

MONTANA DEPARTMENT OF TRANSPORTATION

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**ROAD DESIGN MANUAL**

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Chapter 7  
Multimodal Design Considerations

September 2016





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# Chapter 7

## Multimodal Design

### Considerations

#### 7.1 INTRODUCTION

The explicit design for all modes of travel is an integral part of a roadway project and has an impact on the safety and operational performance for various road users, as well as construction and maintenance costs. This chapter presents the basic design principles and approach for designing multimodal design elements, including pedestrian facilities, bicycle facilities, shared used paths, crossing treatments, and transit facilities. The *Montana Department of Transportation (MDT) Geometric Design Standards* provides specific cross sectional dimensions relative to a roadway's functional classification (1). The design team should also coordinate with the Traffic and Safety Bureau and Planning Division to obtain an understanding of local plans, operational and safety aspects, as well as the traffic engineering design elements for signing and pavement markings associated with the multimodal design.

#### 7.2 DESIGN PRINCIPLES AND APPROACH

Roadway facilities should be designed and operated to enable safe access for various users, including pedestrians, bicycles, motorists, and transit riders of all ages and abilities. A fundamental consideration in establishing a multimodal improvement project is an overall vision for the facility tailored toward the specific users, project context, and desired outcome. The intended function of the facility is a key aspect in the development of an overall vision for its use.

With a clear understanding of the users and intended functions of a highway or street, the design team can work toward establishing a design that best serves the vision for the facility. Overarching design principles for each mode of travel is described below.

**MDT Geometric Design Standards provide a starting point for the design team to make a thoughtful evaluation of the project needs in consideration of the specific context.**

**An enhanced crossing provides additional treatments (e.g., signing, pavement markings, beacons, signals) to make it easier for multimodal users to cross a roadway.**

- **Pedestrian facilities.** Adjacent land uses and roadway conditions frequently create a need for a certain quantity or quality of pedestrian facility above the minimum. For example, people who are walking along a high-speed roadway, benefit from more separation from motorized vehicles, while people walking in a downtown environment with a higher density of land uses may need wider pedestrian facilities to accommodate a larger walking demand.
- **Bicycle facilities.** The diversity of rural and urban roadways and the diversity of people’s cycling skills and comfort levels makes bicycle facility design complex. As a result, treatments often need to be tailored to individual situations. For example, if a project goal is to attract new bicycle users, then the design team should consider providing some separation from vehicular travel lanes.
- **Shared facilities.** The anticipated usage of shared facilities will likely determine the width of the facility to minimize conflicts, as well as access to recreational destinations.
- **Crossing treatment.** The existing and/or future land uses along the roadway will likely result in natural origin-destination walking paths. People who are walking typically follow the shortest path, so the design team should consider appropriate locations at regular intervals to provide enhanced crossings based on pedestrian volumes.
- **Transit facilities.** The location (upstream or downstream of intersections) and type of bus stop (in-lane or pullout) used along a corridor are key transit design elements. The design team should coordinate with and incorporate recommendations from the MDT transit policy and local transit entity to establish desired design elements early in the project.

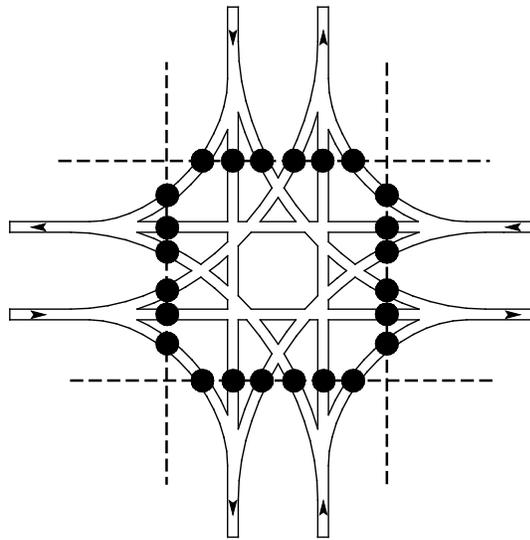
The criteria provided in the *MDT Geometric Design Standards* are a starting point for the design team to make a thoughtful evaluation of the project needs in consideration of the specific context. In addition, a performance-based design approach can help document the decision-making process and help the design team understand the trade-offs.

## 7.3 PEDESTRIANS

This section provides design guidance for pedestrian facilities and their integration into the roadway design. Additional design considerations and details for pedestrian facilities may be found in the *American Association of State Highway and Transportation Officials (AASHTO) Guide for the Planning, Design, and Operation of Pedestrian Facilities (2)*.

### 7.3.1 Conflict Areas

A pedestrian/vehicle conflict point exists anywhere a pedestrian path crosses a vehicular path, such as where a pedestrian walking path crosses vehicular travel lanes and the pedestrian is exposed for the entire duration when crossing a roadway. Exhibit 7-1 illustrates a typical intersection and highlights the pedestrian/vehicle conflict points.



