MONTANA DEPARTMENT OF TRANSPORTATION

ROAD DESIGN MANUAL

Chapter 5

Cross Section Elements

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Contents

Chapter 5

Cross Section Elements

The roadway cross section plays a significant role in the basic operational and safety features for the roadway and has a significant impact on the project cost, especially for earthwork. This chapter provides guidance in the design of cross section elements, including the roadway section, shoulders, bicycle lanes, two-way left-turn lanes, on-street parking, curbs, sidewalks, medians, landscape areas, and side slopes. In addition, this chapter provides several typical sections for various roadway types. Refer to the Montana Department of Transportation (MDT) *Geometric Design Standards* document for recommended values for various cross section elements relative to a roadway's functional classification *(1)*. Additional information associated with this chapter can be found in Appendix I.

5.1 DESIGN PRINCIPLES AND APPROACH

A fundamental consideration in establishing cross section elements is an overall vision for the roadway tailored toward the specific users. The intended function of the roadway is a key aspect in the development of an overall vision for its use. For example, the mix of user types on a two-lane, rural highway is often different from the mix of user types on a downtown, urban roadway, thus driving the intended function of these roadways. Because of this, the cross section of these roadways will look very different.

Chapter 1, Section 1.2 provides additional information on applying a performance-based design approach.

With a clear understanding of the mix of user types and intended functions of a roadway, the design team can work toward establishing a cross section that best serves the vision for the roadway. The design team is responsible for understanding whether the cross section elements implemented meet the needs of the different user types and the desired level of performance or function. Different cross section elements have different effects and a different relationship toward one or more aspects of the performance of the roadway. For example, travel lane widths may have an impact on the mobility, safety, and quality of service of a roadway for people driving a motor vehicle but may have limited effect on people walking along the roadway *(2)*.

NCHRP Report 785 **provides additional details on how various design elements may have a direct or indirect effect on various performance measures** ***(2)*****.**

Any cross section elements deviating from the recommended values should also be documented in the Scope of Work Report or the appropriate plans review report.

The MDT *Geometric Design Standards* document provides recommended values for various cross section elements based on the roadway functional classification *(1)*. A design exception is typically required if the recommended values are not met for any cross section elements listed in Chapter 2, Section 2.9.1. Additional information on preparing design exceptions is provided in Chapter 2, Section 2.9. This documentation should include existing cross section information, recommended changes, and justification for design decisions. A performance-based design approach can help document the decision-making process and help the design team understand the trade-offs for evaluating lane widths and other design elements.

For the purposes of the discussion in this chapter, the following terms have been defined, which are also consistent with the definitions in the American Association of State Highway and Transportation Officials' (AASHTO) *A Policy on Geometric Design on Highways and Streets* (Green Book) *(3)*:

1. **Cross section**. A vertical section of the ground and roadway at right angles to the centerline of the roadway, including all elements of a roadway from right-of-way line to right-of-way line.
2. **Roadway**. The portion of a highway, including shoulders, for vehicular use. A divided highway has two or more roadways.
3. **Traveled Way**. The portion of the roadway for the movement of vehicles, exclusive of shoulders and bicycle lanes.

Additional cross section elements, and their nomenclature, are illustrated in the following exhibits. The examples are not meant to represent a specific functional classification or land use area. The specific design for each roadway type and land use area may differ depending on the project context.

1. Freeway: see Exhibit 5-1
2. Two-lane roadway with shoulders: see Exhibit 5-2
3. Two-lane roadway with median and curbs: see Exhibit 5-3
4. Two-lane roadway with bicycle lanes and on-street parking: see Exhibit 5-4

Exhibit 5-1 Example Freeway Cross Section

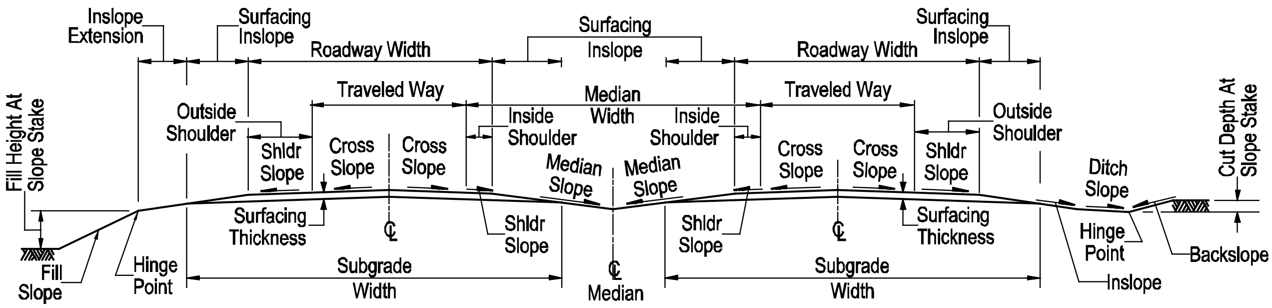


Exhibit 5-2 Example Two-Lane Roadway with Shoulders

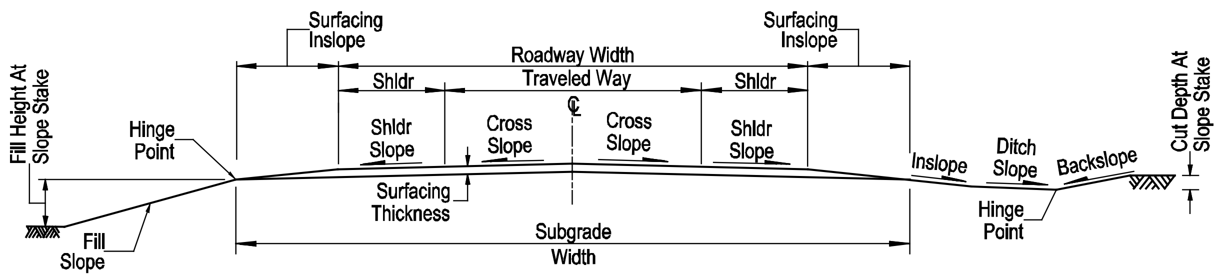


Exhibit 5-3 Example Two-Lane Roadway with Median and Curbs

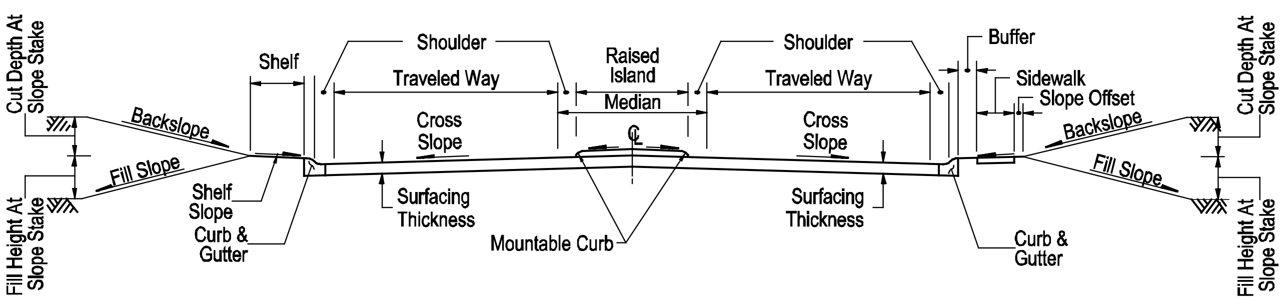
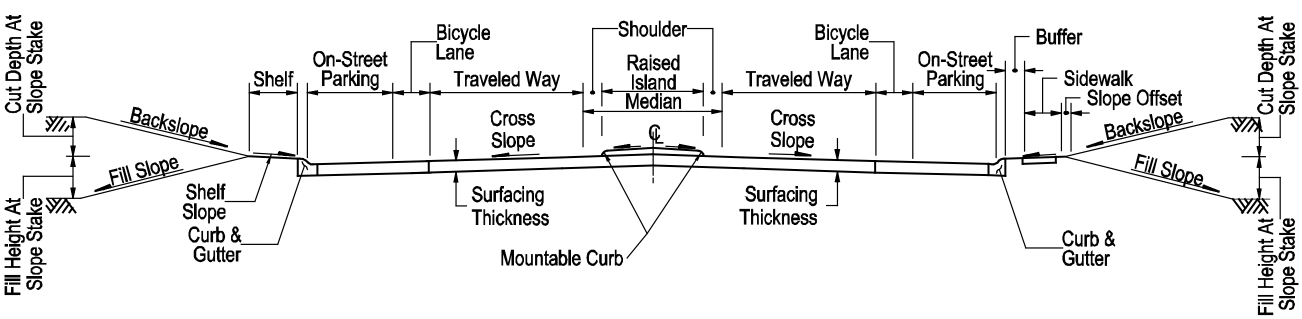


Exhibit 5-4 Example Two-Lane Roadway with Bicycle Lanes and On-Street Parking



5.2 CROSS SECTION ELEMENTS

The most basic roadway section will include two elements: travel lanes and shoulders. Depending on the desired function of the roadway, additional elements can be added to the roadway section. These include additional lanes (such as bicycle lanes, auxiliary lanes, and turn lanes), on-street parking, curbed sections, pedestrian facilities (such as sidewalks and associated buffers), and speed reduction treatments (such as curb extensions and medians). Below is a brief discussion on the roadway width decision process to determine the overall width for a given cross section. The following sections then discuss each individual cross section element and provide guidance for application of each to a given roadway section.

5.2.1 Roadway Width Decision Process

Chapter 2, Section 2.4 provides additional information on the roadway width decision process and the Route Segment Plan.

When making design decisions about roadway cross sections, the design team should consider the *MDT Route Segment Plan*. This plan identifies and defines a consistent pavement width to be used when reconstruction or major widening is conducted on a route segment.

Additional roadway width design information for various types of roadways can be found in the *AASHTO Green Book (3)* and the *FHWA and MDT Guidelines for Nomination and Development of Pavement Projects (5)*. Further coordination with the Traffic and Safety Bureau may also be necessary.

Applying performance-based analysis can help the design team understand the tradeoffs between various roadway widths, while considering the project objectives and contextual environment.

