consider the following options to reduce roadside obstacles during design:

- Remove obstacle
- Redesign obstacle to be safely traversed
- Relocate obstacle

- Reduce impact severity with a breakaway device
- Shield obstacle with barrier that will redirect vehicle or use crash cushion
- Delineate obstacle if other options are not appropriate

Refer to GB Chapter 4 Section 4.6 and RDG Chapter 1 Section 1.2 for more information on roadside design.

Refer to RDM Part I Chapter 6 for additional information regarding the use roadside barriers to shield obstacles.

There are two main considerations for design elements outside of the through traveled way: clear zone and lateral (horizontal) offset.

4.6.1 Clear Zones

The unobstructed traversable area provided beyond the edge of the traveled way is termed the clear zone. This area is used for the recovery of errant vehicles and includes shoulders, bike lanes, and auxiliary lanes. The desired minimum width is dependent upon traffic volumes, speeds, and roadside geometry. Use a reduced clear zone width in urban areas when right of way constraints may prohibit a full-width clear zone.

Refer to GB Chapter 4 Section 4.6.1 and RDG Sections 3.1, 3.3, and Figure 3-2 for more information on clear zones.

Table 3-1 (U.S. Customary Units) from RDG Section 3.1 is reprinted below as Table 4-5.

Table 4-5 Suggested Clear-Zone Distances from Edge of Through Traveled Lane

Design Speed (mph)	Design ADT	Foreslopes			Backslopes		
		1V:6H or flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or flatter
≤ 40	Under 750[c]	7 - 10	7 - 10	See Note b	7 - 10	7 - 10	7 - 10
	750 - 1500	10 - 12	12 - 14		10 - 12	10 - 12	10 - 12
	1500 - 6000	12 - 14	14 - 16		12 - 14	12 - 14	12 - 14
	Over 6000	14 - 16	16 - 18		14 - 16	14 - 16	14 - 16
45 - 50	Under 750[c]	10 - 12	12 - 14	See Note b	8 - 10	8 - 10	10 - 12
	750 - 1500	14 - 16	16 - 20		10 - 12	12 - 14	14 - 16
	1500 - 6000	16 - 18	20 - 26		12 - 14	14 - 16	16 - 18
	Over 6000	20 - 22	24 - 28		14 - 16	18 - 20	20 - 22
55	Under 750[c]	12 - 14	14 - 18	See Note b	8 - 10	10 - 12	10 - 12
	750 - 1500	16 - 18	20 - 24		10 - 12	14 - 16	16 - 18
	1500 - 6000	20 - 22	24 - 30		14 - 16	16 - 18	20 - 22
	Over 6000	22 - 24	26 - 32[a]		16 - 18	20 - 22	22 - 24
60	Under 750[c]	16 - 18	20 - 24	See Note b	10 - 12	12 - 14	14 - 16
	750 - 1500	20 - 24	26 - 32[a]		12 - 14	16 - 18	20 - 22
	1500 - 6000	26 - 30	32 - 40[a]		14 - 18	18 - 22	24 - 26
	Over 6000	30 - 32[a]	36 - 44[a]		20 - 22	24 - 26	26 - 28
65 - 70[d]	Under 750[c]	18 - 20	20 - 26	See Note b	10 - 12	14 - 16	14 - 16
	750 - 1500	24 - 26	28 - 36[a]		12 - 16	18 - 20	20 - 22
	1500 - 6000	28 - 32[a]	34 - 42[a]		16 - 20	22 - 24	26 - 28
	Over 6000	30 - 34[a]	38 - 46[a]		22 - 24	26 - 30	28 - 30

Notes:

a. When a site-specific investigation indicates a high probability of continuing crashes or when such occurrences are indicated by crash history, the designer may provide clear-zone distances greater than the clear zone shown in Table 4-5. Clear zones may be limited to 30 feet for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

b. Because recovery is less likely on the unshielded, traversable 1V:3H fill slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of slope. Determination of the width of the recovery area at the toe of slope should consider right of way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of slope. While the application may be limited by several factors, the foreslope parameters that may enter into determining a maximum desirable recovery area are illustrated in Figure 4-5. A 10-foot recovery area at the toe of slope should be provided for all traversable, non-recoverable fill slopes.

c. For roadways with low volumes, it may not be practical to apply even the minimum values found in Table 4-5. Refer to GB Chapter 12 for additional considerations for low-volume roadways and GB Chapter 10 for additional guidance for urban applications.

d. When design speeds are greater than the values provided, the designer may provide clear-zone distances greater than those shown in Table 4-5.

Source: RDG Chapter 3 Section 3.1 Table 3-1

Place above ground objects as close to the right of way line as possible and outside the clear zone as defined by the RDG.

Refer to *NCDOT Utility Accommodations Manual* Section 3.3 for more information on the placement of utility poles and other above ground objects within the right of way.

In curb and gutter sections, place utility poles and above ground objects outside the clear zone where the posted speed is 45 mph or less. In urban areas and other locations where constraints exist, consideration may be given to allowing the placement of breakaway structures within the clear zone. Ultimately, pole locations and pole type will be determined on a project-by-project basis.

4.6.2 Vehicle Recovery Areas

Vehicle recovery area is defined as a traversable clear zone adjacent to the highway travel lanes within which all fixed hazards have either been removed, reconstructed to acceptable safety criteria, or shielded. The width of a recovery area varies with design speed, traffic volumes, and slope configurations.