**Exhibit 7-1**  
**Diagram of Pedestrian/Vehicle**  
**Conflict Points**

Typical conflict areas include the following:

- **Approaches (driveways).** Drivers need appropriate sight distance to be aware of a potential conflict with a pedestrian while entering and/or exiting an approach. This conflict area can be emphasized by providing pavement markings as well as properly maintaining appropriate landscaping in the vicinity of the approach. Treatments added to emphasize the conflict area should be considered on a case-by-case basis and may not be appropriate for all projects.
- **Intersections.** To properly design an intersection, a design team should understand the factors a pedestrian must consider when crossing at an intersection. The Traffic and Safety Bureau will design the configuration of the intersection and coordinate with the design team to locate crosswalks through the intersection.
  - A signalized intersection provides an indication when to cross a roadway. However, there may be a permissive signal phase that allows vehicular left- and/or right-turns that may conflict with pedestrians in a crosswalk.
  - Pedestrians need an unobstructed sight triangle at an unsignalized intersection to determine an appropriate time to cross.
  - The combination of roadway width and intersection corner radii sets the crossing distance at an intersection. Smaller corner radii can shorten the crosswalk, but the ability to do this depends on the design vehicle for the intersection and how vehicles are allowed to complete their turns. For example, a larger radius (or combination of radii, as discussed in Chapter 6) is typically provided at higher order facilities (e.g., arterials) to accommodate larger trucks who are expected to maintain lane position when turning right.

**The objective is to design an intersection that provides sight distance for the various users to be aware of each other's presence, especially at conflict areas.**

The objective is to design an intersection that provides sight distance for the various users to be aware of each other's presence, especially at these conflict areas. Section 2.8 provides the details for evaluating intersection sight distance.

### 7.3.2 Accessibility Considerations

Pedestrian facilities shall be designed to be accessible to all users, regardless of ability. The United States Access Board provides many additional resources on accessibility and specific requirements for Accessible Public Rights of Way. Accessibility relates to special consideration given to pedestrians with disabilities including accommodating pedestrians with vision or mobility impairments. The design team should be familiar with the policies related to the Americans with Disability Act (ADA) and *Public Rights-of-Way Accessibility Guidelines (PROWAG)* (3).

In the context of the public right-of-way, the basic principles for accessible design can be divided into the pedestrian walkway and the pedestrian crossing location. The following considerations apply:

- Provide a walkway free of obstructions and delineate the walkway through landscaping, curbing, or fencing to assist with wayfinding for visually impaired pedestrians.
- Provide sufficient space (length and width) and recommended slope rates (transverse and longitudinal) for wheelchair users and other non-motorized users such as people pushing strollers and walking bicycles.
- Construct ADA compliant pedestrian ramps with an appropriate landing with flat slopes and sufficient size at crossing points.
- Provide detectable warning devices at the end of the walkway where it intersects the street.
- Align the walkway access point with the street crosswalk, if it is marked. If the crossing is not marked, align the walkway access point to the intended crossing direction. If the crosswalk is marked, the minimum crosswalk width is 8 feet.
- Provide a sufficiently wide crosswalk through the intersection to permit pedestrians, including two wheelchair users, to pass without delay from opposing directions, and provide sufficient storage in sufficiently wide medians to allow all non-motorized users to safely wait when two-stage crossings are desired or required. Crosswalks should be designed to have a cross slope of 2-percent or less. However, the design team should consider a cross slope of 1.5-percent to allow for potential deviations and flexibility during construction.

All people—but especially those with vision, mobility, or cognitive impairments—may benefit from targeted outreach and additional informational material created to illustrate the best and safest way to cross the public roadway and use the pedestrian facilities.

**A pedestrian is defined as any person traveling by foot and any mobility-impaired person using a wheelchair.**

**Pedestrians may benefit from targeted outreach and additional informational material created with pedestrians in mind.**

**A wheelchair is a mobility aid and designed for and used by individuals with mobility impairments.**

### 7.3.3 Pedestrian Treatments

The following sections provide an overview of various pedestrian treatments that provide different levels of separation. The design team should consider the level of separation that appeals to a wide variety of users based on the project context and future vision of the facility.

#### 7.3.3.1 Separated Pedestrian Path

A pedestrian path is a hard-surface path adjacent to the roadway in lieu of a sidewalk in areas where other bicycle facilities exist or where bicyclists typically share the road on a low-volume facility, as shown in Exhibit 7-2. Similar to a sidewalk, pedestrian paths are narrower in width and generally do not invite bicycle travel.

Typical applications are:

- In constrained rural areas where sidewalks are not present and shared use paths cannot be accommodated.
- As an interim treatment in urbanizing areas to make connections between sidewalk facilities.

Design considerations are:

- Typically a minimum width of 6 feet (8 feet preferred) asphalt surface.
- Pedestrian paths are typically separated from the roadway by a gravel or vegetated buffer instead of a curb and gutter.
- Though not intended for bicyclists, pedestrian paths will attract bicyclists if a separate bicycle facility is not provided.



**Exhibit 7-2**  
**Separated Pedestrian Path**

#### 7.3.3.2 Sidewalks

A sidewalk is a dedicated pedestrian facility adjacent to the roadway and separated from vehicular traffic by a curb (e.g., curb-tight sidewalk) and buffer area (detached sidewalk), as shown in Exhibit 7-3 and Exhibit 7-4. The following guidance will help determine the need for sidewalks:

1. **Sidewalks Currently Exist (Roadway or Bridge).** Where sidewalks currently exist along a roadway, the sidewalk will normally be replaced. If a bridge with an existing sidewalk is replaced or rehabilitated, the sidewalk will normally be replaced.