Roadway width decisions can also be examined using a performance-based road design approach. Applying performance-based analysis can help the design team understand the tradeoffs between various roadway widths, while considering the overall project objectives and surrounding contextual environment. Deviations from the design criteria for roadway width may result in the need for a design exception, which can be supported through the documentation process used in a performance-based analysis approach. Chapter 1, Section 1.2 provides additional information on performance-based road design, and Chapter 2, Section 2.9 provides additional information on design exception documentation.

5.2.2 Travel Lanes

Travel lanes are those lanes intended primarily for vehicular use and are designed to provide the appropriate lane width, surface type, and cross slope to serve the desired function and vehicle composition. Lane widths generally vary between 10 feet and 12 feet, depending on traffic volumes, functional classification, and design speed. Refer to the *MDT Geometric Design Standards* document for specific travel lane width standards based on functional classification *(1)*.

5.2.2.1 Surfacing Width

Travel lane width is a key parameter in making effective use of available right-of-way, particularly in constrained environments (established land uses, topography, and natural resources). Travel lane width is typically measured from center of stripe to center of stripe, or from center of stripe to face of curb/edge of pavement (if no striped shoulder).

Many factors influence the decision on appropriate lane width, including roadway location (intersection or segment), functional classification (freeway, arterial, collector, or local road), number of lanes, travel speed, percent of truck or bus traffic, area type (urban or rural), and on-street parking. In turn, lane width can have an effect on the mobility, operations, safety, and accessibility of various users of a roadway. The design team should consider the various types of users for a roadway and understand the trade-offs for making lane width design decisions.

5.2.2.2 Changes in Surfacing Width

When travel lanes are narrowed or widened or the number of travel lanes on a roadway section is reduced, the design team should apply transition taper rates to provide adequate distance for drivers to safely negotiate the width and lateral position changes. For roadways with a design or statutory speed limit of 45 miles per hour or greater, transition tapers are developed such that one foot of width change occurs over a length equal to the design or statutory speed of the roadway. For roadways with a design or statutory speed limit of less than 45 miles per hour, the transition taper rate for one foot of width change is equal to the formula shown in Exhibit 5-5. For design purposes, these values should be rounded up to the next highest multiple of five. Exhibit 5-5 provides transition taper rates for various design speeds.

The design team should coordinate with the Traffic and Safety Bureau for additional guidance on appropriate taper rates for the addition of auxiliary lanes at an intersection.

Exhibit 5-5
Travel Lane Transition Taper Rates

Design Speed (mph)	Transition Taper Rate
20	10:1
25	15:1
30	20:1
35	25:1
40	30:1
45	45:1
50	50:1
55	55:1
60	60:1
65	65:1
70	70:1
75	75:1
80	80:1

For Design Speed (S) < 45 mph, Taper Rate = $(S^2/60)$:1
For Design Speed (S) ≥ 45 mph, Taper Rate = S:1
Taper Length (L) = Taper Rate x Offset Distance

5.2.2.3 Surfacing Type

The surfacing type will be dependent on several factors (traffic volume, composition, and soil characteristics) and may also be influenced by the pavement design. The RDM does not address pavement design in detail but relies on the *MDT Pavement Design Manual* for additional details *(6)*. However, the following guidelines can be used when determining if a roadway will be paved or left as gravel.

1. **Rural and Urban Freeways.** All freeways will be paved.
2. **Rural and Urban Minor and Principal Arterials.** All arterials will be paved.
3. **Rural Collectors.** In most cases, rural collectors will be paved. However, existing gravel roads may remain gravel.
4. **Urban Collectors.** Urban collectors will be paved.
5. **Non-State Roadways (including Local Roadways)**. On projects where State and/or Federal funds are used on non-State roadways, the pavement surfacing type will normally be determined at the Preliminary Field Review.

5.2.2.4 Cross Slope

Surface cross slopes are required for proper drainage of travel lanes and are most commonly crowned at the centerline of the roadway section. Roadway sections with depressed medians may be crowned to drain some or all of the pavement area to the depressed median. See Section 5.3.1 for more information on the design and application of depressed medians. The following will generally apply:

1. **Paved**. The travel lane cross slope is typically 2 percent.
2. **Curbed.** On curbed roadways, the cross slope is typically 2 percent. Depending on site conditions, a cross slope between 1.5 percent and 3 percent is acceptable for NHS roadways and between 1 percent and 4 percent is acceptable for non-NHS roadways.
3. **Gravel.** The travel lane cross slope is typically 3 percent. At bridge ends the gravel lane cross slopes must transition to match the bridge cross slopes, which are generally 2 percent.

5.2.3 Shoulders

Shoulders are contiguous with the traveled way and, depending on width, can provide many benefits to a cross section. Generally the wider the shoulder, the greater the benefit provided. Use of shoulders provides:

- Structural support to the traveled way (minimize pavement edge drop-offs);
- Improved operation and increased roadway capacity;
- Improved safety through increased clear recovery area and increased sight distance for horizontal curves;
- Space for emergency and discretionary stops;
- A sense of openness and roadway aesthetics; and
- Space for pedestrian and bicycle use, on-street parking, or both.

The design team should aim to provide a consistent shoulder along a corridor to meet driver expectation, particularly for segments that are narrower than the majority of segments on the corridor.

5.2.3.1 Surfacing Width

Shoulder width will vary according to roadway functional classification, traffic volumes, and urban or rural location. Refer to the *MDT Geometric Design Standards* document for recommended shoulder width values based on functional classification *(1)*. In addition, the design team should consider the following:

1. **Roadside Barriers**. For roadway widths less than 28 feet, shoulder widths should be increased to 2 feet when a roadside barrier is present. Chapter 9 provides more information on offsets to barriers.
2. **Curb and Gutter.** The minimum shoulder width adjacent to a curb is 2 feet measured from the edge of the traveled way to the face of curb.
3. **On-Street Parking.** Shoulders may be eliminated altogether or reduced in width when on-street parking is provided.

Refer to Exhibits 5-21 and 5-22 for typical section illustrations of shoulder width and on-street parking adjacent to curb.

5.2.3.2 Changes to Surfacing Width

In general, the following taper rates should be used for shoulder width transitions:

- For design speeds of 45 mph or greater, use a 25:1 taper rate
- For design speeds less than 45 mph, use an 8:1 taper rate

Adjustments to shoulder transition rates may be appropriate to fit site constraints or reduce the number of typical sections.

5.2.3.3 Surfacing Type and Cross Slope

The type of surfacing and cross slope used for the shoulder should match that used for the traveled way. The cross slope may vary in areas where adjacent development or access requires modification. Examples include meeting drainage needs, limiting roll over differences (approaches to superelevated roadways), and matching to existing features on rehabilitation projects.

5.2.3.4 Subgrade Slopes

The following applies for subgrade slopes:

1. **Tangent Sections**. For tangent sections, the cross slope of the top of the subgrade should be the same as the cross slope of the paved surface.
2. **Superelevated Sections.** For superelevated sections, the cross slope of the top of subgrade should be the same as the cross slope of the paved surface from the subgrade shoulder (hinge point in fill sections) on the high side of the section to a point directly below the edge of the shoulder on the low side of the section. From this point to the subgrade shoulder on the low side, the subgrade cross slope should match the cross slope of the normal crown section (2 percent for paved roadways). This change in subgrade cross slope results in the subgrade shoulder at the inside of the superelevated section being the same distance from the centerline of the

Refer to the typical section exhibits in Section 5.6 for illustrations of subgrade slopes for different roadway types and superelevation conditions.

pavement as the subgrade shoulder of the tangent section. Maintaining a constant location of the subgrade shoulder on the low side of curves maintains the ditch offset distance, reduces depressions in the ditch grade, and aids in the staking of the subgrade.

3. **Variable Surfacing Depths**. Where adjoining typical sections have different surfacing depths, use a taper rate of 20:1 to transition between the subgrade widths.

5.2.4 Dedicated Bicycle Lanes

Chapter 7 provides additional information on dedicated bicycle lane design considerations.

Dedicated bicycle lanes should be considered when evaluating the cross section of a roadway. If a roadway is expected to have a high volume of bicyclists or if the roadway is a designated bicycle route, the cross section should provide adequate space for a dedicated bicycle lane, separate from vehicles and pedestrians. If shoulder rumble strips are present on the roadway, the bicycle lane width should be exclusive of the width of the rumble strips.

Additional information on dedicated bicycle lanes is provided in Chapter 7, and the design team should also reference the *AASHTO Guide for the Development of Bicycle Facilities (7)*. Refer to the *MDT Geometric Design Standards* document for recommended bicycle lane width values based on functional classification *(1)*.

5.2.5 Rumble Strips

Longitudinal shoulder and centerline rumble strips may be added to a roadway cross section to alert drivers who may be tired or inattentive. When adding rumble strips to the roadway cross section, the design team should consider the presence of bicyclists, pavement life, maintenance operations, and initial construction costs. Rumble strips should be installed in accordance with *MDT Rumble Strip Guidance* and in conjunction with the MDT Detailed Drawings (Chapter 14) or project plan details. Additional national guidance for rumble strip design and installation is provided in *NCHRP Report 641: Guidance for the Design and Application of Shoulder and Centerline Rumble Strips (8).*

5.2.6 Auxiliary Lanes

Auxiliary lanes are any lanes beyond the basic through travel lanes occurring along a roadway segment (auxiliary turn lanes and auxiliary through lanes at intersections are discussed in Chapter 6). They are intended for use by vehicular traffic for specific functions, such as truck climbing lanes, passing lanes, and two-way, left-turn lanes. With the exception of two-way, left-turn lanes, the width of an auxiliary lane is typically the same as that of the adjacent through lane. It may be justified to provide a narrower width due to restricted right-of-way. Also, the cross slope of the auxiliary lanes should match that of the adjacent travel lanes.

