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Chapter 12 - Pedestrian and Bicycle Facilities

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General Sidewalk Requirements

A. Introduction

Sidewalks are an integral component of the transportation system. They provide a designated area, separated from the roadway, for pedestrians to use for both travel and recreation. Along roadways where pedestrians are present or anticipated, consideration should be given to constructing sidewalks on both sides of the road to minimize conflicts between vehicles and pedestrians.

Where sidewalks are provided, they must be constructed so they are accessible to all potential users, including those with disabilities. Design standards for pedestrian access routes are provided in [Section 12A-2](#).

B. Sidewalk and Walkway Widths

A 5 foot sidewalk is the minimum sidewalk width required for Iowa DOT projects and local projects with state or federal funding. Local jurisdictions may have minimum sidewalk width standards of 4 feet. Consideration should be given to providing minimum 5 foot sidewalks (or wider). A 5 foot sidewalk better accommodates two people walking abreast, and allows for encroachment on the sidewalk by snow, shrubbery, and grass. If sidewalks are less than 60 inches wide, a passing area at least 60 inches on all sides must be constructed a maximum of every 200 feet to comply with ADA requirements.

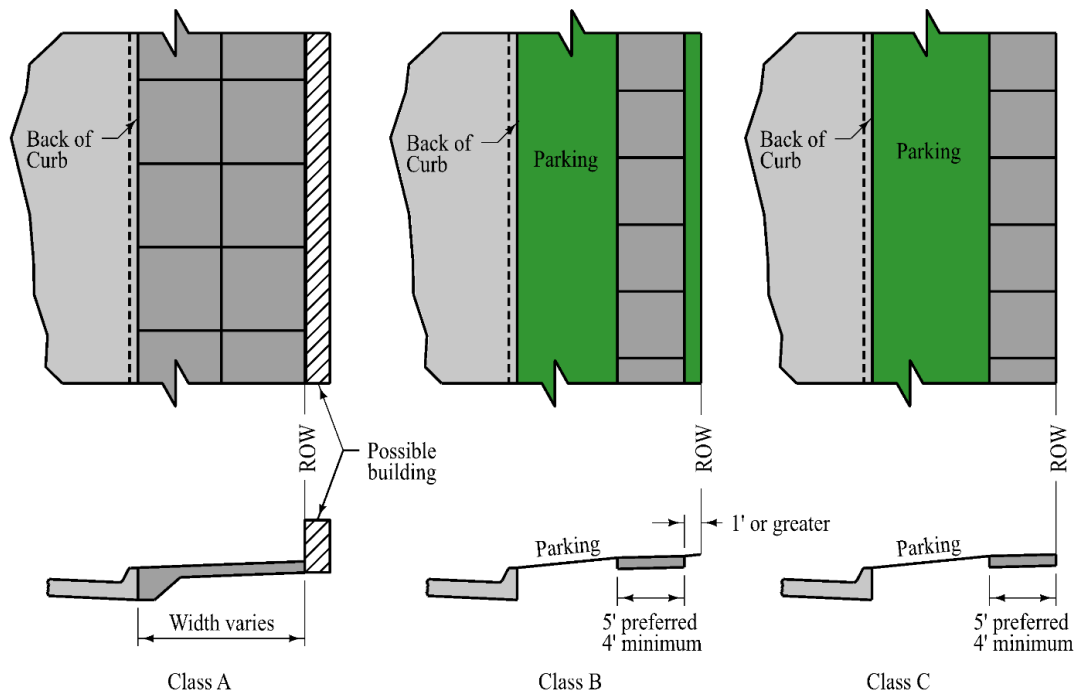
Clear sidewalk widths greater than the minimum are desirable in many locations. Along arterials not in downtown areas, sidewalk widths of 6 to 8 feet are desirable where a planting strip is provided between the sidewalk and curb, and sidewalk widths of 8 to 10 feet are desirable where the sidewalk is flush against the curb. In downtown areas, the desirable sidewalk width is 10 feet or sufficiently wide to provide the desired level of service to accommodate particular volumes, see the Highway Capacity Manual. Contact the local jurisdiction for minimum width requirements.

C. Sidewalk Classes

SUDAS identifies three classes of sidewalks, which are described below. Class B and C sidewalks provide a grass strip between the back of curb and the sidewalk, often referred to as the “parking.”

1. **Class A:** Class A sidewalks begin at the back of curb and generally extend to the right-of-way line. These types of sidewalks are typical in downtown areas. Consideration must be given to street sign location, street lighting, utilities, mailboxes, snow storage, and other potential obstacles.
2. **Class B:** Class B sidewalks are constructed with the back edge of the sidewalk 1 foot or more off of the right-of-way line.
3. **Class C:** Class C sidewalks have the back edge of the sidewalk on the right-of-way line.