**Exhibit 7-3**  
**Curb-tight Sidewalk**

**Exhibit 7-4**  
**Detached Sidewalk**



2. **Sidewalks Currently Do Not Exist (Roadway).** The need for sidewalks will be determined on a case-by-case basis in cooperation with the local community. In general, the design team should consider providing sidewalks along any roadway where people normally walk or would be expected to walk if they had a sidewalk available (a latent demand exists). In addition, sidewalks may be required at specific sites even if they are not needed along the entire length of the roadway.

These include points of community development (schools, local businesses, shopping centers) resulting in pedestrian concentrations along the roadway. If curb and gutter is included in the roadway section, the need for sidewalks should be evaluated. This evaluation is especially critical in developing transitional areas between rural and urban areas. Where new curb and gutter sections are being proposed without sidewalks, the design team should consider adding a berm behind the curb that is wide enough to accommodate a future sidewalk.

3. **Bridge without Sidewalk/Roadway with Sidewalk.** If a bridge without a sidewalk will be replaced or rehabilitated, and if existing sidewalks approach the bridge, a sidewalk will normally be included in the bridge project. Even if not currently on the approaching roadway, sidewalks may still be necessary on the bridge if the approach roadway is a candidate for future sidewalks.

As a more general statement of MDT policy, bridge projects within urban areas will have a sidewalk where pedestrians are legally allowed, unless there is a compelling reason not to provide a sidewalk. In addition, bridges at interchanges near urban areas should normally include sidewalks to accommodate the commercial development that may occur in the immediate vicinity of interchanges.

4. **Sidewalks Currently Do Not Exist (Underpasses).** If an underpass is within the limits of a project that includes sidewalks, then sidewalks will normally be provided through the underpass, unless this would involve unreasonable costs to modify the bridge substructure.

For new and reconstruction underpass projects, the bridge substructure should allow space for future sidewalks through the underpass based on the eventual need for sidewalks on the roadway.

5. **One Side vs. Two Sides.** Sidewalk requirements for each side of the roadway or bridge will be evaluated individually; placing a sidewalk on each side will be based on the specific characteristics of that side.

6. **Approval.** For all projects in urban areas, the addition of sidewalk should be documented and approved in the Scope of Work Report. This applies to the roadways, bridges, and underpasses.

Design considerations are:

- Typically 6 feet or wider depending on the project context. Sidewalks should be constructed at least 5 feet wide, with a minimum of 4 feet of clear width, excluding any obstructions (e.g., utility poles).
- A buffer area between the roadway and the sidewalk is preferable in urban areas, particularly in residential areas and in locations with higher traffic speeds and volumes. This area also may be used for snow storage during maintenance activities.
- Wider sidewalks of 12 to 20 feet can be beneficial in commercial or “town center” areas to accommodate higher pedestrian volumes, street furniture, pedestrian scale lighting, business signage, bicycle parking, transit stops, and other amenities.

## 7.4 BICYCLES

This section provides design guidance for bicycle facilities and their integration into the roadway design. Additional design considerations and details for bicycle facilities may be found in the *AASHTO Guide for the Development of Bicycle Facilities, 4th Edition (4)*.

### 7.4.1 Bicycle Lane Design at Intersections

Bicyclists may use different paths riding through an intersection, depending on their skill and comfort riding with motorized vehicle traffic. There are several locations that need to be addressed when planning and designing for bicycles at an intersection. These options are in addition to traveling through the intersection as a pedestrian, which may be preferable for some people.

- **Through movement.** There are two common conditions for which a bicyclist needs to navigate through an intersection: a shared through/right lane with a bicycle lane on the outside, and a separate right-turn lane on the outside of the bicycle lane.
  - For the shared through/right lane condition, both the bicyclist making a through movement and the right-turning vehicle should be aware of the potential conflict.
  - When a separate right-turn is present, a bicyclist may have to ride between two streams of vehicles along the length of the right-turn lane. The entrance to the right-turn lane also presents a bicycle-vehicle conflict point.