5.2.6.1 Auxiliary Lanes on Freeways

An auxiliary lane on a freeway is defined as the portion of the roadway adjoining the through lanes for speed change, turning, storage for turning, weaving, truck climbing, and other purposes that supplement through-traffic movement. An auxiliary lane should not trap a driver at its termination point or the point where it continues onto a ramp or turning roadway. The width of the auxiliary lane should be equal to the width of the adjacent through lanes. The width of the shoulder adjacent to the auxiliary lane should be 10 feet unless the roadway is located in mountainous terrain, where 8 feet may be used. Generally, auxiliary lanes should be parallel to the adjacent through lanes. Auxiliary lane lengths should be in accordance with values given in Chapter 10 of the *AASHTO Green Book (3)*.

5.2.6.2 Passing Lanes

In some situations it will be necessary to provide additional lanes to allow vehicles to make passing movements. A passing lane is defined as a short added lane provided in one or both directions of travel on a two-lane, two-way highway to improve passing opportunities. They may present a relatively low-cost improvement for traffic operations by breaking up traffic platoons and reducing delay on roadways with inadequate passing opportunities. Truck-climbing lanes are one type of passing lane used on steep grades to provide passenger cars with an opportunity to pass slow-moving trucks. The Traffic and Safety Bureau will typically determine the need for passing lanes.

Coordinate with the Traffic and Safety Bureau for additional guidance related to passing lanes.

5.2.6.3 Two-Way, Left-Turn Lanes (TWLTL)

Two-way, left-turn lanes (TWLTL) are a cost-effective method to accommodate a continuous left-turn demand and reduce delay and crashes compared to an undivided roadway section. The Traffic and Safety Bureau will typically determine the need for TWLTLs. In general, conditions where a TWLTL should be considered include areas with a high number of approaches per mile, areas with a high-density of commercial development, and areas with a relatively continuous demand for mid-block left turns.

Coordinate with the Traffic and Safety Bureau for additional guidance related to two-way, left-turn lanes.

The desirable width for a TWLTL is 14 feet for all roadway types, urban and rural. For rural areas, the minimum width for a TWLTL is 14 feet. For urban principal arterials, the minimum TWLTL width is 12 feet, and for urban minor arterials and collectors, the minimum TWLTL width is 11 feet. In general, the desirable width should be used for roadways with higher volumes, higher speeds, in industrial areas, or combinations thereof. Refer to the *MDT Geometric Design Standards* document for specific TWLTL width standards based on functional classification *(1)*.

Roadways requiring installation of a TWLTL are often located in areas of restricted right-of-way, and conversion of the existing cross section may be challenging. To obtain the TWLTL width, consider the following options:

- Acquire additional right-of-way to expand the roadway width by the amount needed for the TWLTL,
- Eliminate existing buffer areas behind curbs and reconstructing curb and gutter and existing sidewalks,
- Eliminate existing parking lanes,
- Eliminate or reduce the width of existing shoulders and ditches,
- Reduce the width of existing through lanes, and/or
- Reduce the number of existing through lanes.

Prior to reducing shoulder width, consider the volume of bicycles.

The design team should carefully evaluate the trade-offs between the benefits of the TWLTL and the negative impacts of the alternatives listed above. This may involve a capacity analysis, a study of the current and anticipated use of the corridor, or an evaluation of the existing crash history. This evaluation should be coordinated with the MDT Traffic and Safety Bureau.

At all intersections with public roads, the TWLTL should either be terminated in advance of the intersection to allow for the development of an exclusive left-turn lane, or else the TWLTL should be extended up to the intersection. Where the TWLTL is extended up to the intersection, the pavement markings will switch from two opposing left-turn arrows to one left-turn arrow only where justified by traffic volumes. When determining the intersection treatment, consider the following:

1. **Signalization**. At signalized intersections, the TWLTL should be terminated because these intersections will typically have an exclusive left-turn lane. At unsignalized intersections, the TWLTL may be extended through the intersection if an exclusive left-turn lane is not justified.
2. **Turning Volumes**. The left-turn demand into the intersecting road is a factor in determining the proper intersection treatment. As general guidance, if the minimum storage length will govern, it will probably be preferable to extend the TWLTL up to the intersection and not provide an exclusive left-turn lane.
3. **Length of TWLTL**. The TWLTL should have sufficient length to operate properly. A TWLTL can be interrupted by the need to provide specific left-turn treatments at public intersections and high-volume approaches. This may still allow room to accommodate mid-block access between these left-turn treatments. On two-lane, rural roadways, the overall length needs to be evaluated because a TWLTL may encourage inappropriate passing when carried for extensive distances and will contribute to the overall cost and right-of-way impacts of the roadway.
4. **Operational/Safety Factors**. Extending the TWLTL up to an intersection could result in operational or safety issues. Some drivers may, for example, pass through the intersection in the TWLTL and turn left just beyond the intersection into an approach which is very close to the intersection. If operational or safety issues are known or anticipated at an intersection, it may be preferable to remove the TWLTL prior to the intersection and provide an exclusive left-turn lane.

The design team should coordinate with the Traffic and Safety Bureau on the appropriate treatment and design of TWLTLs and exclusive left-turn lanes at intersections.

5.2.7 On-Street Parking

Coordinate with the Traffic and Safety Bureau for additional guidance related to parking.

The decision to retain existing on-street parking or to introduce on-street parking will typically be made by the Traffic and Safety Bureau and be based on a case-by-case assessment in cooperation with the local community. Adjacent land uses may create a demand for on-street parking along a roadway in an urban area. On-street parking provides convenient access for motorists to businesses and residences but may impact the traffic operations and safety on a corridor. The design team should consider the project context and understand the trade-offs when making design decisions for on-street parking.

The two basic types of on-street parking are parallel and angle parking (includes forward and back-in angle parking). The total entrance and exit time for parallel parking exceeds that required for angle parking. Parallel parking and back-in angle parking require a vehicle to stop in the travel lane and await an opportunity to back into the parking space. However, angle parking requires a greater cross section width. Therefore, when roadway space is limited, parallel parking is the preferred arrangement.

When additional roadway space is available, angle parking provides more spaces per linear foot than parallel parking. When angle parking is considered, back-in angle parking is the preferred arrangement. Both forward and back-in angle parking have similar common dimensions, but the back-in angle parking is superior for safety reasons due to better visibility when leaving. For roadways with high motor vehicle, pedestrian, and bicycle volumes, or where drivers find their views blocked by large vehicles or other objects, back-in angle parking provides greater safety benefits over forward angle parking. Back-in angle parking prevents drivers from backing blindly into an active traffic lane. Also, the open doors of the vehicle block pedestrian access to the travel lane and guide pedestrians to the sidewalk, which is a safety benefit, particularly for children. Furthermore, back-in angle parking positions cargo loading on the curb, rather than in the roadway *(9)*.

The following summarizes MDT's design criteria for on-street parking:

1. **Stall Width**. The desirable width for parallel parking stalls is 10 feet. For parallel parking, stall widths are measured from the edge of traveled way to the face of curb. The desirable width for angle parking stalls is 9 feet, measured from stripe to stripe. Refer to the *MDT Geometric Design Standards* document for recommended parking stall width values based on functional classification *(1)*.
2. **Stall Layout**. Exhibit 5-6 provides the layout criteria for parking stalls for various configurations. The exhibit also indicates the number of stalls which can be provided for each parking configuration for a given curb length. For angle parking, desirably, the roadway width allocated to parking will be the sum of "A" and "B" as shown in Exhibit 5-6.

   "A" is the desired distance between the face of curb and the back of the stall. "B" is the minimum clear distance needed between the back of the parking stalls and the edge of traveled way to allow for a parked vehicle to pull into or out of the stall and clear adjacent parking vehicles without encroaching on the traveled way. In constrained areas, a portion of the "B" dimension may need to be allocated to the through travel lane, thereby reducing the roadway width allocated to angle parking.

   For dimension "A", it is assumed that the bumper of a parked car does not extend beyond the face of curb. In constrained locations, it can be assumed that the car will move forward until its tire contacts the curb. The design team should provide adequate sidewalk width to meet *Americans with Disabilities Act (ADA)* requirements to accommodate this bumper overhang distance if needed. In these cases, the "A" distances in the figure may be reduced as shown in Exhibit 5-7.

Exhibit 5-6
Curb Parking Configuration

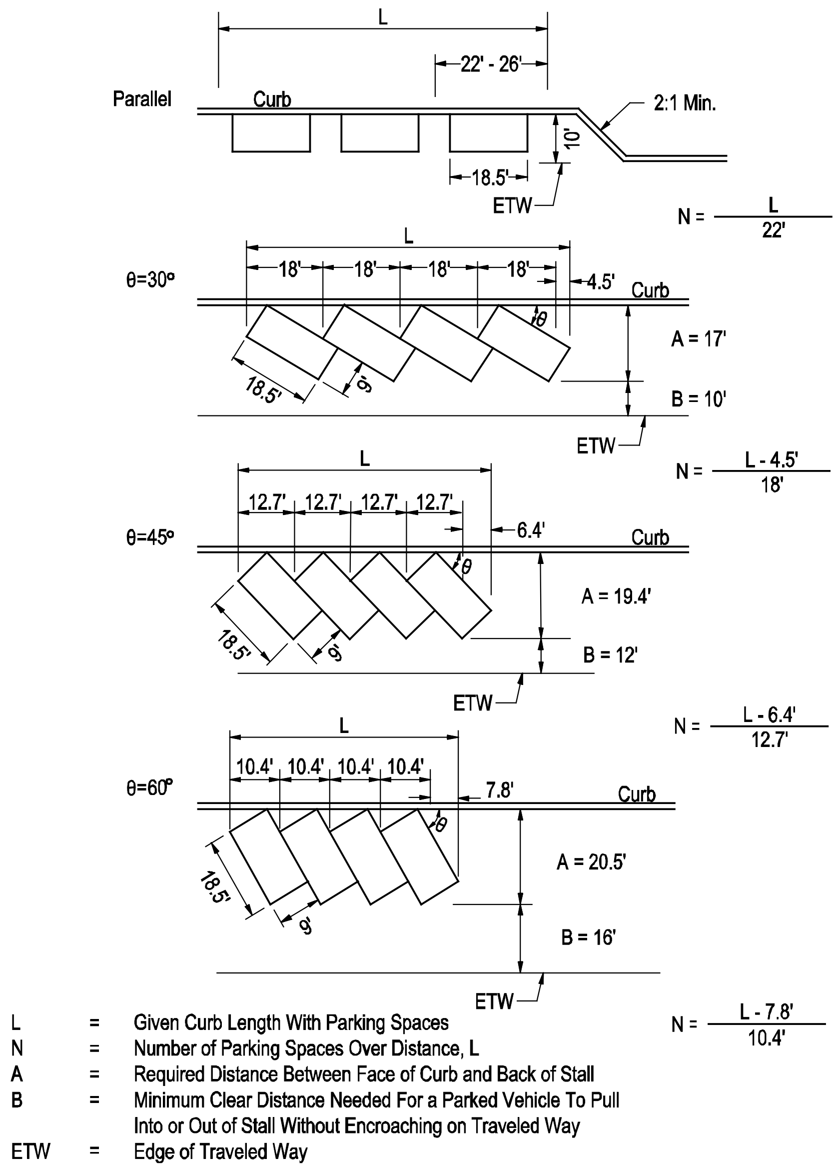


Exhibit 5-7
Parking Stall Additional Reduction in "A"

Angle of Parking	Additional Reduction in "A"
30 degree	1.3 feet
45 degree	2.0 feet
60 degree	2.3 feet

3. **Cross Slope**. The cross slope of the parking lane should match that of the adjacent through travel lane whenever possible. However, cross slopes

between 1 percent and 4 percent are allowed to fit actual field conditions. The longitudinal slope of the parking lane should be equal to or steeper than the adjacent through lane to promote proper drainage.