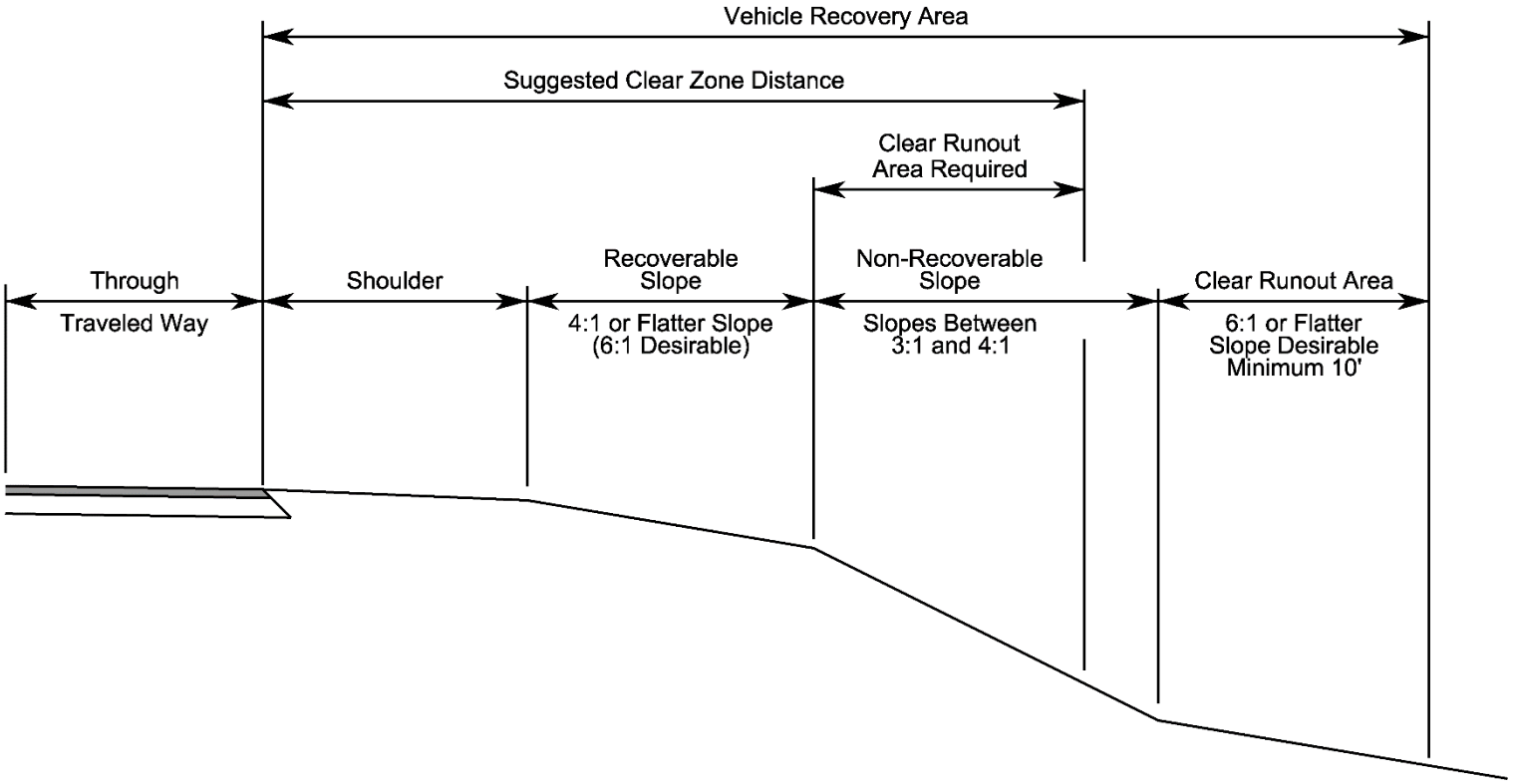
A traversable and recoverable clear zone indicates there are no slopes encountered within the clear zone which are steeper than 4:1. Slopes between 3:1 and 4:1 are traversable, but not recoverable. Any slopes steeper than 3:1 are classified as critical; an errant motorist will not be able to traverse or recover on these slopes.

Refer to RDG Section 3.2 and Figure 4-5 below for more detail on slopes.

Place all utility poles outside the clear zone as defined by the RDG. Refer to *NCDOT Utilities Accommodation Manual* Section 3.3 for additional guidance regarding above ground utilities.

Refer to RDG Chapter 3 for more detail on roadside design and vehicle recovery area.

Figure 4-5 Detail Guide for Vehicle Recovery Areas



Note: Clear runout area is additional clear zone space that is needed because a portion of the suggested clear zone distance falls on a non-recoverable slope. The width of the clear runout area is equal to that portion of the clear zone distance located on the non-recoverable slope.

4.6.3 Lateral Offset

The horizontal clearance from the edge of the traveled way, shoulder or other designated point to a vertical roadside element is known as the lateral offset distance. These dimensional values are not calculated and are not intended to constitute a clear zone. They are intended to provide a roadside environment that is not likely to have an adverse effect on motorists' using the roadway. Lateral offsets provide a clearance for mirrors on trucks and buses that are in the extreme right lane of a roadway and for opening curbside doors of parked vehicles. Curbs, walls, barriers, piers, sign and signal supports, mature trees, landscaping items, and power poles are primary examples of the type of features that can affect a driver's speed or lane position if located too close to the roadway edge.

The roadway designer has a significant degree of control over roadside geometry and right of way for rural conditions and especially new rural highways. In urban settings, right of way can be very limited, and it may be impractical from a cost and impact standpoint to establish the minimum clear zone recommended in the RDG. Consider use of a lateral offset in cases that typically have lower operating speeds, on street parking and numerous fixed objects (for example: poles, fire hydrants). In locations where curb is used, lateral offset is measured from the face of curb. Provide a minimum lateral offset of 1.5 feet from the face of curb with 3 feet at intersections; the desirable lateral offset value is 4 to 6 feet.

Refer to GB Chapter 4 Section 4.6.2 and RDG Chapter 3 Section 3.4.1 and Chapter 10 Section 10.1 for more information on lateral offset.

Refer to RDM Part I Chapter 5 for detailed information regarding offsets and structure widths for structure and bridge locations.

4.7 Curbs

Curbs fill multiple purposes and therefore the decision to use curbs and curb and gutter should be discussed with the project team. The designer must consider the environment and type when deciding to use curb, curb and gutter, or gutter in a location as it affects driver behavior. The clear zone behind curb and lateral offset, in an urban setting, should have a minimum offset which is influenced by the roadway design speed as curbs have limited redirection capabilities. The hydraulics engineer may also recommend curb or curb and gutter for drainage purposes.

Refer to RDM Part I Chapter 7 for hydraulic considerations on the use of curbs.

Refer to GB Chapter 4 Section 4.7 and RDG Chapter 3 Section 3.4.1 and Chapter 10, Section 10.2.1.1 for more information on curbs.

Refer to *NCDOT Roadway Standard Drawings*, Std. No. 846.01 (Sheet 1-3 of 3) for curb, gutter, and curb & gutter sections.