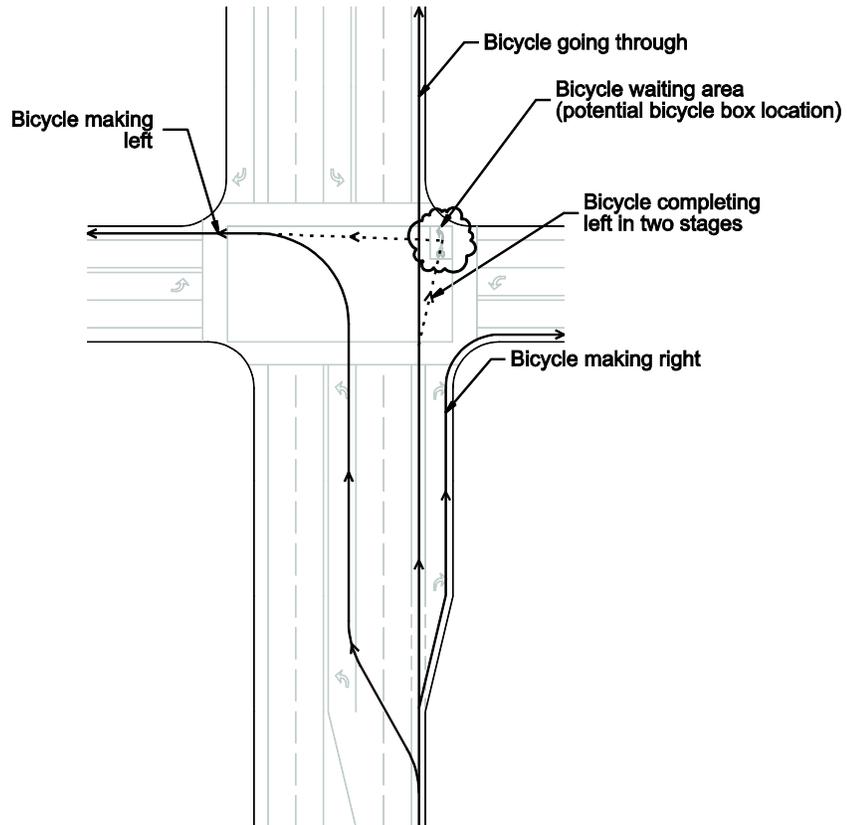
There may be a need to emphasize the areas where bicyclists are exposed at these conflict areas by delineating the bicycle travel areas through the intersections.

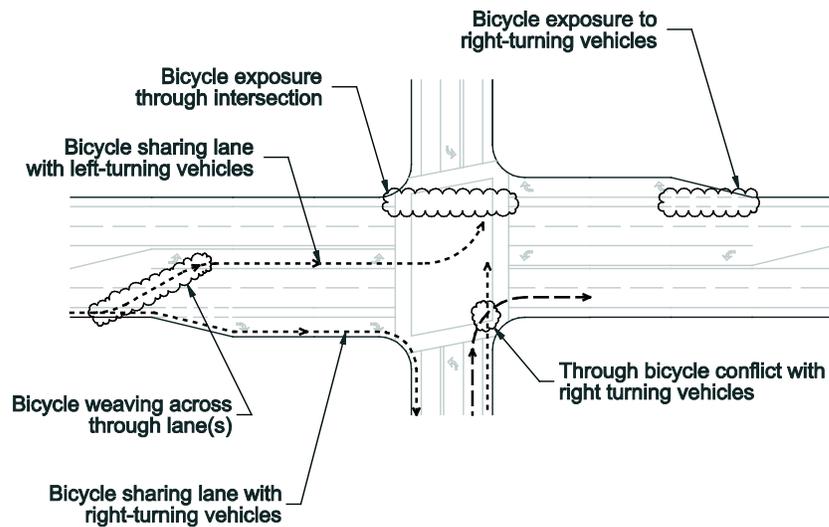
- **Right turn.** For the shared through/right lane condition, bicyclists will follow the bicycle lane and turn right onto the side street. If a right-turn lane is present, right-turning motorized vehicles and bicycles typically share the right-turn lane and, depending on their respective volumes and travel speeds, bicyclists may choose to use the sidewalk.

- **Left turn.** There are two ways for a bicycle to complete a left-turn at an intersection:
  - Weaving across one or more traffic lanes to use the left-turn lane, as a motorized vehicle would do. This may present a challenge especially in high-volume high-speed conditions.
  - If the intersection geometry provides a refuge area in the far-side corner, a bicycle box can be placed to allow a two-stage left turn by bicyclists. Sometimes there is no defined bicycle box, but bicyclists still complete the left turn in two stages by waiting in the far-side intersection corner.

Exhibits 7-5 and 7-6 show the range of bicyclist paths through the intersections and highlight the conflict areas and the opportunities that the design team needs to address in the design.

**Exhibit 7-5**  
**Bicycle Path**





**Exhibit 7-6**  
**Bicycle Conflict Areas**

## 7.4.2 Bicycle Treatments

The following sections provide an overview of bicycle treatments that provide different levels of separation. The design team should consider the level of separation that will appeal to a wide variety of users based on the project context, consistency with local plans and future vision of the facility. For example, bicycle treatments are commonly categorized by the level of separation they provide bicyclists from motorized vehicles. Separated facilities have been found to attract more bicyclists of a variety of ages and abilities and are generally considered “lower stress” facilities. However, separated facilities must be carefully designed to allow for safe crossings and turning movements for both motorized vehicles and bicyclists at intersections.

### 7.4.2.1 Paved Shoulder

A paved road shoulder can serve as space for bicycles that is separated from motorized vehicle traffic in rural areas, as shown in Exhibit 7-7.

Typical applications are:

- Typically applied on rural roadways.

Design considerations are:

- Rumble strips or pavement markings can be used to enhance safety and minimize motorists encroaching on the shoulder. The design team should verify the use of rumble strips based on the most recent policy, which is further discussed in Chapter 5.



**Exhibit 7-7**  
**Paved Shoulder**

**If the road is designated as a bicycle route, then consider bicycle lane treatments as described in future sections.**

**Exhibit 7-8**  
**One-Way Separated**  
**Bicycle Lane**

#### 7.4.2.2 *Standard Bicycle Lane*

A standard bicycle lane is an on-street facility that provides space designated for bicyclists, separated from vehicles by pavement markings, as shown in Exhibit 7-8.