4. **Accessibility for Disabled Individuals**. Where on-street parking is permitted, a certain number of parking spaces should be provided for accessibility for the disabled, and their design should meet the applicable accessibility design criteria.
5. **Intersection Curb Radii.** Parking may need to be restricted for a certain distance from intersections to allow the design vehicle to properly negotiate turning movements at the intersection. Chapter 6 provides additional information on intersection design considerations.
6. **Location.** For most sites, a sight distance evaluation should be conducted when locating parking spaces. In addition to State and local regulations, these guidelines should be followed when locating parking spaces:
   a. Locate at least 20 feet from any crosswalk.
   b. Locate at least 10 feet from the beginning of the curb radius at mid-block approaches.
   c. Locate at least 50 feet from the nearest rail of a railroad/highway crossing.
   d. Locate at least 30 feet from the approach leg of any intersection with a flashing beacon, stop sign, or traffic signal.
   e. Locate parking away from areas designated by local traffic and enforcement regulations (e.g., near school zones, fire hydrants). See local ordinances for additional information on parking restrictions.
   f. Locate parking away from bus stops.
   g. Parking should not be located on bridges or within a highway tunnel.
   h. Parking should not be located across from a T- intersection.

5.2.8 Curbs and Curbed Sections

Curbs are often used on urban roadways to facilitate proper drainage, delineate the pavement edge, channelize vehicular movements, control access, limit right-of-way needs, provide separation between vehicles and pedestrians, and improve aesthetics. Curbs are typically not used in rural areas. For urban and transitional areas, selecting a curbed section or uncurbed section depends upon many variables, and the decision will be made on a case-by-case basis. Evaluate the following factors to determine whether or not a curbed section is preferred:

- Existing conditions (curbed or uncurbed);
- Local preference;
- Drainage impacts;
- Construction costs;
- Impacts on maintenance operations;
- Roadside safety impacts (see Chapter 9);

- Sidewalk guidelines (see Section 5.2.9 and Chapter 7, Section 7.3.3.2);
- Control of access to abutting properties;
- Impacts on traffic operations, for example, vehicular channelization at intersections;
- Right-of-way restrictions; and
- Vehicular speeds (the use of curbs is not preferred where speeds are greater than 45 miles per hour).

Where a curbed section is warranted, MDT uses concrete curb exclusively. Typically, the curb will be a mountable sloped shape. This applies to both outside curbs and curbs used for raised medians. On roadways with curbs and no sidewalks, a shelf (a flat area typically 3 feet in width, measured from the back of curb) is provided, and the side slope is located beyond the shelf. See the typical sections in Section 5.6.

Curbs must be designed with curb ramps at all pedestrian crosswalks to provide adequate access for the safe and convenient movement of physically disabled individuals. The MDT Detailed Drawings provide specifics for those curbs used by MDT.

5.2.9 Pedestrian Facilities

Refer to Chapter 7 for information on determining the need for pedestrian facilities and for guidance in selecting the proper type of facility.

Cross section design considerations for pedestrian facilities include sidewalks (both attached and detached) and pedestrian and shared use paths. The following sections provide design guidelines for each facility type.

5.2.9.1 Sidewalks

If a sidewalk is justified based on the guidance provided in Chapter 7, Section 7.3.3.2, the design team should consider the following:

1. **Typical Widths**. Sidewalks should typically be 6 feet wide or wider depending on the project context. The minimum sidewalk width is 5 feet, as measured from the back of the curb. Sidewalk widths vary depending on specific characteristics along the roadway including land use, obstructions, and/or appurtenances along the roadway. Also, the design team should consider compatibility with local city and community criteria during design.
2. **Appurtenances**. The design team should consider the impacts of roadside appurtenances within the sidewalk (e.g., fire hydrants, parking meters, utility poles, signs). These elements will reduce the effective width of the sidewalk because they interfere with the pedestrian’s natural walking path. Preferably, place these appurtenances behind the sidewalk, or within the furniture zone. If they are placed within the sidewalk, the sidewalk should have a minimum clear width of 4 feet around the appurtenance; preferably 5 feet of clear width should be provided. The clear width will be measured from the edge of the appurtenance to the edge of the sidewalk.
3. **Central Business District (CBD) Areas**. The entire area between the curb and any adjacent buildings is often fully used as a paved

sidewalk. Coordinate with local agencies for potential encroachments under sidewalks.

4. **Cross Slope.** The maximum cross slope on the sidewalk is 2 percent. Typical practice is to design sidewalks at a cross slope of 1.5 percent to allow for potential deviations and flexibility during construction. Sidewalks should be sloped toward the roadway unless site constraints dictate otherwise in order to convey drainage runoff into the roadway and away from private properties.
5. **Buffer Areas.** If the available right-of-way is sufficient, buffer areas between the curb and sidewalk are desirable. Refer to Section 5.2.10 for additional information on buffer areas.
6. **Sidewalk Material.** Sidewalks will be concrete.
7. **Bridges.** The Bridge Bureau is responsible for the dimensioning and structural design of all sidewalks on bridges.

If a sidewalk is placed on a bridge, it may be necessary to provide the standard bridge rail to separate the vehicular traffic from pedestrians and then use a pedestrian rail on the outside edge of the sidewalk. Consider the need for a separate pedestrian rail on a case-by-case basis. Evaluate the following factors:

- Design speed;
- Pedestrian volumes;
- Traffic volumes;
- Crash history;
- Geometric impacts (e.g., sight distance);
- Practicality of providing proper end treatments;
- Construction costs; and
- Local preference.

If a bridge with a sidewalk is on a designated bicycle route or experiences heavy bicycle traffic, and a dedicated bicycle lane is not provided, the railings/barriers must be a minimum of 4.5 feet high. In addition, barriers should have smooth rub rails at a 3.5-foot height. The Bridge Bureau will be responsible for the final decision on when to use a pedestrian rail in combination with the standard bridge rail. Due to the steepness of the roadway inslopes near the bridge ends, it is recommended that the pedestrian rail extend at least 25 feet beyond the end of the bridge.

The need to extend the rail and the length of the extension should be determined at the Plan-in-Hand.

5.2.9.2 Pedestrian & Shared Use Paths

Pedestrian and shared use paths are typically constructed adjacent to roadways without curb and gutter, with a buffer area between the roadway and pathway. Pedestrian and shared use paths may be constructed in conjunction with a curb and gutter roadway section where the pathway is established for recreational use and is designed as part of the overall landscaping. The following will apply to the design of pedestrian and shared use paths:

Refer to Chapter 7 for additional information on pedestrian and shared use paths.

1. **Typical Width.** The minimum paved width for a pedestrian path is 6 feet, with 8 feet being the preferred width. A minimum 10-foot width is recommended if the path will be a shared use path with bicycles. According to the *AASHTO Guide for the Development of Bicycle Facilities*, a

reduced width of 8 feet may be used for shared use paths in very rare circumstances *(7)*.

2. **Appurtenances**. Do not place appurtenances within a pedestrian or shared use path.
3. **Cross Slope.** The maximum cross slope on a pedestrian or shared use path is 2 percent. Typical practice is to design pathways at a cross slope of 1.5 percent to allow for potential deviations and flexibility during construction. Generally, slope the pathway toward the roadway; however, it may be sloped in either direction as determined by field conditions. For shared use paths, the recommended cross slope is 1 percent according to the *AASHTO Guide for the Development of Bicycle Facilities (7).*
4. **Separation.** The separation between the roadway and the pedestrian path should be as wide as practical, but at least a minimum of 3 feet. For shared use paths, a 5-foot minimum separation is recommended according to the *AASHTO Guide for the Development of Bicycle Facilities (7).*
5. **Pathway Material**. Pedestrian and shared use paths will typically be paved with bituminous asphalt.
6. **Bridges**. The pedestrian or shared use path should connect to the bridge, unless a separate, adjacent pathway bridge is provided. The Bridge Bureau is responsible for designing the bridge to accommodate the pathway across the bridge.

5.2.10 Buffer Areas

The buffer area is the area between the roadway and the sidewalk that provides space between motorized vehicle traffic and non-motorized users (pedestrians and bicycles). Buffer areas may be included as part of the cross section, particularly in urban and transitional areas, to enhance public safety by separating various users and provide an aesthetic feature to the community. Buffer areas should be at least 3 feet wide to be effective and, if practical, should be wider. Landscaping may also be installed within a buffer area, median, or splitter island. Additionally, planting vegetation may be installed for erosion-control purposes. If the area is landscaped, additional width is often necessary to accommodate plantings.