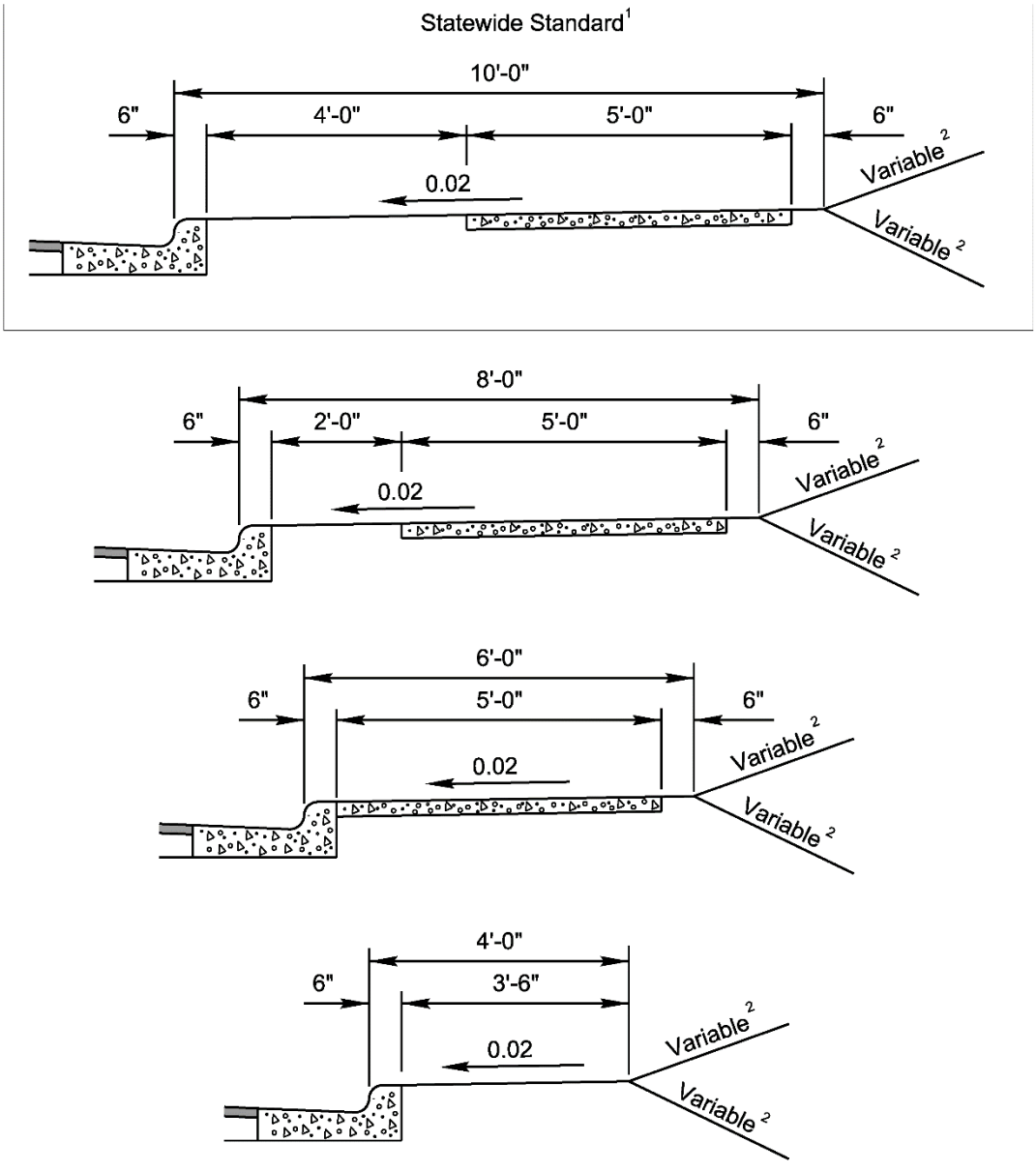
Use expressway gutter in combination with guardrail only in locations where the increased curb height is absolutely necessary to control water and reduce the erosion of fill slopes. Limit this combination only when Hydraulic Unit approves on freeways with three or more lanes of pavement sloped in the same direction and generally on the low side of a superelevated curve in a fill section. Use shoulder berm gutter for all other locations warranting a concrete gutter in front of guardrail.

Refer to Figure 4-6 for berm widths showing desirable and minimum sections. Construct one of these sections if sidewalk is not constructed initially but is anticipated.

Coordinate with municipalities when sidewalk is placed at the back of curb. Sidewalk widths greater than 5 feet may be required.

Refer to RDM Part II Chapter 4 for right of way placement.

Figure 4-6 Berm Width



Notes:

1. Statewide Standard should be used on projects where sidewalks are proposed or being accommodated for in the future. More narrow berms may be used on projects with right of way restrictions or terrain constraints. Wider berms may be needed at guardrail locations. Refer to NCDOT Roadway Standard Drawings Std. No. 862.01, Sheet 11 of 11.
2. Slope based on height of fill or cut as shown.

Fill or Cut Heights	Slope
0′ to 5′	4:1
5′ to 10′	3:1
Greater than 10′	2:1

4.8 Glare Screens

Glare screens are used in temporary and permanent medians to improve safety by blocking headlight glare from oncoming traffic. Design parameters for glare screens include median width, barrier type, vertical curvature, and horizontal curvature.

- Criteria for use of glare screens
  - Consider using glare screens in the median on multilane highways, in interchange areas, and where service roads are in close proximity to major arterials.
  - Use glare screens whenever possible for opposing traffic with 20 feet or less of separation.
  - Consider widths of 21 feet to 50 feet on a project-by-project basis and justify using the following criteria:
    - New facilities
      - Vertical and horizontal alignment
      - Traffic volumes
      - Field review of graded roadway
    - Existing facilities
      - Accident experience
        - Day/night ratio of accidents
        - Age of drivers in night accidents
        - Unusual distribution by type of accident
      - Day/night traffic volumes
      - Public input
      - Vertical and horizontal alignment
      - Measure of glare (Use Pritchard photometer)
  - Glare screens are not needed for traffic separated by 50 feet or more .
  - Cutoff angle for opposing highlight glare for screens on tangent alignments is twenty degrees. The cutoff angle for screens on horizontal curves is twenty degrees plus degree of curvature.
  - Consider use of glare screen should be given when transit facilities (light rail or bus rapid transit) are adjacent to roadway facilities.
  - Use engineering judgement for selection of type and height of glare screen.
- Types of glare screens:
  - Type I – A continuous screen that is opaque to light from all angles.
  - Type II – A continuous screen of an open material that is opaque to light at angles to about 20 degrees and increasingly transparent beyond 20 degrees.
  - Type III – Individual elements positioned to block light at angles from 0 degrees to 20 degrees. Beyond 20 degrees, visibility is clear between the elements.

- The following types of glare screens are recommended:
  - Plants
  - Extended concrete barrier
  - 0.5-inch mesh chain link fence (vinyl coating optional); standard height is 48 inches
  - Modular guidance system

The State Roadway Design Engineer's approval is required for any use of glare screen in areas other than interchanges or in areas in the 21-foot to 50-foot width. Include drawings and justifications in the submittal.

Refer to RDG Chapter 9 Section 9.5.1 for more detail on glare screen in work zones.

Refer to *NCDOT Roadway Standard Drawings*, Std. No. 866.05 for information on glare screens mounted on guardrails.

4.9 Medians

A median is a section of highway that separates opposing lanes. The separation can be paved or unpaved. The median width is the distance between the inside edge of travel way of the inside lanes of the opposing lanes. The comprehensive planning and design of typical highway cross sections provide guidance on various median widths in relation to the road type and posted speed limit. The final cross section and final median width will be developed during the preparation of the environmental documentation and final design.

Common median widths are listed below and in Table 4-6.

- Median widths for interstates and freeways are as follows:
  - 70-foot Standard
  - 46-foot Minimum (without concrete barrier)
  - 27-foot Minimum for six or more lanes with concrete barrier
  - 27-foot Standard for four lanes with concrete barrier

Table 4-6 Median Widths for Highways other than Freeways

New Location	Widening to Four Lane Divided
60′ Standard	60′ Desirable with ditch
46′ Minimum	46″ Standard with ditch
	*30′ Minimum with ditch
	**23′-30′ with raised median

Notes:
(*) Do not use a 30-foot median at intersections subject to heavy school bus crossings. A 46-foot median is recommended at these intersections. Discuss median widths with the project team.
(**) Median widths may have to be adjusted to accommodate median bridge piers.

In some cases, narrower medians will not have enough room to provide a ditch deep enough to handle water runoff. In these cases, a method of resolving this situation is called a positive drainage treatment. Positive drainage treatment is required when the ditch is less than 18 inches below the subgrade at the edge of the nearest traffic lane. Obtain the positive

drainage treatment from the Pavement Management Unit. This treatment must be a median underdrain or a minimum roadway grade of 1 percent in satisfactory drainage soils, or 1.5 percent in soils, which do not have satisfactory drainage properties. If marginal situations occur, place appropriate median drainage structures to provide adequate ditch drainage.

Refer the RDM Part I Chapter 7 Section 7.6 for additional information on median drainage.