Typical applications are:

- Streets without sufficient right-of-way or pavement width for buffered bicycle lanes or separated bicycle lanes (SBLs).

Design considerations are:

- Typical bicycle lane width is 6 feet, with 5 feet in constrained locations. A minimum 4-foot width can be used on constrained segments where on-street parking is not present.
- Colored pavement can add visibility and awareness in “conflict areas” or intersections where bicycle and vehicle travel paths cross.



**Exhibit 7-9**  
**Buffered Bicycle Lane**

#### 7.4.2.3 *Buffered Bicycle Lane*

Buffered bicycle lanes are on-street lanes that include an additional striped buffer, typically 2 to 3 feet wide, between the bicycle lane and the motorized vehicle travel lane (as shown in Exhibit 7-9) and/or between the bicycle lane and the motorized vehicle parking lane.

Typical applications are:

- Long-distance links within and between communities.
- Streets with sufficient pavement width to provide a buffer.
- Widely applicable in both urban and rural settings.
- Segments of the bicycle network with moderate vehicle speeds or volumes.

Design considerations are:

- Typical buffer width is 2 to 3 feet, in addition to the standard bicycle lane width of 5 to 6 feet.
- Colored pavement can add visibility and awareness in “conflict areas” or intersections where bicycle and motorized vehicle travel paths cross.
- Buffer space can have diagonal stripes and/or rumble strips to discourage motorized vehicles from traveling or parking in the space.



#### 7.4.2.4 One-Way Separated Bicycle Lane (Cycle Track)

A one-way separated bicycle lane (SBL), also known as a cycle track or protected bicycle lane, is a bicycle facility within the street right-of-way separated from motorized vehicle traffic by a buffer and/or a physical barrier. Exhibit 7-10 shows on-street parking as a buffer for the bicycle treatment. On two-way streets, a one-way SBL would be found on each side of the street, similar to a standard bicycle lane.



**Exhibit 7-10**  
**One-Way Separated Bicycle Lane**

**Colored pavement is not effective at adding visibility and awareness during snow and ice conditions.**

Typical applications are:

- Roadway segments with sufficient right-of-way or where a motorized vehicle lane reduction (also referred to as a “road diet”) can be implemented.
- Key segments of the bicycle network where more protection is desirable, such as areas with higher traffic volumes or speeds, or routes to common destinations, such as schools.
- Roadways with infrequent approaches (driveways) and side street accesses.

Design considerations are:

- Intersections must be designed to ensure visibility of bicyclists using the facility. Treatments may include high visibility pavement markings.
- Buffer type can vary depending on context, presence of parking, and available right-of-way (e.g., planters, flexible posts, parked cars, or a mountable curb).
- Colored pavement can add visibility and awareness in “conflict areas” or intersections where bicycle and motorized vehicle travel paths cross.
- Refer to the Federal Highway Administration (FHWA) *Separated Bike Lane Planning and Design Guide* for further design considerations (5).

#### 7.4.2.5 Two-Way Separated Bicycle Lane (Cycle Track)

A two-way separated bicycle lane (SBL), also known as a two-way cycle track or two-way protected bicycle lane, is a facility within the street right-of-way separated from motorized vehicle traffic by a buffer and a physical barrier, as shown in Exhibit 7-11. Two-way SBLs serve bi-directional bicycle travel within the facility on one side of the street.



**Exhibit 7-11**  
**Two-Way Separated Bicycle Lane**

Typical applications are:

- On-street connections between off-street shared use paths.

- Roadways with infrequent approaches (driveways) and side street accesses.
- Key segments of the bicycle network where more protection is desirable, such as areas with higher traffic volumes or speeds, or routes to common destinations, like schools.
- On one-way streets where two-way bicycle travel is desirable.

Design considerations are:

- Intersections must be designed to ensure visibility of bicyclists using the facility. Treatments may include high visibility pavement markings.
- Buffer type can vary depending on context, presence of parking, and available right-of-way (e.g., planters, flexible posts, parked cars, or a mountable curb).
- Colored pavement can add visibility and awareness in “conflict areas” or intersections where bicycle and vehicle travel paths cross.
- Refer to the *Federal Highway Administration (FHWA) Separated Bike Lane Planning and Design Guide* for further design considerations (5).

## 7.4.3 Bicycle Intersection Treatments

### 7.4.3.1 Pavement Markings Through Intersections

Pavement markings can be extended through the intersection for both cycle tracks and bicycle lanes, as shown in Exhibit 7-12. Colored pavement can be used in “conflict zones” where vehicles and bicycles may cross paths in intersections, at approaches (driveways), or at right turn lanes.

Typical applications are:

- Intersections and conflict zones, especially in high-volume and/or high-speed areas.

Design considerations are:

- Consider white extension pavement markings to extend a treatment through an intersection or across a conflict zone. Dashed pavement markings can enhance awareness and visibility.



**Exhibit 7-12**  
**Pavement Markings Through**  
**Intersections**

### 7.4.3.2 Two-Stage Left-Turn Box

Two-stage left-turn boxes allow bicyclists to safely and comfortably make left-turns at multilane intersections from a right-side bicycle lane or cycle track, as shown in Exhibit 7-13. Bicyclists arriving on a green light travel into the intersection and pull out into the two-stage turn queue box away from through-moving bicycles and in front of cross street traffic, where they can wait to proceed through on the next green signal phase.