Landscape designs in a buffer area or median should consider the following:

- Provide sufficiently wide, clear, and safe pedestrian pathways and bicycle facilities within existing or planned right-of-way.
- Install and maintain shrubs and trees to meet sight distance and roadside clearance guidelines.
- Evaluate street light poles for their proximity to trees to maintain the appropriate roadway lighting, as well as lighting the sidewalk.
- Design proper drainage for landscaping that requires irrigation. Chapter 11 provides additional design information for drainage and irrigation designs.
- Ongoing maintenance of irrigation, shrubs, trees, and other landscape features should be considered in the design.

Landscaping can also provide erosion control and should be developed to keep with the character of the roadway and its environment. The design team should consider preserving or transplanting any existing vegetation where practical. The design should help improve the aesthetics without increasing the potential crash severity associated with errant motor vehicles.

5.3 MEDIANS

A median is defined as the portion of a divided highway separating directionally opposed traveled ways. Depending on the type of median, the principal functions of a median are to:

- Provide separation from opposing traffic;
- Prevent undesirable turning movements;
- Provide an area for deceleration and storage of left-turning vehicles;
- Provide an area for storage of vehicles for emergency stopping;
- Facilitate drainage collection;
- Provide a recovery area for run-off-the-road vehicles;
- Provide an opportunity for two-stage crossing and turning movements;
- Improve sight lines for left-turning vehicles relative to oncoming traffic;
- Provide an area for pedestrian refuge; and
- Provide width for future lanes.

Coordinate with the Traffic and Safety Bureau to determine the appropriate placement of medians.

5.3.1 Median Types

Medians may be depressed, raised, or flush with the roadway surface and should be highly visible both day and night. The three types of medians, and their typical application, are discussed below. Section 5.6 provides typical sections for various median types.

5.3.1.1 Depressed Medians

A depressed median is typically used on freeways and other divided rural arterials. Depressed medians should have good drainage characteristics. Depressed medians should be as wide as practical to allow for the addition of future travel lanes on the inside while maintaining a sufficient future median width.

The minimum width for depressed medians is 36 feet. Depressed medians 36 feet to 44 feet wide should be developed with 6:1 side slopes to the point where the side slopes meet. This allows for a ditch with sufficient depth to accommodate the drainage runoff. Depressed medians greater than 44 feet wide to 76 feet wide should be developed with 6:1 side slopes out to a minimum of 15 feet and a maximum of 24 feet from the median edge of pavement depending on the subgrade and intermediate surfacing widths. When the width of the median is greater than 76 feet, the two roadways of the divided facility are treated as independent roadways. In these cases, a 6:1 side slope should be developed on either side of the depressed median for 10 feet from the daylight of the subgrade to the hinge point. From this point, variable side slopes may be used to best fit the terrain and drainage needs. See Exhibits 5-9 through 5-14 at the end of this chapter for illustrations of the various depressed median conditions described above.

5.3.1.2 Raised Medians

Raised medians may be used on roadways in urban and transitional areas to control access and left turns. The use of raised medians is not recommended on high-speed roadways (speeds greater than 45 miles per hour). Raised medians should be illuminated such that they are visible under nighttime conditions. See Section 5.3.3 for information on the design of raised medians.

5.3.1.3 Flush Medians

Flush medians are often used on urban roadways. The typical width of a flush median should range from 4 feet to 16 feet. They are paved and striped for lane delineation. The design team should coordinate with the Traffic and Safety Bureau to determine if flush medians are appropriate for traffic volumes present on the roadway. To provide proper drainage, flush medians are typically crowned in the center with a cross slope equal to the cross slope of the adjacent travel lanes.

One potential disadvantage of flush medians is that they do not effectively deter cross-median vehicular movements, nor do they provide refuge for pedestrians. If this is perceived as a problem, the design team, in coordination with the Traffic and Safety Bureau, should consider providing a raised median.

Two-way, left-turn lanes (TWLTL) are also considered flush medians. Desirably, the roadway cross section with a flush median will allow ultimate development for a future TWLTL in urban and transitional areas. See Section 5.2.6.3 for more information and design details for TWLTLs.

5.3.2 Selecting a Median Type

Each median type provides unique advantages and disadvantages. The design team should evaluate the impacts of each median type on a case-by-case basis and coordinate the selection of a median type with the Traffic and Safety Bureau. The comments below may be used to guide the decision-making process.

When compared to flush medians, raised medians offer several advantages, including the following:

- Mid-block left turns are controlled;
- Left-turn channelization can be more effectively delineated;
- A distinct location is available for traffic signs, signals and pedestrian refuge;
- Limited physical separation is available;
- Uncontrolled cross-traffic movements are prevented; and
- They reduce the potential for head-on collisions.

The disadvantages of raised medians when compared to flush medians include the following:

- Access for emergency vehicles may be more difficult;

- Prohibiting mid-block left turns may overload intersections and may increase the number of U-turns, and they also may impact other roadways in the vicinity of the corridor;
- They may need greater roadway widths to serve the same function (for example, left-turn lanes at intersections) because of the raised island and offset between curb and travel lane;
- Curbs may result in adverse vehicular behavior upon impact;
- They may cause drainage and snow removal issues;
- They are more expensive to construct and more difficult to maintain; and
- Prohibiting mid-block left-turns causes drivers to take inconvenient alternative access routes to and from adjacent properties.

5.3.3 Raised Median Design

If a raised median will be used, consider the following in the design of the median:

Refer to Chapter 6 for information and guidance on the location and design of openings in raised medians.

1. **Curb Type**. Typically, mountable concrete curbs are used for raised medians.
2. **Width.** The width of a raised median is measured from the two inside edges of the traveled ways and includes the median shoulders. For example, a median width of 20 feet provides for:
   a. A 2-foot offset from the through lane shoulder stripe to the face of curb on each side of the raised median, and
   b. A 16-foot raised median from face of curb to face of curb.

   The 16-foot width of the median should allow for the development of a 12-foot wide channelized left-turn lane. Where the raised median exceeds 16 feet, the design team should center the opposing lanes opposite each other at intersections or, if practical, provide left offset left-turn lanes. This will enhance the ability of a left-turning vehicle to see around the opposing left-turning vehicle. Refer to the *MDT Geometric Design Standards* document for recommended median width values based on functional classification *(1)*.
3. **Surfacing.** The raised portion of the median is usually paved with concrete. Alternate treatments such as landscaping should be determined on a case-by-case basis and in collaboration with the local community.
4. **Lighting and Delineation.** Where raised medians are used, the roadway should be well lit, and the medians should be delineated.

Evaluate all existing raised medians within the project limits for their current appropriateness. The existing configuration of the raised median should be evaluated with its consistency to the existing geometric needs. This includes sight distance for the left-turn bays, storage lengths, and turning paths for vehicles entering and exiting the roadway.

5.4 SIDE SLOPES

Refer to Chapter 9 and the *MDT Geometric Design Standards* document for detailed information and recommended ratios for side slopes.

Side slopes on roadway sections refers to both fill slopes and cut slopes used to conform to existing conditions along the roadside. MDT protocol for slope notation is "X:1", where "X" is the horizontal dimension and the vertical dimension is represented by the value of "1". Section 5.6 presents typical sections for side slopes for various types of roadways. The following provides a general discussion of side slopes.

5.4.1 Fill Slopes

Fill slopes are the slopes extending outward and downward from the hinge point to intersect the natural ground line. The fill slope design criteria depend upon the functional classification, fill height, urban/rural location, and the presence of curbs. The design team should also consider right-of-way restrictions, utility considerations, roadside safety, and roadside development in determining the appropriate fill slope for the site conditions. Refer to the MDT *Geometric Design Standards* document for recommended fill slope ratios based on functional classification (*1*).

5.4.2 Cut Slopes

Cut slopes, also called backslopes, are the slopes extending outward and upward from the ditch line to intersect the natural ground line. Refer to the MDT *Geometric Design Standards* document for recommended cut slope ratios based on functional classification (*1*). In earth cuts on roadways without curbs, roadside ditches are provided to control drainage. The ditch section includes the inslope, ditch width, and backslope, as appropriate for the roadway type.

5.4.2.1 Earth Cuts

In earth cuts on roadways without curbs, roadside ditches are provided to control drainage. The ditch section includes the inslope, ditch width, and backslope, as appropriate for the roadway type.

The following will apply to earth cuts:

1. **Snow Drifting**. One of the following two methods can be used to control snow drifting in cuts.
   a. Design the backslope so that an imaginary line between the finished shoulder and the top of the cut (intersection with natural ground) has a slope of 11:1 or flatter.
   b. Increase the width of the flat-bottomed ditch to provide additional snow storage. Use the method described in the Strategic Highway Research Program's *Design Guidelines for the Control of Blowing and Drifting Snow* to determine the necessary width of the ditch *(10)*.
2. **Superelevated Sections.** On superelevated sections, a 6:1 side slope on the high side of the section extends outward and downward from the subgrade shoulder. This slope should extend a sufficient distance such that the distance from the centerline of the pavement (or traveled way

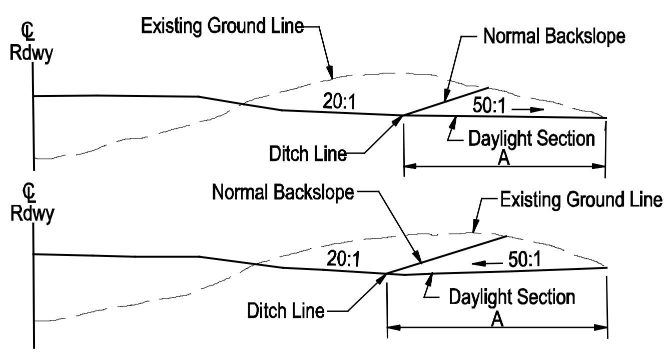
for sections with depressed medians) to the end of the 6:1 side slope is the same as the distance from the centerline of the pavement to the subgrade shoulder on the tangent section. As with the break in the subgrade cross slope, the use of the extended 6:1 slope maintains the ditch offset distance and avoids depressions in ditch grades.

3. **Daylighting.** Daylighting slopes can provide several benefits, including:
    - Enhancing roadside safety;
    - Providing needed fill material;
    - Removing undesirable features;
    - Obliterating existing roadbeds;
    - Providing convenient outfall points for roadside drainage; and
    - Enhancing aesthetics.