Design special grading for medians in superelevation in accordance with *NCDOT Roadway Standard Drawings* Std. Nos. 560.01 and 560.02.

For arterial or collectors with curb and gutter with raised medians, consider a 23-foot or 17.5-foot median.

Use a 23-foot raised median where practical. This width accommodates median left turn lanes with a 4-foot offset for increased visibility and sight distance. A 17.5-foot minimum can be considered but does not provide adequate room for the 4-foot offset.

Refer to GB Chapter 4 Section 4.11 for additional information on medians.

4.9.1 Median Crossovers

A median crossover is defined as any connection of the opposing travel lanes that crosses the median of a divided highway. The crossover can be an opening for left turns, U-turns, a full intersection, or an opening for emergency vehicles.

4.9.1.1 Median Crossover Guideline Statement

Median divided facilities provide the benefits of separating opposing travel lanes, controlling left turn conflicts, allowing a recovery area for out-of-control vehicles, and providing space for future travel lanes. Research data also concludes that the median divided facilities improve traffic flow (travel speeds), traffic operations (reduces congestion), and traffic safety (lower crash rates), when compared to non-divided facilities. Median crossovers may be necessary on median divided facilities that are not fully access controlled to allow for additional turning and through movements.

Consider placement of crossovers carefully since crossovers introduce conflict points along a divided facility and thus may reduce the safety and capacity of the median divided facility. The following guidelines have been developed as a guide for design engineers, traffic engineers, and field personnel when considering the placement or addition of median crossovers. The median crossover guidelines shall be used for all new crossovers, even in the cases where adjacent crossovers were approved under previous guidelines.

Note: The State Traffic Safety Engineer and the Mobility and Safety Field Operations Engineers will review and approve all median crossover requests that meet Department Policies and guidelines, and all exceptions are required to be brought to the attention of the State Traffic Engineer or designee.

4.9.1.2 Types of Crossover Design

When a crossover is deemed justified by the Department, only the crossover type that meets the operational and safety needs of the location will be considered. The type of crossover design below is listed from the most desirable to least desirable.

- Use of alternative routes and access – This level uses the existing infrastructure of streets, highways, intersections, and existing crossovers to provide the mobility a proposed crossover would serve.

- Directional Crossovers – A directional crossover provides for left turns in one direction only. These crossovers are preferred because they provide for the predominant movement and are much safer for the traveling public. This technique provides positive access control on major roadways through the design of median openings to allow only designated movements. Typically, these crossovers only provide for left turns from the major route to the side street. No left turns or straight across movements are allowed from the side street. Where the minimum spacing requirements are not met and there is a defined need for left-turn access, only a directional crossover will be considered. However, the general guidelines must be met for the directional crossover to be considered.
- Median U-turn Crossovers – Median U-turns allow a vehicle to make a U-turn and do not allow for through movement from a side street or driveway.
- Directional Crossovers with Median U-turns – The combination of these two crossover types may be used on a case-to-case basis where it is deemed desirable. Refer to RDM Part I Chapter 8 Section 8.8 for more information.
- All-Movement Crossovers – All-movement crossovers provide for all movements at the intersection or driveway. The use of all-movement crossovers is reserved for situations where there is sufficient spacing, and other crossover designs cannot adequately meet the operational needs of the location. Limit the use of this crossover design because it decreases capacity, increases delay and congestion, may increase pollutants from vehicles, and some studies indicate it may have a higher propensity for crashes.

4.9.1.3 General Guidelines for Median Crossover Installations on New and Existing Facilities

All proposed median crossovers on existing and new facilities shall be evaluated from an operational and safety perspective. The availability of reasonable alternative routes, access points, and existing crossovers, along with the desire to preserve the capacity and safety of the facility shall be considered in all proposed crossovers.

The availability of adequate spacing for a crossover shall be considered when determining if a crossover is justified. However, the availability of adequate spacing alone does not warrant a new crossover.

A median crossover shall only be considered when the Department deems it necessary to service traffic generated by existing (and proposed) roadways, businesses, or other development; and this traffic cannot be adequately serviced with the existing crossovers at intersections, reasonable alternative routes, or other access points.

It is the requesting party's responsibility to provide the justification, or means to acquire the information for justification, for new crossovers. If this information is not provided, the crossover will not be reviewed or approved. As part of the justification, provide a Traffic Impact Analysis to be reviewed by NCDOT personnel.

When the Department has deemed a median crossover is necessary, the only crossover type considered will be that which meets the operational and safety needs of the facility.

A median crossover shall not be allowed unless an adequate length left turn deceleration lane and taper can be provided, and the addition of the crossover will not impede the storage requirements of adjacent intersections. Left turn lanes will be installed to serve all nonemergency crossover movements allowed on the divided facility at the time of installation.

When crossovers are considered, U-turn movements must be adequately accommodated or restricted. When warranted, the roadway designer will design the crossover to accommodate U-turn movements based on the design vehicle. The use of bulb outs or additional widening may be required beyond the standard roadway typical width.

Median crossovers shall not be located where intersection sight distance (both vertical and horizontal) cannot meet current NCDOT design criteria.

Median crossovers shall not be placed in areas where the grade of the crossover will exceed 5 percent. Give special consideration to the vertical profile of any median crossover that has the potential for future signalization to ensure a smooth crossing from a present or future side street.

It is desirable to place median crossovers on facilities that have median widths 23 feet or greater..

Avoid crossovers that require a signal or where there is expected potential for a future signal in an otherwise unsignalized area.

The Department retains the authority to close or modify any crossover that it deems to be operationally unsafe to the traveling public.

4.9.1.4 Median Crossover Guidelines for North Carolina Streets and Highways

Interstate and Non-Interstate Highways with Full Control of Access

No public-use median crossovers will be allowed.

U-turn median openings for use by authorized vehicles for the maintenance and policing of highway or emergency response can be allowed when an engineering study clearly indicates a need. Abide by the following guidelines for the spacing of median openings:

- U-turn median openings can be provided if a need has been determined and that they can be added in a safe location where decision sight distance is available. When adding a crossover, it should be located at least one-half mile from any overhead structure and at least one mile from the terminus of a ramp acceleration lane or a deceleration lane. The median crossover should be signed appropriately.
- The minimum spacing of adjacent U-turn median crossovers between interchanges is 3 miles. However, spacing alone is not justification for a crossover.
- On urban freeways, the interchange spacing is generally close enough that openings are not warranted. Therefore, U-turn openings are not allowed. In addition, on facilities where acceptable gaps are unlikely due to high ADTs, U-turn openings are not allowed.

Divided Highways without Full Control Access (Posted speeds of greater than 45 mph)

On highways with higher traveling speeds, the potential for more severe crashes is greater. Also, on high-speed facilities, development is usually not as concentrated as on lower speed facilities. In order to maximize the safety of these facilities, crossover spacing is critical.

All-movement crossovers shall not be any closer than 2,000 feet apart on divided highways. However, spacing alone is not justification for a crossover. It must be determined that a crossover addition is needed to meet the operational requirements of the facility. Where this spacing requirement is not met and there is a defined need for left-turn access, a directional crossover will be considered. However, the general guidelines must be met in order for the directional crossover to be added.