**Exhibit 7-13**  
**Two-Stage Left-Turn Box**

Typical applications are:

- At signalized intersections with multilane roadways, and
- At locations where a low-stress left-turn movement for bicyclists is desirable.

Design considerations are:

- Two-stage left-turn boxes should be located out of the way of through bicyclists, usually between the bicycle lane and the crosswalk. If there is on-street parking, space may be available between the bicycle lane and vehicle travel lane.
- Consider using passive bicycle detection in the two-stage left turn box to actuate the green signal phase for bicyclists.

### 7.4.3.3 Bicycle Boxes

Bicycle boxes are designated spaces at signalized intersections, placed between a set-back stop line and the crosswalk, that allow bicyclists to queue in front of motorized vehicles at traffic signals, as shown in Exhibit 7-14.



**Exhibit 7-14**  
**Bicycle Box**

Typical applications are:

- Signalized intersections with high bicycle volumes, and
- Signalized intersections where a designated bicycle route turns left.

Design considerations are:

- Minimum depth of the bicycle box should be 10 feet, and it should extend across the bicycle lane, any buffer space, and at least one adjacent vehicle travel lane.

**The main purpose of a bicycle box is to prevent collisions between bicyclists and right-turning motorists. Bicyclists are more visible to motorists when waiting in a bicycle box because they are in front of them rather than beside them.**

**Exhibit 7-15**  
**Shared Use Paths**

## 7.5 SHARED USE PATHS

Shared use paths are paved, bi-directional, trails away from roadways that can serve both pedestrians and bicyclists, as shown in Exhibit 7-15. Shared use paths can be used to create longer-distance links within and between communities and provide regional connections. They play an integral role in recreation, commuting, and accessibility due to their appeal to users of all ages and skill levels.



Additional design considerations and details for bicycle facilities may be found in the *AASHTO Guide for the Development of Bicycle Facilities, 4th Edition (4)*. Chapter 5, Section 5.2.9 provides additional cross section information for shared use paths.

Typical applications are:

- Medium- to long-distance links within and between communities that provide for commuter and recreational use.
- Parallel to roads in rural areas where sidewalks and on-street facilities are not present.

Design considerations are:

- Shared-use paths are best suited in areas where roadway crossings can be minimized (such as parallel to travel barriers such as uninterrupted roadways, railroad tracks, rivers, shorelines, and natural areas).
- Crossings may need high-visibility treatments.
- A width of 10 feet is recommended for low-pedestrian/bicycle-traffic contexts; 12 feet or wider should be considered in areas with moderate to high levels of bicycle and pedestrian traffic. An 8-foot width may be acceptable in constrained settings.
- The minimum recommended separation between the roadway and the shared use path is 5 feet.
- The maximum cross slope on a shared use path is 2 percent.
- Pavement markings can be used to indicate distinct space for pedestrian and bicycle travel.

**Design cross slope for 1.5 percent to allow for potential deviations and flexibility during construction. The AASHTO Green Book recommends a 1 percent cross slope, as discussed in Chapter 5, Section 5.2.9.2.**

## 7.6 CROSSING TREATMENT

The design team should coordinate with the Traffic and Safety Bureau to identify and understand the operational review and study completed to determine the appropriate treatment. This coordination should provide documentation to support the treatment decision, regarding the type and location of treatment. In addition, documentation will provide an overview of the various treatments considered.

### 7.6.1 Crossing Evaluation Considerations

The design team should coordinate with the Traffic and Safety Bureau to identify the appropriate crossing treatment. *NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings*, supplemented with research on the rectangular rapid flashing beacon (RRFB), provides guidance on improving pedestrian safety at unsignalized crossings (6). The RRFB is a pedestrian-actuated set of amber light-emitting diodes (LEDs) that rapidly flash when actuated. The NCHRP report provides tools for developing appropriate crossing treatments based on vehicle speeds, traffic volumes, and anticipated number of pedestrian and bicycle crossings.

Potential crossing treatments may include any of the following, or in some cases a combination of two or more of these: pavement markings, signing, flashing beacons, RRFBs, pedestrian hybrid beacons (PHBs), raised crosswalks and fully signalized crossings that are coordinated with the main intersection. Speech messages for visually impaired pedestrians may be considered for signalized type crossings.

### 7.6.2 Enhanced Crossing Treatments

Enhanced crossing treatments provide different levels of improvements for multimodal users. The design team should consider treatments that appeal to a wide variety of users based on the project context and future vision of the facility. For example, treatments for pedestrian mid-block crossings range from a high-level of enhancement, such as a grade-separated crossing structure, to a lower level of enhancement, such as the warning offered with a high-visibility crosswalk. Intermediary levels of enhancement can be provided with a pedestrian hybrid beacon or rectangular rapid flashing beacon. The design team should coordinate with the Traffic and Safety Bureau to determine the need for an operational study to identify the appropriate type of treatment. The design team should incorporate the results from the study.

#### 7.6.2.1 High Visibility Crosswalk

High visibility crosswalks consist of reflective pavement markings and accompanying signage at intersections and priority crossing locations, as shown in Exhibit 7-16. The location of the crosswalk is coordinated with the Traffic and Safety Bureau.