    Exhibit 5-8 illustrates how to daylight slopes. A 50:1 slope is typically used either away from or towards the ditch line, as appropriate. The dimension "A" in the exhibit refers to the lateral distance needed to excavate to daylight a slope. Whether a given site should be daylighted, based on "A", will be determined on a case-by-case basis.

Note that daylighting should not be used if it results in the need for a traffic barrier.

Exhibit 5-8 Daylighting



4. **Additional Right-of-Way.** If additional right-of-way is needed to accommodate utilities or to address slope stability, these features will need to be included in the final construction limits or coordinated with the Right of Way Bureau.
5. **Geotechnical Investigations**. Backslopes steeper than 3:1 should be reviewed for stability by the Geotechnical Section.

5.4.3 Existing Roadside Development

Where roadside development is extensive and the general elevation on one side is higher than on the other, an asymmetrical roadway section may be advantageous. Roadway cross slopes less than or greater than the typical cross slopes may be necessary in order to adapt to roadside elevations and constraints. Also, it may be advantageous to offset the crown point from the centerline. Typical locations for offset crown points are at lane lines. Introducing changes in cross slope (additional "crown points") from one lane to another or between the outside travel lane and shoulder is an additional technique for conforming to existing roadside development.

Asymmetrical features should be clearly defined in the typical sections and shown in the cross sections. It will likely also be necessary to provide separate profiles at the top of curbs to match existing development. Providing an asymmetrical cross section may be preferred and more cost effective than reshaping existing sidewalks, parking lots, lawns, or other features to meet the revised profile.

5.5 BRIDGE AND UNDERPASS CROSS SECTIONS

The roadway cross section should be carried across and under bridges, which often requires special considerations because of the confining nature of bridges and their high unit costs.

5.5.1 Bridges

Coordinate with the Bridge Bureau to determine widths on new and reconstructed bridges and on existing bridges to remain in place.

5.5.2 Underpasses

Coordinate with the Traffic and Safety Bureau to determine if future widening of a roadway is anticipated.

The approaching roadway cross section, including shoulders, bicycle lanes, and auxiliary lanes, should be carried through the underpass. Sidewalks may also be necessary through the underpass as described in Section 5.2.9.

When determining the cross section width of an underpass, the design team should also consider the likelihood of future roadway widening. Widening an existing underpass in the future can be extremely expensive and challenging. If the potential for future traffic growth and roadway expansion exists, the design team should evaluate the possibility of providing additional width for the underpass. If appropriate, a reasonable allowance for future widening may be to provide sufficient lateral clearance for one additional lane in each direction.

5.5.3 Traveled Way Width Reductions

When an approaching roadway has a different width than a bridge or underpass, in certain situations the traveled way width may need to be widened or reduced in advance to allow the roadway to pass over or under a bridge. These traveled way width transitions should be designed according to the guidance in Section 5.2.2.2 and using the taper rates in Exhibit 5-5.

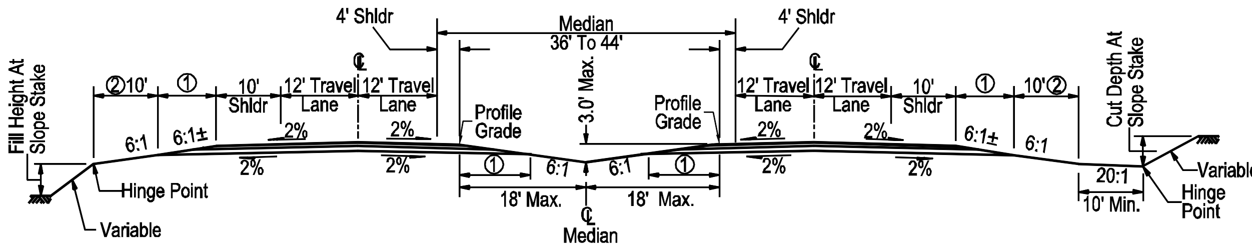
5.6 TYPICAL SECTIONS

The following exhibits present typical sections which will apply to various types of roadways for all projects. The MDT *Geometric Design Standards* presents recommended values for cross section elements based on the roadway functional classification *(1)*. The typical section exhibits are:

1. Exhibit 5-9: Typical Freeway with Depressed Median Section (Tangent Section) (Medians 36 feet to 44 feet);

2. Exhibit 5-10: Typical Freeway with Depressed Median Section (Superelevated Section) (Medians 36 feet to 44 feet);
3. Exhibit 5-11: Typical Freeway with Depressed Median Section (Tangent Section) (Medians >44 feet to 76 feet);
4. Exhibit 5-12: Typical Freeway with Depressed Median Section (Superelevated Section) (Medians >44 feet to 76 feet);
5. Exhibit 5-13: Typical Freeway with Depressed Median Section (Tangent Section) (Medians >76 feet wide);
6. Exhibit 5-14: Typical Freeway with Depressed Median Section (Superelevated Section) (Medians >76 feet wide);
7. Exhibit 5-15: Typical Four-Lane Divided Roadway with Flush Median Section (Tangent Section);
8. Exhibit 5-16: Typical Four-Lane Divided Roadway with Flush Median Section (Superelevated Section);
9. Exhibit 5-17: Typical Four-Lane Divided Roadway with Raised Median Section (Tangent Section);
10. Exhibit 5-18: Typical Four-Lane Divided Roadway with Raised Median Section (Superelevated Section);
11. Exhibit 5-19: Typical Two-Lane Roadway (Tangent Section);
12. Exhibit 5-20: Typical Two-Lane Roadway (Superelevated Section);
13. Exhibit 5-21: Typical Curbed Roadway (Tangent Section);
14. Exhibit 5-22: Typical Curbed Roadway (Superelevated Section);
15. Exhibit 5-23: Typical Off-System Roadway (Tangent Section); and
16. Exhibit 5-24: Typical Off-System Roadway (Superelevated Section)

Exhibit 5-9 Typical Freeway with Depressed Median Section (Tangent Section) (Medians 36 feet to 44 feet)

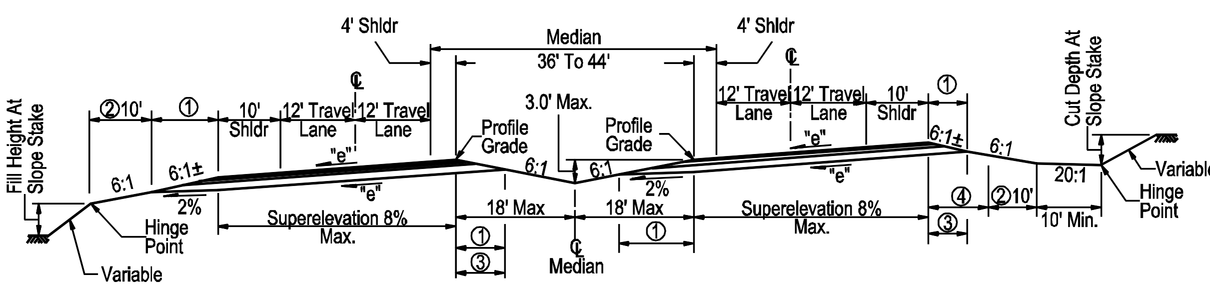


General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes)

① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

② For rehabilitation projects, an existing 6 foot width may be retained with documentation.

Exhibit 5-10 Typical Freeway with Depressed Median Section (Superelevated Section) (Medians 36 feet to 44 feet)



General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes). See Chapter 3 for details on superelevation.

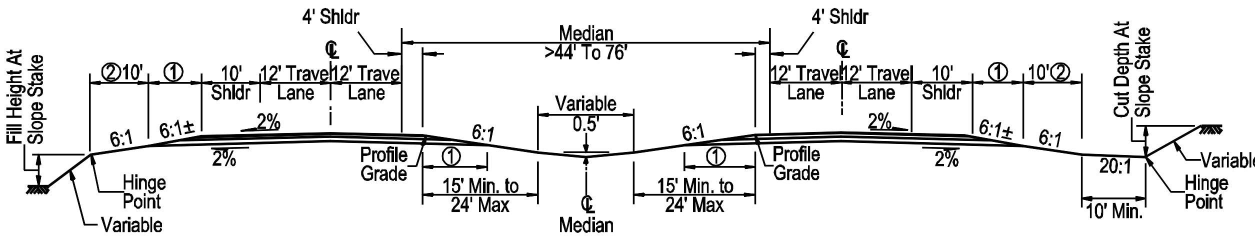
① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

② For rehabilitation projects, an existing 6 foot width may be retained with documentation.

③ Compute distance for each superelevation on the project.

④ This distance will be equal to the ① distance on the tangent section (Exhibit 5-9).

**Exhibit 5-11 Typical Freeway with Depressed Median Section (Tangent Section)
(Medians >44 feet to 76 feet)**

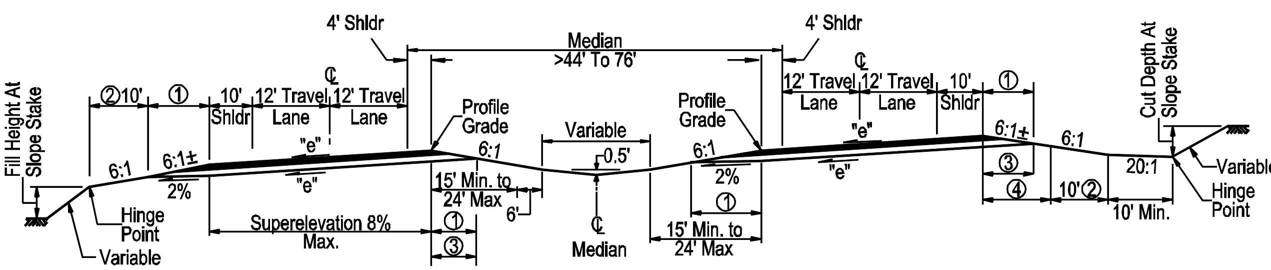


General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes)

① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

② For rehabilitation projects, an existing 6 foot width may be retained with documentation.