Divided Highways without Full Control Access (Posted speeds of 45 mph and less)

For divided highways without full control of access there are more access points along the facility, and thus there is usually more demand for median crossovers. This is usually the case on lower speed facilities. Because of the density of the development and lower traffic speeds, it is acceptable to provide a closer spacing of median crossovers. However, the availability of adequate spacing alone is not justification for a crossover. Crossovers must be justified to meet operational and access needs the existing facility cannot adequately serve. Only the type of crossover that meets the operational, access and safety needs of the facility shall be added. Directional crossovers are preferred where they meet the operational and access needs of the roadway.

The spacing of crossovers is largely dependent upon the need for adequate storage for left turning vehicles or U-turn vehicles at intersections. A crossover shall not be placed where it interferes with the storage requirement for existing intersections.

All-movement crossovers shall not be spaced any closer than 1,200 feet apart on divided highways with posted speed of 45 mph and less. Where this spacing requirement is not met and there is a defined need for left-turn access, a directional crossover will be considered. However, the general guidelines must be met in order for the directional crossover to be added.

Responsibility of Locating Crossovers on Active Roadway Design Projects

The roadway designer is responsible for locating the crossovers for a highway while a project is in design and during the life of the construction of the project. Only crossovers at arterials, major collectors, and major traffic generators will be shown on the hearing maps. The Division shall be consulted regarding the level of access management desired for the project.

Determine if the crossover is justified and determine the appropriate crossover design type. Priority will be given to placing median crossovers at existing intersecting streets. After the crossovers are located for existing streets that justify a crossover, examine the remainder of the highway facility, along with reasonable alternative routes and access points, to determine if there are any other major traffic generators that require consideration for a crossover. Follow the minimum spacing as outlined previously in these guidelines when considering the intermediate crossover locations, follow the minimum spacing as outlined previously in these guidelines. Show the crossover design that meets the operational, access, and safety requirements.

All crossovers are subject to the review of the Transportation Mobility and Safety, the Division, and the appropriate local officials if applicable.

Special circumstances may justify the need to deviate from these guidelines. If requests are made for crossovers that deviate from these guidelines, Transportation Mobility and Safety, and the Division will review the location of the crossover and offer recommendations. The State Traffic Engineer will be responsible for granting any exceptions to these guidelines on active design and construction projects. Prior to approval of any contractual agreements for crossovers, all negotiated crossovers must be reviewed and approved by Transportation Mobility and Safety, State Roadway Design Engineer, Division, and the appropriate local officials if applicable.

Final approval or denial of the request shall be the responsibility of the State Traffic Engineer. If any aspect of the requested median crossover deviates from the guidelines, the Transportation Mobility and Safety and the Division will confer to determine the necessary action to be taken. The State Traffic Engineer will be responsible for granting any exceptions to the guidelines on

existing facilities. The State Traffic Engineer will notify the Division Engineer and the State Roadway Design Engineer of the decision reached.

Crossovers Considered for Private Developments on Existing facilities

A private development that justifies direct access and benefits from an added median crossover will be responsible to construct or fund its installation. In addition, it is the responsibility of the requesting party to provide the justification and means to acquire the information for justification, for new crossovers. If this information is not provided, the crossover will not be reviewed or approved. The developer will be required to submit a complete set of plans and specify the exact location, design, and construction requirements for the proposed median crossover. Only the type of crossover that meets the operational and safety needs of the facility shall be added. Directional crossovers are preferred where the design meets the operational and access needs of the roadway. Approval of such a crossover is subject to a traffic engineering investigation and approval procedures as outlined in these guidelines.

Any drainage facilities required by the construction of the crossover will be installed or funded by the developer or the applicant at their expense. After the construction has been completed in accordance with the Division of Highways requirements and standards and passes inspection by the Division, the Division of Highways will assume ownership and maintenance of the crossover.

Failure to comply with the location, design, or construction requirements will result in the crossover being barricaded or removed until the deficiencies have been corrected at the applicant's expense. Once the Division of Highways assumes the ownership, the median crossover will then be subject to the regulations exercised under the police power of the State of North Carolina.

The Department retains the authority to close or modify any crossover it deems to be operationally unsafe to the traveling public; or causes undue delay, congestion, or adverse impact to traffic operations.

Special Use Crossovers

Median crossovers for special purposes, such as fire protection, ambulance services, etc. shall be considered on an individual basis after a traffic engineering investigation.

Emergency response plans and expected level of need, in addition to the geometric limitations of the facility will be used in consideration for special use crossovers. Approved special use crossovers shall be appropriately designed, delineated, and regulated. However, the availability of adequate spacing alone does not warrant a new crossover.

4.10 Service Roads

A service road (also known as a frontage road or access road) is a local road that runs parallel to a higher speed, limited access facility. A service road may be used to control access to a higher type facility and to separate local traffic from the higher speed through traffic. This minimizes interference with the operations of the through traffic and provides access to adjoining properties. A service road can also be used to provide access to a property that will be landlocked by the proposed roadway project. In this case, complete a service road study to determine the efficacy of the service road. Where possible, the appropriate clear zone distance should be provided between the throughway and the service road. If the appropriate clear zone cannot be obtained, then the use of longitudinal barriers should be investigated.

Refer to GB Chapter 4 Sections 4.12 and 4.13, also Chapter 7 Section 7.3.15, Chapter 8 Section 8.2.12, and Chapter 9 Section 9.11.1 for detailed information on service roads.

4.10.1 Service Road Study

A service road study is done to determine whether it is more economical to purchase a landlocked property(s) or to provide an access to mitigate property damages. Consult local Division and right of way personnel when a service road study is being developed. It is the roadway designer's responsibility to design the preliminary access road and develop the construction cost. Submit a right of way cost request to the NCDOT Right of Way Branch for them to develop a right of way cost for the right of way needed to construct the service road. Once the costs associated with the service road are received, a decision will be made on whether it is economically feasible to construct the service road or to take the entire property. If approved, include the service road in the final construction plans.

Refer to *NCDOT Right of Way Manual* Chapter 5.111 to 5.114 for more information on the right of way portion of this process.

4.11 Cul-de-Sacs

A cul-de-sac is a street that is closed at one end. Assess dead end streets and, if applicable, provide a barrier or a way to turn around. Barriers can be in the form of an earth berm, concrete barrier, or steel beam guardrail. A turnaround can be in the form of an "L", a "T" or circular in shape. Each type of turnaround has its advantages and disadvantages, but, in general, the final type provided should provide enough room for a school bus to turn around. Discuss the use of turnarounds at the Field Inspection. The Division engineer will be responsible for any administrative action required in the closing or dead-ending of a facility. A sign noting the dead-end street will be provided for a cul-de-sac.

Refer to *NCDOT Subdivision Roads Manual* for more information on NCDOT's turnaround design and width requirements.

Refer to GB Chapter 5 Section 5.3.2.10 for universal information on cul-de-sacs and turnarounds.

4.12 Roadside Control

Property owners abutting highways have rights of access, but it is important that the highway authority have the power to control and regulate the location, design, and operation of these accesses as well as other roadside elements.

Refer to GB Chapter 4 Section 4.15 for a more detailed roadside control definition.