Typical applications are:

- At intersections of arterials, collectors, and/or other facilities with moderate to high pedestrian/bicycle usage, vehicle volumes and speeds.
- At midblock locations, especially in conjunction with other treatments.
- At designated school crossings.



**Coordinate with the Traffic and Safety Bureau to identify the appropriate crossing treatment.**

**Exhibit 7-16  
High Visibility  
Crosswalk**

**Coordinate with the Traffic and Safety Bureau for the appropriate crosswalk striping and signing to be installed at crosswalks.**

**Exhibit 7-17  
Raised Pedestrian Crossing**

**Raised pedestrian crossings are typically provided on lower order facilities (e.g., local roads or collectors).**

Design considerations are:

- Crosswalk pavement markings may vary (e.g., continental)
- Crosswalks should have a minimum width of 8 feet, but wider crossings are preferred in areas with a high number of pedestrians.

### 7.6.2.2 Raised Pedestrian Crossing

Raised pedestrian crossings bring the level of the roadway up so that it is even with the level of the sidewalk. The objective is to provide a level pedestrian crossing path and require vehicles to slow down to pass over the pedestrian crossing, as shown in Exhibit 7-17. Raised pedestrian crossings can be used at midblock crosswalks or intersections.



Typical applications are:

- At midblock crossings where speed control is desired.
- At intersections where low-volume streets intersect with high-volume streets or where a roadway changes character (such as from commercial to residential).
- Generally not on transit routes for passenger comfort.

Design considerations are:

- Raised crosswalks should be at the same level as the sidewalk and at least as wide as the sidewalk or pedestrian path that approaches the intersection. In some cases, the level of the sidewalk is sloped downward and the elevation of the roadway sloped upward to join at a midway point.
- Detectable warning devices are needed for pedestrians where they leave the sidewalk and enter the crossing area.
- Provide appropriate treatments for drainage needs.
- Maintenance activities should be considered, particularly for roadways that are generally plowed during snow conditions.

### 7.6.2.3 Bulb-Out/Curb Extensions

These include an extension of the curb or the sidewalk into the street (in the form of a bulb), usually at an intersection, that narrows the vehicle path, inhibits fast turns, and shortens the intersection crossing distance for pedestrians, as shown in Exhibit 7-18.

**Exhibit 7-18  
Bulb-Out/Curb Extension**



Typical applications are:

- Midblock or intersection pedestrian crossings on streets with unrestricted on-street parking.

Design considerations are:

- The curb extensions need accessible curb ramps and detectable warnings.
- Landscaping on the curb extension differentiates the path for pedestrian travel, especially for pedestrians with vision impairments.
- Appropriate space should be provided to accommodate design vehicles identified for the specific roadway.
- Drainage should be maintained along gutter pan or designed with added elements to change the drainage pattern.

#### 7.6.2.4 Crossing Island (Pedestrian Refuge)

A crossing island in the median provides an area in the middle of the road for pedestrians to stop if needed when crossing the road in two stages (i.e., crossing one direction of vehicular travel at a time), as shown in Exhibit 7-19. Also called pedestrian refuge islands or median refuges, they can be used at intersections or midblock crossings. Exhibit 7-20 shows a crossing island for an intersection with a channelized right-turn lane.

Typical applications are:

- Potential treatment for crossings of multilane roadways.
- Often used in areas with high levels of vulnerable pedestrian users, such as near schools or senior centers/housing.
- Often applied in areas with high traffic volumes.

Design considerations are:

- Crossing islands must have at least 6 feet of raised median width (measured face-to-face)
- They can be applied in conjunction with other traffic control treatments.



Exhibit 7-19  
Crossing Island



Exhibit 7-20  
Crossing Island with  
Channelization

**It is not always feasible to provide a desirable median width for pedestrian refuge; a narrow median with a cut-through may be used as a speed management technique.**

**Exhibit 7-21**  
**Rectangular Rapid Flashing Beacon**

**7.6.2.5 Rectangular Rapid Flashing Beacon (RRFB)**

These crossing treatments include signs that have a pedestrian-activated “strobe-light” flashing pattern to attract motorists’ attention and provide awareness of pedestrians and/or bicyclists that are intending to cross the roadway, as shown in Exhibit 7-21.



Typical applications are:

- Midblock crossings or shared use paths with medium to high pedestrian or bicycle demand and/or medium to high traffic volumes.

Design considerations are:

- The push button to activate the RRFB should be compliant with the *Manual on Uniform Traffic Control Devices (MUTCD)* and easily accessible by pedestrians, including wheelchair users (7).
- A push button in the median island (if present) can help pedestrians when crossing multilane facilities.

**7.6.2.6 Pedestrian Hybrid Beacon**

**Exhibit 7-22**  
**Pedestrian Hybrid Beacon**

**Coordinate with the Traffic and Safety Bureau to identify the appropriate treatment location.**

A pedestrian hybrid beacon is a pedestrian/bicyclist activated signal that rests in dark when not in use, as shown in Exhibit 7-22. It begins with a yellow light flashing that turns solid to alert drivers to slow, and then displays a solid red light requiring drivers to remain stopped while pedestrians and bicyclists receive a walk indication. Finally, the beacon changes to alternating flashing red lights while pedestrians and bicyclists receive a flashing don’t walk indication to signal that motorists may proceed after pedestrians and bicyclists are no longer in conflict.