Figure 12A-1.01: Classes of Sidewalk



D. Accessible Sidewalk Design

It has been common practice to place the responsibility for sidewalk ramp layout on the contractor or construction inspector. This has resulted in the sidewalk, curb ramps, driveway crossings, etc. being designed in the field, often with mixed accessibility results. As public right-of-way accessibility comes under greater scrutiny, it is increasingly important that newly constructed or altered sidewalks meet accessibility requirements. Therefore, sidewalks, curb ramps, and street crossings shall be included as part of the design process and the details of those designs shall be included in the contract documents as appropriate. Projects reviewed or let by the Iowa DOT will require use of S sheets according to the [Iowa DOT Design Manual Section 1F-18](#).

E. Construction Requirements

- 1. Sidewalk Thickness:** Sidewalks should be constructed of PCC with a minimum thickness of 4 inches. Where sidewalks cross driveways, the minimum thickness is 6 inches, or the thickness of the driveway, whichever is greater.
- 2. Obstructions:** All obstructions are to be removed or relocated except for those that are impractical to move. In new development areas, these items should never occur, but in older, established areas, they will have to be addressed. In the case where the sidewalk is shifted to avoid an obstacle, use of a minimum 2:1 taper to and from the obstruction with a straight section adjacent to the obstruction should be considered. Flatter tapers may be used if space is available and user volume is high.
- 3. Construction Tolerances:** Dimensions are subject to conventional industry tolerances except where dimensions are stated as a range, minimum, or maximum. Conventional industry tolerances include tolerances for field conditions and tolerances that may be a necessary consequence of a particular manufacturing process. Conventional industry tolerances do not apply to design work; see PROWAG R103.1. Designing features to the target values, rather than the allowable maximum or minimum, allows for appropriate construction tolerances and field adjustment during construction while maintaining compliance with PROWAG.

Accessible Sidewalk Requirements

A. Introduction

SUDAS and Iowa DOT jointly developed this section based on the July 26, 2011 “Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way.” This section was developed in accordance with Federal regulations ([23 CFR 652](#) and [28 CFR 35](#)) and is the standard for use by all governmental entities in the State of Iowa. A local jurisdiction may elect to produce their own standards; however, these will require review and approval by FHWA and/or the United States Department of Justice.

Where sidewalks are provided, they must be constructed so they are accessible to all potential users, including those with disabilities. This section establishes the criteria necessary to make an element physically accessible to people with disabilities. This section also identifies what features need to be accessible and then provides the specific measurements, dimensions, and other technical information needed to make the feature accessible. The requirements of this section were developed based on the following documents:

1. **ADAAG:** The “[Americans with Disabilities Act Accessibilities Guidelines](#)” (ADAAG) was written by the US Access Board and adopted by the Department of Justice (DOJ) in 2010. This document includes a broad range of accessibility guidelines including businesses, restaurants, public facilities, public transportation, and sidewalks. These standards were originally adopted in 1991 and have been expanded and revised several times.
2. **PROWAG:** The July 26, 2011 “Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way” was written by the US Access Board and is also known as the Public Right-of-Way Accessibility Guidelines or PROWAG. PROWAG provides more specific information than the ADAAG for transportation facilities within the right-of-way including pedestrian access routes, signals, and parking facilities. The PROWAG requirements are currently in the development and adoption process and have not been officially adopted by the Department of Justice; however, the Federal Highway Administration has issued guidance that the draft version of the PROWAG is “currently recommended best practices, and can be considered the state of the practice that could be followed for areas not fully addressed” in the existing ADAAG requirements.

Due to the widespread acceptance of the PROWAG, and its pending adoption in the future, the standards of this chapter are based upon the PROWAG requirements. The designer is encouraged to reference the complete PROWAG document for additional information (www.access-board.gov). References to the PROWAG in this section are shown in parentheses, e.g. (R302.7). Buildings and other structures not covered by PROWAG must comply with the applicable requirements of the ADAAG. For parks, recreational areas, and shared use paths, refer to other sections within this chapter.