4.12.1 Driveways

Driveways are essentially low-volume intersections which can affect the operation of the roadway. Consider these elements when designing a driveway:

1. Purpose of the driveway (commercial, residential, private, etc.)
2. Types of vehicles using the driveway
3. Impacts to the intersecting roadway
4. Adequate sight distance
5. Design features of the driveway (width of the entrance, length, grade, skew of drive, etc.)

6. Replacing an existing driveway or a new proposed driveway

Generally, ensure all driveways have a grade that slopes away from the highway surface at a rate equal to the slope of the shoulder, but not less than 1/4-inch per foot, or greater than 1-inch per foot in a normal crown typical section. Continue the slope for a distance equal to the prevailing shoulder width or longer so as not to cause a hump or a depression in the shoulder area. Beyond the shoulder, the grade of commercial driveways within the right of way should not exceed plus or minus 10 percent. Maintain the slopes of drives compatible with provisions for drainage of the designed cross section. Where special circumstances require driveway grades in excess of these requirements, NCDOT may approve deviation on a case-by-case basis.

Where a sidewalk is located close to the curb line and the driveway opening is to be provided across a depression or curb cut; construct the sidewalk to conform to the driveway profile. Either one or both edges of the sidewalk may be depressed across the driveway provided the resulting change in vertical drop at the driveway does exceed 1/2-inch or cumulative 10 percent slope. In some cases, it may be necessary to discontinue the sidewalk across the driveway and construct a curb along each driveway edge. In such instances, construct the curb cuts and curb ramps in conformance with the latest edition of the *NCDOT Roadway Standard Drawings for Curb Ramps*; the U.S. Department of Justice *2010 ADA Standards for Accessible Design*; and U.S. Access Board *(Proposed) Public Right of Way Accessibility Guidelines* (PROWAG).

Where curbs are cut for the construction of driveways, remove the entire curb and gutter section. Removal of only the raised portion of the curb and paving over the gutter section is not allowed. Taper cut curb ends from full height to ground level in a distance of approximately 2 feet or constructed with radii as required. Where drainage is carried along the curb, construct the driveway in such a fashion to prevent runoff from spilling into private property.

Ensure the maximum difference between the cross slope of the travel way (usually 1/4-inch per foot or approximately 2 percent) and the slope of the driveway to the sidewalk does not exceed 5 percent. Breakover (rollover) angles in excess of 5 percent may not provide for satisfactory driveway speeds. The maximum breakover angle also applies to roadways with shoulders especially on high-speed rural highways. On high volume driveways, use a vertical curve with the access connection to the adjacent public roadway.

Include a driveway design (alignment, profile, typical section) in the plans if the driveway is longer than the clear zone, ties beyond the right of way line, or when the grade is greater than 10 percent.

In general, replace driveways in kind. If the grade of the driveway being replaced is greater than 7 percent, pave the driveway. Consult the Pavement Management Section for the type and thickness of the pavement to be used.

For commercial driveway entrances (those that generate more than 500 ADT or more), design a paved driveway turnout in accordance with *NCDOT Roadway Standard Drawings* Std No. 848.04. Commercial driveway entrances should be designed to accommodate the predominant design vehicle used at the commercial facility. Discuss the width of commercial driveways with the Division at the Field Inspection. For commercial driveway entrances that generate less than 500 ADT, a paved driveway turnout in accordance with *NCDOT Roadway Standard Drawings* Std. Nos. 848.02 or 848.03 may be used.

Provide a 20-foot minimum width for private driveway turnouts with curb and gutter in accordance with *NCDOT Roadway Standard Drawings* Std. Nos. 848.02 or 848.03. Where justified and approved, the minimum 20-foot width may be reduced to 16 feet. For non-curb and gutter facilities, provide a total graded width of no less than 16 feet. This provides for an effective 12-foot paved or aggregate travel way.

Refer to RDM Part I Chapter 7 Section 7.5 for treatment of driveway cross pipes.

Discuss standard street and driveway turnouts during the Field Inspections.

Lay out driveways with sidewalk crossings in accordance with *NCDOT Roadway Standard Drawings* Std. Nos. 848.02 and 848.03.

When widening an existing roadway, ensure all existing access connections being replaced conform to the current edition of the NCDOT Policy on Street and Driveway Access to North Carolina Highways**.** Do not place or alter new driveway turnouts or connections on the final plans without the express consent and approval of the local district engineer. When it is determined that a new access connection will be allowed, a separate agreement between the Department of Transportation and the applicant will be required.

Refer to GB Chapter 4 Section 4.15.2, and Chapter 9 Section 9.11.6 for additional driveway information.

Refer to *NCDOT Policy on Street and Driveway Access to North Carolina Highways f*or more information on driveway access.

4.12.2 Mailboxes

Mailbox placement may create a risk to motorists. Consider factors such as sight distance near the mailbox, highway or street cross sectional dimensions, and traffic volume when determining their location.

Refer to GB Chapter 4 Section 4.15.3 for more information on mailbox placement.

Refer to RDG, Chapter 11; North Carolina Administrative Code Section 2E.0404 *Highway Obstructions Interfering with Traffic/Maintenance*; and *NCDOT Subdivision Roads Manual* for more detailed information on mailbox placement and design considerations.

4.12.3 Fencing

Fences are barriers used to contain, enclose, or delineate one area from another. Fencing is used by NCDOT to delineate the control of access for a highway. On projects where existing fencing is removed, where applicable, NCDOT will replace or remove and reset the fence that was disturbed. Temporary fencing is used to contain livestock while a project is being constructed until final fencing can be installed. Common fencing types are chain link, barbed wire, and woven wire. When a project falls within their jurisdiction, municipalities may request special or decorative fencing.

Refer to RDM Part II Chapter 4 Sections 4.6, 4.7, and 4.8 for detailed information on fencing placement in NCDOT plans.

4.13 Tunnels

Consider the use of a tunnel when encountering a natural obstacle or need to minimize the effects of the roadway or highway on a community. Tunnels can be broken down into two categories: those constructed with mining methods and those constructed by cut and cover methods. Consider pedestrians in tunnel design, either for maintenance or mobility. Once it is determined a tunnel may be required, consult with the Structures Management Unit and Geotechnical Engineering Unit for design considerations.

Refer to GB Chapter 4 Section 4.16 for more information on tunnel considerations and tunnel typical sections.

Refer to RDM Part II Chapter 6 Section 6.4.5 for information on tunnel lighting.

4.14 Pedestrian Facilities

Pedestrian networks are fundamental to the supporting transportation for people of all ages, abilities, and economic opportunities. Consider pedestrian facilities, such as sidewalks, sidepaths, and crossings, as a critical part of the roadway design with few exceptions. The following sections provide a few elements to consider. In considering these elements, follow *PROWAG* and the *2010 ADA Standards for Accessible Design*.

Refer to GB Chapter 4 Section 4.17 and *NCDOT Complete Streets Policy* for additional design elements to consider.

4.14.1 Sidewalks and Berms

Sidewalks are an integral part of multimodal transportation networks where people are expected to walk to destinations as part of urban, suburban, or rural settings. Sidewalks provide a path for pedestrians parallel to the roadway, providing safter access to destinations and public transportation. Widths of sidewalk vary depending on their use and volume of foot traffic. NCDOT policy is to replace existing sidewalk that has been disturbed by an NCDOT project. When a project falls within their jurisdiction, municipalities may request sidewalks throughout the project, or to connect one existing section of sidewalk to another existing section of sidewalk. Municipalities may also request wider sidewalk or multi-use paths to accommodate pedestrians and bicycles. Coordination with the municipality, facility cost, and impacts will determine when a sidewalk is wider than the standard width.