**Exhibit 5-12 Typical Freeway with Depressed Median Section (Superelevated Section)
(Medians >44 feet to 76 feet)**



General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes). See Chapter 3 for details on superelevation.

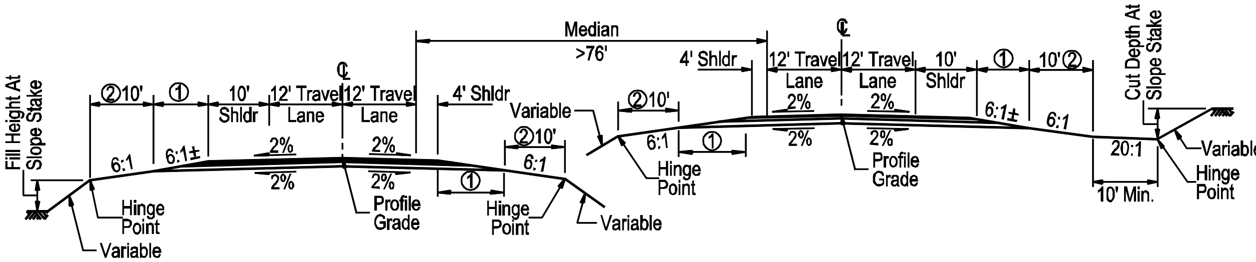
① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

② For rehabilitation projects, an existing 6 foot width may be retained with documentation.

③ Compute distance for each superelevation on the project.

④ This distance will be equal to the ① distance on the tangent section (Exhibit 5-11).

Exhibit 5-13 Typical Freeway with Depressed Median Section (Tangent Section) (Medians >76 feet wide)



General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes)

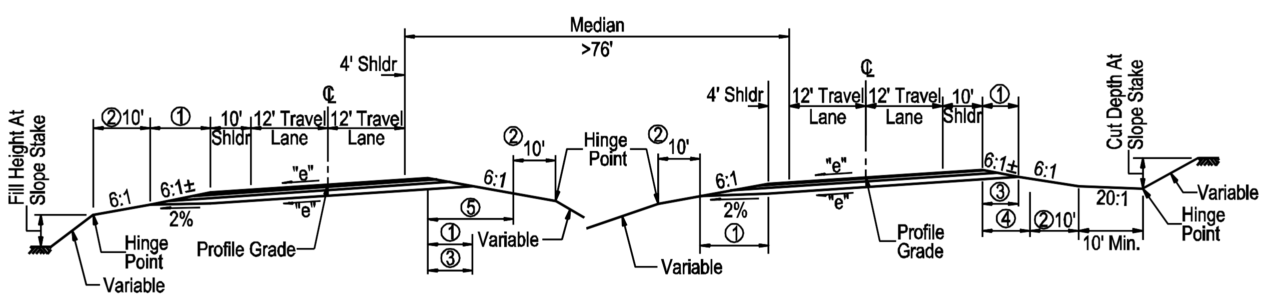
Generally, this typical section will be used only where terrain warrants the use of independent grade lines. Median slope intersections will be determined by the designer to meet individual conditions. In cases where median widths vary (from 36' to 76' and over) within a given project, the profile grade will be carried on the finished median shoulder.

Where practical, natural growth in place between roadways should be preserved.

① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

② For rehabilitation projects, an existing 6 foot width may be retained with documentation.

Exhibit 5-14 Typical Freeway with Depressed Median Section (Superelevated Section) (Medians >76 feet wide)



General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes). See Chapter 3 for details on superelevation.

Generally, this typical section will be used only where terrain warrants the use of independent grade lines. Median slope intersections will be determined by the designer to meet individual conditions. In cases where median widths vary (from 36' to 76' and over) within a given project, the profile grade will be carried on the finished median shoulder.

Where practical, natural growth in place between roadways should be preserved.

① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

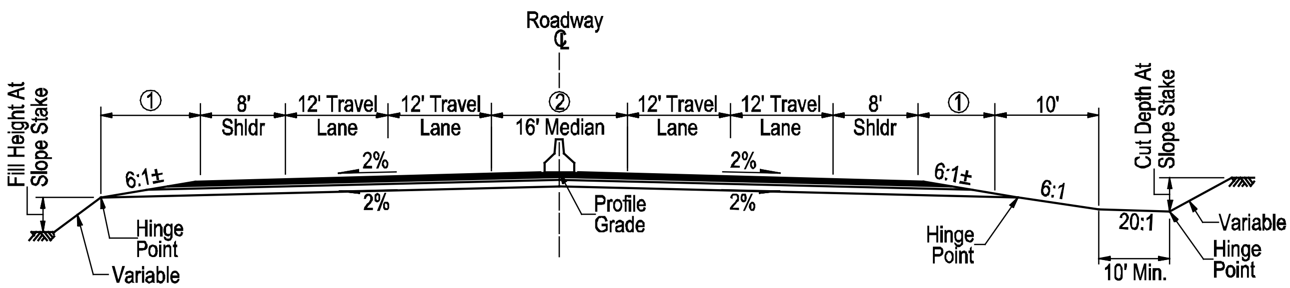
② For rehabilitation projects, an existing 6 foot width may be retained with documentation.

③ Compute distance for each superelevation on the project.

④ This distance will be equal to the ① distance on the tangent section (Exhibit 5-13).

⑤ This distance will be equal to the ① distance on the tangent section plus 10'.

Exhibit 5-15 Typical Four-Lane Divided Roadway with Flush Median Section (Tangent Section)



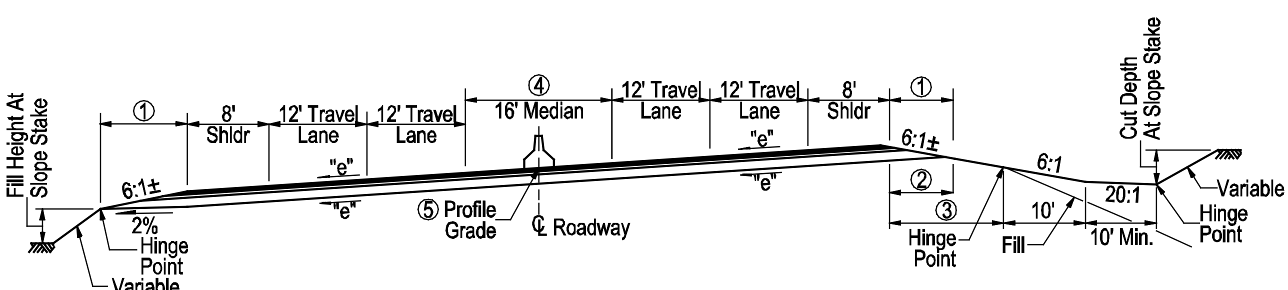
General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes)

The need for a median barrier will be determined on a case-by-case basis.

① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

② A reduced median width may be used, see MDT Geometric Design Standards

Exhibit 5-16 Typical Four-Lane Divided Roadway with Flush Median Section (Superelevated Section)



General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes). See Chapter 3 for details on superelevation.

① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

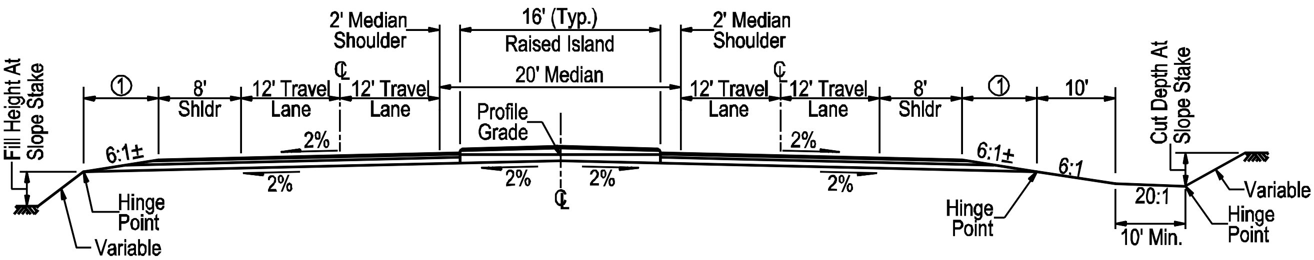
② Compute distance for each superelevation on the project.

③ This distance will be equal to the ① distance on the tangent section (Exhibit 5-15).

④ A reduced median width may be used, See MDT Geometric Design Standards

⑤ For medians >10 feet wide, separate profile grade lines at the median-edge of pavement may be appropriate.

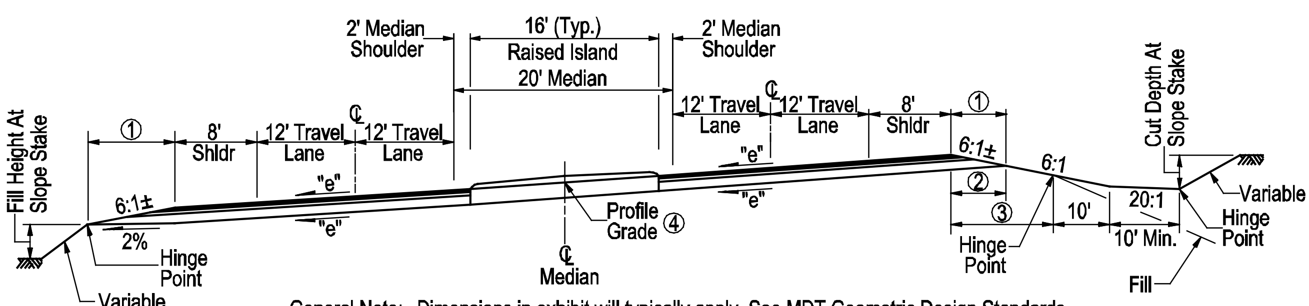
Exhibit 5-17 Typical Four-Lane Divided Roadway with Raised Median Section (Tangent Section)



General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes)

① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

Exhibit 5-18 Typical Four-Lane Divided Roadway with Raised Median Section (Superelevated Section)



General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes). See Chapter 3 for details on superelevation.