Typical applications are:

- Midblock crossings with high pedestrian or bicycle demand.
- At locations where shared use paths intersect the mainline roadways, where appropriate.
- At multilane roundabout entries and exits.

Design considerations are:

- The push button to activate the pedestrian hybrid beacon should be compliant with the *Manual on Uniform Traffic Control Devices (MUTCD)* and easily accessible by pedestrians, including wheelchair users (7).

### 7.6.2.7 Pedestrian Signal

This crossing type can provide pedestrians with a signal-controlled crossing where pedestrian volumes warrant full signalization, as shown in Exhibit 7-23. The signal remains green for the mainline traffic movement until actuated. Pedestrian signals are typically applied at intersections that were previously stop controlled and pedestrian/bicycle volumes warrant a signal. The push button to activate the pedestrian signal should be compliant with the *Manual on Uniform Traffic Control Devices (MUTCD)* and easily accessible by pedestrians, including wheelchair users (7). Refer to ADA and *PROWAG* for additional guidance (3).



**Exhibit 7-23**  
Pedestrian Signal

### 7.6.2.8 Grade Separated Crossing

A grade-separated crossing is a bridge (overpass/underpass) that carries non-motorized traffic over or under a motorized corridor or other barrier to travel, as shown in Exhibit 7-24 and Exhibit 7-25.

Typical applications are:

- Crossings of limited access freeways, multilane roadways, or railroads.
- Shared use path crossings may have grade-separated crossings to provide comfortable and safe crossings for users of all skills and levels.

Design considerations are:

- If a substantial slope or out-of-direction travel is required, some bicyclists or pedestrians may avoid using the crossing; therefore, consider minimizing slope and out-of-direction travel, if possible.
- In selecting a grade separated crossing, consider the surrounding topography and natural features.
- Consider sight distance for bicyclists entering the facility to see oncoming bicyclists or pedestrians. If not possible, consider providing a stop controlled traffic device.
- If the crossing is used by pedestrians, it must be accessible to all users and meet ADA requirements.



**Exhibit 7-24**  
Grade Separated  
Crossing - Overpass



**Exhibit 7-25**  
Grade Separated  
Crossing - Underpass

**Exhibit 7-26**  
**Transit Stop**

## 7.7 TRANSIT

The design team needs to work collaboratively with transit and local agencies to incorporate transit design (e.g., bus stop locations) into transportation improvement projects when appropriate. In addition, the design team should refer to MDT transit policy for guidance. Transit stops are inherently associated with people walking to and from the stop, so the same principles that apply to pedestrian crossings also apply to transit stops. An example of a transit stop is shown in Exhibit 7-26.



There are a few additional principles to consider for bus stops:

- **Bus position relative to lane.** There are two options: stopping in the travel lane or using a bus pullout.
  - Stopping in the lane will impact traffic operations (e.g., delay in through traffic), and will also influence bicycle travel when a bus stops in the bicycle lane when present. However, stopping in the lane is easier for bus drivers to resume travel after stopping.
  - A bus pullout allows traffic to continue while the bus is stopped. However, bus drivers sometimes have a challenge (e.g., finding a gap) entering the travel lane from the bus pullout. If right-of-way is available, a bus pullout will be required. If right-of-way is not feasible to acquire, in-lane bus stops may be considered.
- **Location at intersection.** Buses typically stop either near-side or far-side at an intersection. Sometimes buses will use an upstream (near-side) location in a right-turn lane to pull out of traffic without building a separate bus pullout. The location depends on the overall signal operations along the corridor and may include the following:
  - Transit signal priority
  - Queue jump opportunities
- **Midblock location.** A bus stop at a midblock location may be desired due to a destination that attracts high transit usage along a road segment. When midblock stops are used, signal control such as a RRFB, a pedestrian hybrid beacon, or a traditional midblock signalized crossing should be considered. Buses typically stop beyond the crossing to allow pedestrians to cross behind the bus where they are more visible to oncoming traffic.

The overall goal is to design a system that provides facilities (e.g., bus stops) in a consistent manner to meet user expectancy.

**Coordinate with the Traffic and Safety Bureau to determine if a feasibility study is needed to identify appropriate locations for bus stops at an intersection.**

**Coordinate with the Traffic and Safety Bureau to determine if a feasibility study is needed to consider transit signal priority and/or queue jump opportunities.**

## 7.8 REFERENCES

1. Montana Department of Transportation (MDT). *Geometric Design Standards*. MDT, Helena, MT, 2016.
2. AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*. AASHTO, Washington, D.C., 2004.
3. United States Access Board. *Public Right-of-Way Accessibility Guidelines (PROWAG)*. Website: <http://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way>
4. AASHTO. *Guide for the Development of Bicycle Facilities, 4th Edition*. AASHTO, Washington, D.C., 2012.
5. FHWA. *Separated Bike Lane Planning and Design Guide*. FHWA, Washington, D.C., 2015.
6. Fitzpatrick, K., et. al., *TCRP 112/NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings*. Transportation Research Board of the National Academies, Washington, D.C., 2006.
7. FHWA. *Manual on Uniform Traffic Control Devices (MUTCD)*. FHWA, Washington, D.C., 2009.