Refer to *NCDOT Complete Streets Implementation Guide* Chapter 6 for details on sidewalk cost sharing.

Sidewalks are warranted on projects in accordance with *NCDOT Complete Streets Policy*. If sidewalk construction is proposed, include information in the project planning report and ensure design meets all of the ADA requirements. The widths shown in Table 4-7 will work for most projects, but heavy pedestrian traffic may warrant wider widths:

Table 4-7 Desirable and Minimum Sidewalk and Berm Widths

	Commercial and School Routes		Residential Areas	
	Desirable	**Minimum**	**Desirable**	**Minimum**
Sidewalk Width	10′	5′	5′	4’
Berm Width	17′	6′	10′	5′

Refer to Section 4.7 above for more information on berm widths.

Construct one of the berm sections shown in Figure 4-6 if sidewalk is not constructed initially but is anticipated.

Place sidewalk at a rising 0.02 slope from the back edge of curb and gutter. Use 4-inch thick sidewalk unless conditions warrant otherwise. Refer to *NCDOT Roadway Standard Drawings* Std. No. 848.01.

For pedestrian safety in areas of high fill or shear drop, the addition of pedestrian safety rail or fencing may be required. Where the drop is greater than 30 inches adjacent to the pedestrian facility, include pedestrian safety railing or fencing for fall protection.

Refer to AASHTO *Guide for the Development of Bicycle Facilities* 2012 Fourth Edition:

- Minimum pedestrian-only railing height – 42 inches
- Minimum shared-use (pedestrian and bicycle) railing height – 48 inches

Collaborate with NCDOT Integrated Mobility Division to determine the best treatment for each situation.

Refer to RDM Part I Chapter 6 Section 6.3 for information on the placement of guardrail in relation to sidewalks.

Refer to GB Chapter 4 Section 4.17.1, and *NCDOT Complete Streets Policy* for detailed sidewalk information.

4.14.1.1 Shared-Use Paths, Sidepaths, and Greenways

Shared-use paths, often referred to as greenways, are paths physically separated from motor vehicle traffic and used by pedestrians, bicyclists, skaters, wheelchair users, and other non-motorized users. Most shared-use paths are designed for two-way travel. Sidepaths are shared-use paths located immediately adjacent to and parallel to the roadway, or within the right of way.

Sidepaths and other shared-use paths are wider than sidewalks, accommodating both bicyclists and pedestrians, and are used for both transportation and recreational uses. The width of a shared-use path may vary, based on expected user volumes and context. Minimum widths do not include graded areas or buffers on either side of the pathway.

- Desirable width – 12 to 14 feet
- Minimum width – 10 feet; 8 feet in exceptionally constrained areas
- Vertical clearance, minimum – 8 feet

Shared-use paths follow federal requirements for accessibility per the U.S. Access Board and the U. S. Department of Justice. Refer to *PROWAG* Chapter 3 Section R302.5 and R302.6. Minimum requirements follow the *2010 ADA Standards for Accessible Design*.

Refer to *NCDOT Minimum Design Recommendations for Greenways* for pavement design, when applicable.

Refer to AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, and AASHTO *Guide for the Development of Bicycle Facilities* 2012 Fourth Edition, Chapter 5 for more detailed information.

4.14.2 Grade Separated Pedestrian Crossings

Grade separated facilities allow pedestrians to cross over or under a roadway safely without vehicle interference or conflict. Ensure grade separated pedestrian crossings meet all ADA requirements. Include pedestrian overpasses in the environmental document for the project. Submit design of pedestrian overpasses as a structure recommendation report to the Federal Highway Administration or the Structures Management Unit, or both as needed.

Refer to RDM Part I Chapter 5 Section 5.4 for design details on grade separated pedestrian crossings.

Consider pedestrian underpasses where greenway facilities with pedestrian or bicycle use are existing or part of a planned system. Where greenway facilities are being considered under a

bridge, design the bridge with sufficient width under the structure to accommodate the greenway.

Refer to Section 4.14.1.1 above for more information about walkway vertical clearance standards.

Refer to *NCDOT Guidelines for Inclusion of Greenway Accommodations Underneath a Bridge as part of a NCDOT Project* for more information on cost sharing guidelines.

Underpasses for greenways that are determined by using floodway maps and have not been designated as actual trails can be constructed if the city or county supplements the cost in accordance with Chapter 6 Cost Share of the *NCDOT Complete Streets Policy*.

Refer to GB Chapter 4 Section 4.17.2, and *NCDOT Complete Streets Policy* for more information on grade separated pedestrian crossings.

4.14.2.1 Pedestrian Roadway Crossings

Anticipate pedestrian crossings both at intersections and at midblock locations, where pedestrian destinations are on either side of the roadway.

Refer to *NCDOT Roadway Standard Drawings* Std. Nos. 848.05 and 848.06 for detailed dimensions for pedestrian refuge islands, crossing islands at channelized right turn lane intersections, curb extensions, and raised crossings.

Consult with the NCDOT Traffic Safety Unit and the division traffic engineer and the Integrated Mobility Division to determine placement and design of pedestrian roadway crossings.

Refer to *FHWA Manual on Uniform Traffic Control Devices* (MUTCD) for information on marked crosswalks, signs and traffic control devices at pedestrian crossings. For additional information about required roadway markings and signage for pedestrian crossings, consult with the NCDOT Signing and Delineation Unit.

Refer to *NCDOT Pedestrian Crossing Guidance* for more information on pedestrian crossings.

4.14.3 Curb Ramps

Facilities for pedestrians are required to be readily accessible to and usable by individuals with disabilities. Curb ramps are necessary to provide access between the sidewalk and street at pedestrian crossings. The Signing and Delineation Unit is responsible for showing the Curb Cuts and Ramps on the Pavement Marking Plans. The symbol used to denote Curb Cuts and Ramps on the plan sheets is “CR”. The roadway engineer is responsible for the coordination of Curb Cuts and Ramps locations for possible conflicts with pavement markings, signal poles, fire hydrants and other utilities. Coordinate with other units whose designs are impacted by the placement of the curb cuts and ramps placement. Ensure curb ramps meet all ADA requirements. Include detectable warnings to alert visually impaired persons. Design curb ramps for the handicapped in accordance with *NCDOT Roadway Standard Drawings* and Curb Ramp Details. Show a special detail in the plans when any type of curb ramp is proposed on a project that is not in accordance with *NCDOT Roadway Standard Drawings* Std. Nos. 848.05 and 848.06.

Curb ramps and their locations will continue to be shown in the pavement marking plans. The Signing and Delineation Unit will coordinate with the Divisions and the roadway designer to determine if standard curb ramps can be used.

If it is determined that the standard curb ramps shown in the NCDOT Roadway Standard Drawings are not applicable, the Signing and Delineation Unit will be responsible to notify the

Contract Standards and Development Unit and the roadway designer with the proposed alternate curb ramp types.