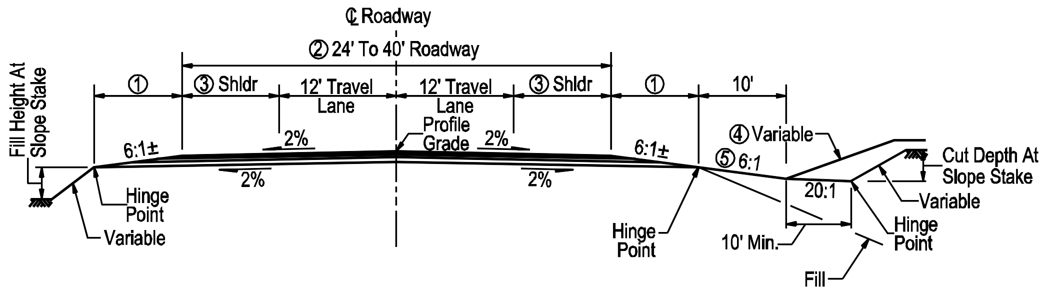
① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

② Compute distance for each superelevation on the project.

③ This distance will be equal to the ① distance on the tangent section (Exhibit 5-17).

④ For medians >10 feet wide, separate profile grade lines at the median-edge of pavement may be appropriate.

Exhibit 5-19 Typical Two Lane Roadway (Tangent Section)



General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes)

① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

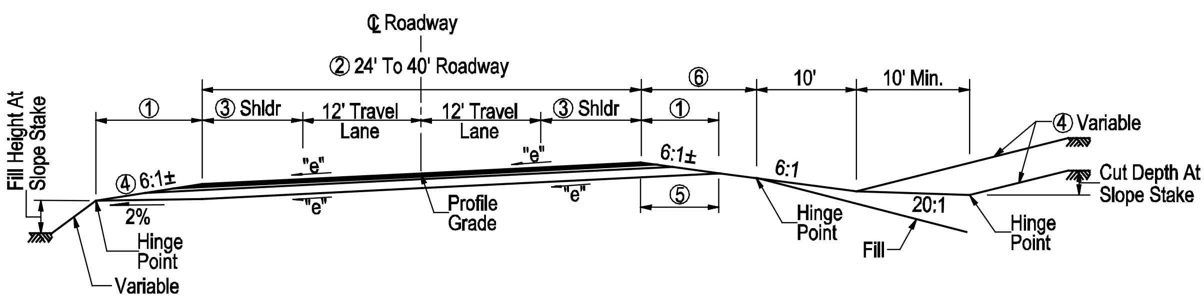
② Roadway width will vary. See MDT Geometric Design Standards for specific criteria.

③ Shoulder width will vary. See MDT Geometric Design Standards for specific criteria. New projects should include full-depth shoulders.

④ V-ditches may be used in special cases. Check Chapter 9: Roadside Safety for traversability criteria for roadside ditches.

⑤ The inslope may be 4:1 for some major collectors, See MDT Geometric Design Standards for specific criteria.

Exhibit 5-20 Typical Two-Lane Roadway (Superelevated Section)



General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes). See Chapter 3 for details on superelevation.

① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

② Roadway width will vary. See MDT Geometric Design Standards for specific criteria.

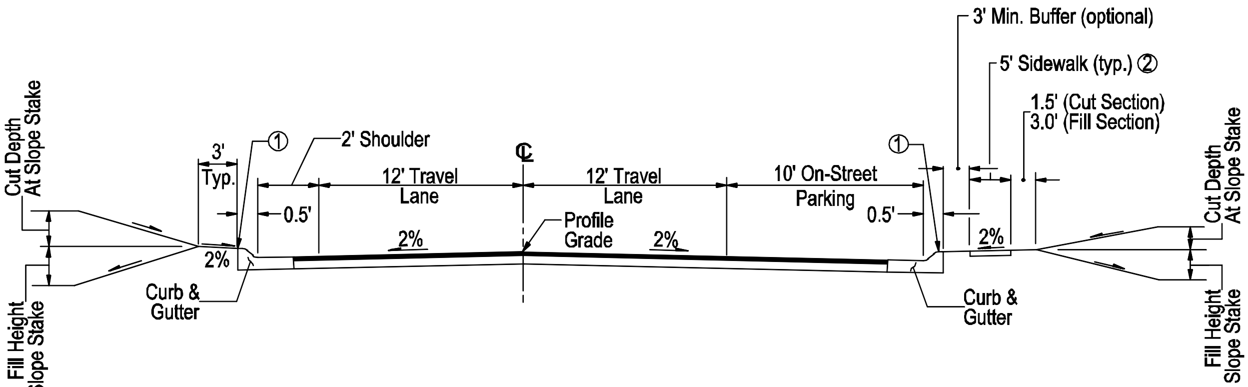
③ Shoulder width will vary. See MDT Geometric Design Standards for specific criteria. New projects should include full-depth shoulders.

④ See Chapter 13: Quantity Summary for method of computing intermediate thickness on low side of curves.

⑤ Compute distance for each superelevation on the project.

⑥ This distance will be equal to the ① distance on the tangent section (Exhibit 5-19)

Exhibit 5-21 Typical Curbed Roadway (Tangent Section)

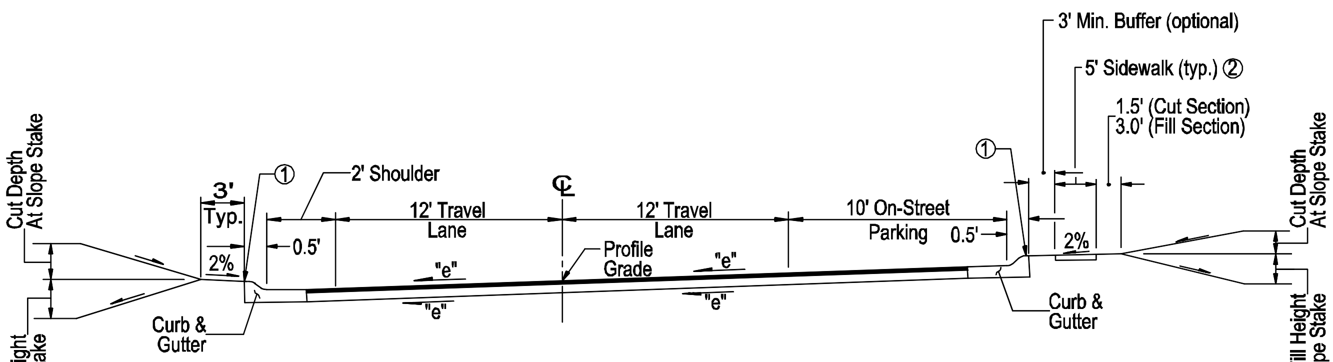


General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes)

① It may be necessary to use separate profiles at the top back of curb to promote positive drainage and to match existing development

② See Section 5.2 for sidewalk design criteria.

Exhibit 5-22 Typical Curbed Roadway (Superelevated Section)



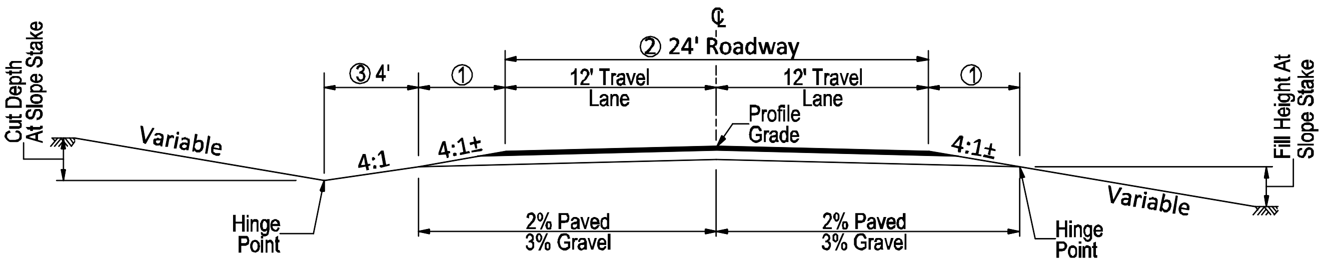
General Note: Dimensions in exhibit will typically apply. See MDT Geometric Design Standards for specific cross section criteria for various conditions (e.g. for cut and fill slopes). See Chapter 3 for details on superelevation.

Superelevation of 4% max applies to low-speed urban streets with V ≤ 45 mph.

① It may be necessary to use separate profiles at the top back of curb to promote positive drainage and to match existing development

② See Section 5.2 for sidewalk design criteria.

Exhibit 5-23 Typical Off-System Roadway (Tangent Section)



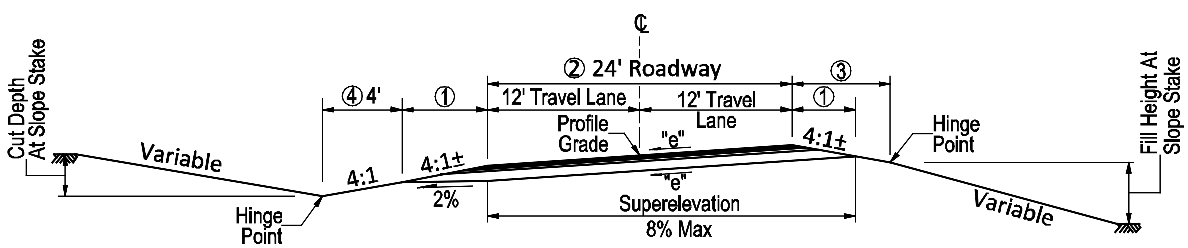
General Note: For ADT > 300, use the criteria for a major collector.

① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

② Roadway width may vary; see MDT Geometric Design Standards.

③ Check Chapter 9: Roadside Safety for traversable requirements. For non-traversable ditches, place the tow of the ditch outside the clear zone.

Exhibit 5-24 Typical Off-System Roadway (Superelevated Section)



① Compute subgrade and intermediate surfacing widths to nearest 0.1 foot. Slope is indicated as ± due to rounding.

② Roadway width may vary; see MDT Geometric Design Standards.

③ This distance will be equal to the ① distance on the tangent section (Exhibit 5-23)

④ Check Chapter 9: Roadside Safety for traversable requirements. For non-traversable ditches, place the tow of the ditch outside the clear zone.

5.7 REFERENCES

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