B. Transition Plan

The ADA law passed in 1990 required public entities with more than 50 total employees to develop a formal transition plan identifying the steps necessary to meet ADA accessibility requirements for all pedestrian access routes within their jurisdiction by upgrading all noncompliant features. Recognizing that it would be difficult to upgrade all facilities immediately, the law provided the opportunity to develop a transition plan for the implementation of these improvements. Covered entities had until 1992 to complete a transition plan. In addition, any local public agency that is a recipient of US DOT funds must have a transition plan. For those agencies that have not completed a transition plan, it is critical that this process be completed. Although the transition plan may cover a broader scope, this section will only cover requirements within the public right-of-way.

Key elements of a transition plan include the following:

- Identifying physical obstacles in the public agency's facilities that limit the accessibility of its programs or activities to individuals with disabilities.
- A detailed description of the methods that will be used to make the facilities accessible.
- A schedule for taking the steps necessary to upgrade pedestrian access in each year following the transition plan.
- Identification of the individual responsible for implementation of the plan.

The document: *ADA Transition Plans: A Guide to Best Management Practices* (NCHRP Project No. 20-7 (232)) provides guidance for the development and update of transition plans. The document also assists communities in prioritizing required improvements for accessibility.

Public entities not required to have a formal transition plan are still required to address noncompliant pedestrian access routes.

C. Definitions

Accessible: Facilities that comply with the requirements of this section.

Alteration: An alteration is a change that affects or could affect the usability of all or part of a building or facility. Alterations of streets, roadways, or highways include activities such as reconstruction, rehabilitation, resurfacing, widening, and projects of similar scale and effect.

Alternate Pedestrian Access Route: A route provided when a pedestrian circulation path is temporarily closed by construction, alterations, maintenance operations, or other conditions.

Curb Line: A line at the face of the curb that marks the transition between the curb and the gutter, street, or highway.

Cross Slope: The grade that is perpendicular to the direction of pedestrian travel.

Crosswalk: See pedestrian street crossing.

Curb Ramp: A ramp that cuts through or is built up to the curb. Curb ramps can be perpendicular, parallel, or a combination of parallel and perpendicular curb ramps.

Detectable Warning: Detectable warnings consist of small, truncated domes built in or applied to a walking surface that are detectable by cane or underfoot. On pedestrian access routes, detectable warning surfaces indicate the boundary between a pedestrian route and a vehicular route for pedestrians who are blind or have low vision.

New Construction: Construction of a roadway where an existing roadway does not currently exist.

Pedestrian Access Route: A continuous and unobstructed path of travel provided for pedestrians with disabilities within, or coinciding with, a pedestrian circulation path.

Pedestrian Circulation Path: A prepared exterior or interior surface provided for pedestrian travel in the public right-of-way.

Pedestrian Street Crossing: A marked or unmarked route providing an accessible path to travel from one side of the street to the other. Pedestrian street crossings are a component of the pedestrian access route and/or the pedestrian circulation path.

Running Slope: The grade that is parallel to the direction of pedestrian travel.

PROWAG: The Public Right-of-way Accessibility Guidelines establish the criteria for providing a feature within the public right-of-way that is physically accessible to those with physical disabilities.

Scope of the Project: Work that can reasonably be completed within the limits of the project. This is not defined by the written project scope; however, it focuses on whether the alteration project presents an opportunity to design the altered element, space, or facility in an accessible manner.

Structurally Impracticable: Something that has little likelihood of being accomplished because of those rare circumstances when the unique characteristics of terrain prevent the incorporation of full and strict compliance with this section. Applies to new construction only.

Technically Infeasible: With respect to an alteration of an existing facility, something that has little likelihood of being accomplished because existing structural conditions would require removing or altering a load-bearing member that is an essential part of the structural frame; or because other existing physical or site constraints prohibit modification or addition of elements, spaces, or features that are in full and strict compliance with the requirements of this section. (2010 ADAAG 106.5)

Turning Space: An area at the top or bottom of a curb ramp, providing a space for pedestrians to stop, rest, or change direction.

D. Applicability

- 1. New Construction:** Newly constructed facilities within the scope of the project shall be made accessible to persons with disabilities, except when a public agency can demonstrate it is structurally impracticable to provide full compliance with the requirements of this section. Structural impracticability is limited to only those rare situations when the unique characteristics of terrain make it physically impossible to construct facilities that are fully compliant. If full compliance with this section is structurally impracticable, compliance is required to the extent that it is not structurally impracticable. [2010 ADAAG 28 CFR 35.151(a)]
- 2. Alterations:** Whenever alterations are made to the pedestrian circulation path, the pedestrian access route shall be made accessible to the maximum extent feasible within the scope of the project. If full compliance with this section is technically infeasible, compliance is required to the extent that it is not technically infeasible. [2010 ADAAG 28 CFR 35.151(b)]. Alterations shall not gap pedestrian circulation paths in order to avoid ADA compliance.