The Contract Standards and Development Unit and the roadway designer will be responsible to include the alternate curb ramp design details into the roadway plans. Additionally, the roadway designer will add a note to the applicable final roadway design plan sheets for the contractor to refer to the final pavement marking plans for curb ramp type(s). Consult the *State Plans and Standards Engineer* in the Contract Standards and Development Unit to obtain alternate curb ramp design details that could be applicable to the project.

Refer to GB Chapter 4 Section 4.17.3 for more information on curb ramps.

Refer to *NCDOT Roadway Standard Drawings*, Std. Nos. 848.05 and 848.06 for detail drawings.

4.14.4 Stairs

Stairs are a set of steps that lead from one level to another level. The type of stairs to construct shall be determined by the division engineer. When existing steps are being disturbed, it is customary to replace the disturbed stairs with the same type of stairs. Depending on the height of the stairs, handrails may need to be provided for safety purposes.

Refer to *NC State Building Code* to determine when handrails are required on stairs.

If stairs are required for a project, consult the *State Plans and Standards Engineer* in the Contract Standards and Development Unit to request special details to be included.

4.15 Bicycle Facilities

Bicycling is recognized as a mode of transportation. Assume that all roads and streets, where bicyclists are legally permitted, will be used by bicyclists. Consider the needs of bicyclists in the design of each roadway and address those needs in all phases of planning, design, and construction. Determine the need for bicycle facilities as early in the design process as possible since the incorporation of bicycle facilities into the project can affect the cost and overall footprint of the project. The typical width for bicycle lanes is 5 feet. The width and location can vary according to the discussion between NCDOT and local municipalities and their interest in cost sharing in the bicycle facility.

Refer to GB Chapter 2 Section 2.7 and Chapter 4 Section 4.18 for additional information on bicyclists and bicycle facilities.

Refer to AASHTO *Guide for the Development of Bicycle Facilities* 2012 Fourth Edition Chapter 4 and *NCDOT Complete Streets Policy* for more information.

4.15.1 Shared Lanes

A shared lane is where bicyclists and motor vehicles share the same travel lanes; it is not a formal bikeway facility. While these facilities do not generally offer the highest level of comfort for the bicyclists, they are appropriate in settings with low speeds, low volumes, and good sight distance.

Refer to AASHTO *Guide for the Development of Bicycle Facilities* 2012 Fourth Edition Chapter 4 Section 4.3 for additional information.

A marked shared lane facility provides more guidance to both the bicyclists and motorists through the use of a shared lane pavement marking, commonly called a sharrow. These markings are not appropriate on roadways that have a speed limit of about 35 mph.

Refer to AASHTO *Guide for the Development of Bicycle Facilities* 2012 Fourth Edition Chapter 4 Section 4.4 and *FHWA MUTCD* for additional information.

4.15.2 Bicycle Boulevards

A bicycle boulevard is a modified roadway or a network of continuous roadways that function as a through street for bicyclists while discouraging motor vehicle through travel or reduces vehicle travel speeds. Various geometric design features may be considered for bicycle boulevards, including raised islands, curb extensions, raised crossings, and other traffic calming features.

Refer to AASHTO *Guide for the Development of Bicycle Facilities* 2012 Fourth Edition Chapter 4 Section 4.10 for additional information.

4.15.3 Bicycle Lanes

A bicycle lane is a designated portion of the road specifically for use by bicyclists generally denoted by pavement markings and signs. The bicycle traffic is typically one way and in the same direction as that of the adjacent roadway.

Refer to AASHTO *Guide for the Development of Bicycle Facilities* 2012 Fourth Edition Chapter 4 Section 4.5 for additional information.

Refer to the FHWA Bikeway Selection Guide supplement *On Street Motor Vehicle Parking and the Bikeway Selection Process* for design guidance specific to bicycle lanes adjacent to on-street parking.

- Desirable width – 6 to 7 feet, especially adjacent to on-street parking
- Minimum width – 5 feet, not inclusive of gutter pan

4.15.4 Buffered Bicycle Lanes

A buffered bicycle lane is a bicycle lane separated from the adjacent traffic lane and parking by longitudinal pavement markings. The buffer area might include chevron or diagonal markings, typically at least 2 feet wide. Use this type of facility when a separated bicycle lane is desired but not feasible.

Refer to *FHWA Bikeway Selection Guide* Chapter 5 for a more in-depth comparison between buffered and separated bicycle lanes.

4.15.5 Separated Bicycle Lanes

A separated bicycle lane is an exclusive facility for bicyclists located in or directly adjacent to the roadway but physically separated from vehicle traffic with a vertical element. Separated bicycle lanes can be one-way or two-way and may be directional (with traffic flow) or contra-flow to traffic. Two-way separated bike lanes require more consideration at transitions between bikeway types and through intersections.

Refer to *FHWA Separated Bike Lane Planning and Design Guide* for additional information.

- Desired width – 6.5 feet, exclusive of gutter pan (one-way)
- Minimum width – 5 feet, exclusive of gutter pan (one-way)

While these design standards and guidelines are geared towards bicyclists, best practices will also serve other micro-mobility users such as e-scooters.

Refer to GB Chapter 4 Section 4.18, and *NCDOT Complete Streets Policy* for additional information.

Refer to *FHWA MUTCD* for information on signs and traffic control devices associated with bicycle facilities.

Consult with the NCDOT Signing and Delineation Unit for additional information or guidance on required roadway markings or signage for bikeways.

4.16 Transit Facilities

Transit comes in several different modes but the most common a designer may need to design to accommodate are buses, rapid transit, and light rail transit. Transit facilities often include motorists, bicyclists, pedestrians, and transit vehicles. Because of this interaction, discuss incorporation of a transit facility as early in the design process as possible and include representatives from NCDOT, county, and local municipalities.

The *NCDOT Freeway and Street-based Transit (FAST) Vision Study* provides four main recommendations:

1. Create a bus rapid transit system that gives buses priority on roads to get commuters to their destinations quicker
2. Allow busses to use the shoulders in congested traffic
3. Provide signal priority for buses
4. Provide more bus stops

In urban areas, bus transit is the most common form of public transit.

Refer to GB Chapter 4 Section 4.19; AASHTO *Guide for the Design of Transit Facilities on Streets and Highways*; National Association of City Transportation Officials *NACTO Transit Street Design Guide*; and *NCDOT Freeway and Street-based Transit (FAST) Vision Study* for detailed information on transit facilities.

Refer to *NCDOT Bus Shelter & Bus Stop Guidelines* (February 3rd, 2017) for additional guidance on the safe and uniform placement of bus stops, benches, and shelters within NCDOT right of way.

4.17 On-Street Parking

Consider on-street parking in urban areas and rural communities located on arterial highway routes to accommodate existing and developing land uses. When roadway improvements include on-street parking, design for parallel type parking when possible. General guidelines for on street parking include:

1. Provide a minimum parking space width of 10 feet.
2. Provide a minimum parking space length of 20 feet.
3. End parking a minimum of 20 feet before the intersection.

These numbers vary according to the site location constraints.

Consider angled parking if appropriate for the specific function, width of the street, adjacent land use, traffic volume, and anticipated traffic operations.

Refer to GB Chapter 4 Section 4.20; *PROWAG*; and *NACTO Transit Street Design Guide* for a more detailed definition.