Resurfacing is an alteration that triggers the requirement for curb ramps if it involves work on a street or roadway spanning from one intersection to another. Examples include, but are not limited to, the following treatments or their equivalents:

- New layer of surface material (asphalt or concrete, including mill and fill)
- Reconstruction
- Concrete pavement rehabilitation and reconstruction
- Open-graded surface course
- Microsurfacing and thin lift overlays
- Cape seals (slurry seal or microsurfacing over a new chip seal)
- In-place asphalt recycling

[[DOJ/U.S. DOT Glossary of Terms](#) and [DOJ/U.S. DOT Technical Assistance](#); June 28, 2013]

Where elements are altered or added to existing facilities, but the pedestrian circulation path is not altered, the pedestrian circulation path is not required to be modified (R202.1). However, features that are added shall be made accessible to maximum extent feasible. The following are examples of added features:

- Installation of a traffic sign does not require sidewalk improvements; however, the sign cannot violate the protruding objects requirements.
- Installation of a traffic or pedestrian signal does not require sidewalk improvements; however, the signal must be accessible.
- Installation of a bench adjacent to the pedestrian access route would not require sidewalk improvements, but the bench cannot be placed in a manner that would reduce the sidewalk width below the minimum requirement.

3. Maintenance: Accessibility improvements are not required for work that is considered maintenance. Examples of work that would be considered maintenance include, but are not limited to, the following items.

- Painting pavement markings, excluding parking stall delineations
- Crack filling and sealing
- Surface sealing
- Chip seals
- Slurry seals
- Fog seals
- Scrub sealing
- Joint crack seals
- Joint repairs
- Dowel bar retrofit
- Spot high-friction treatments
- Diamond grinding
- Minor street patching (less than 50% of the pedestrian street crossing area)
- Curb and gutter repair or patching outside the pedestrian street crossing
- Minor sidewalk repair that does not include the turning space and curb ramps
- Filling potholes

If a project involves work not included in the list above, or is a combination of several maintenance items occurring at or near the same time, the agency administering the project is responsible for determining if the project should be considered maintenance or an alteration. If either of these two situations is determined to be maintenance, the agency administering the project must document the reasons for this determination. If the project is defined as maintenance, federal funding and Farm-to-Market funds cannot be used.

When a maintenance project modifies a crosswalk, installation of curb ramps at the crosswalks is recommended, if none already exists. The other accessibility improvements of this section are also recommended, but not required with such projects.

4. **Technical Infeasibility:** Examples of existing physical or site constraints that may make it technically infeasible to make an altered facility fully compliant include, but are not limited to, the following:
 - Right-of-way availability. Right-of-way acquisition in order to achieve full compliance is not mandatory, however, it should be considered. Improvements may be limited to the maximum extent practicable within the existing right-of-way.
 - Underground structures that cannot be moved without significantly expanding the project scope.
 - Adjacent developed facilities, including buildings that would have to be removed or relocated to achieve accessibility.
 - Drainage cannot be maintained if the feature is made accessible.
 - Notable natural or historic features that would have to be altered in a way that lessens their aesthetic or historic value.
 - Underlying terrain that would require a significant expansion of the project scope to achieve accessibility.
 - Street grades within the crosswalk exceed the pedestrian access route maximum cross slopes, provided an engineering analysis has concluded that it cannot be done without significantly expanding the project scope (for example, changing from resurfacing an intersection to reconstructing that intersection).
5. **Safety Issues:** When accessibility requirements would cause safety issues, compliance is required to the maximum extent practicable.
6. **Documenting Exceptions:** If the project cannot fully meet accessibility requirements because the accessibility improvements are structurally impracticable, technically infeasible, or create safety issues, a document should be developed to describe how the existing physical or site constraints or safety issues limit the extent to which the facilities can be made compliant. This document should identify the specific locations that cannot be made fully compliant and provide specific reasons why full compliance cannot be achieved. It is recommended that this document be retained in the project file. For local agency projects administered through Iowa DOT, an “Accessibility Exceptions Certification” ([Form 517118](#)) with supporting documentation shall be signed by a registered professional engineer or landscape architect licensed in the State of Iowa and submitted to the Iowa DOT administering bureau. The certification shall be as prescribed by Iowa DOT [Local Systems I.M. 1.080](#). For Iowa DOT projects, contact the Design Bureau, Methods Section.

Note: Documenting exceptions does not remove an agency’s responsibility to consider making accessibility improvements the next time the facility is altered, because physical or site constraints and safety issues may change over time. The determination of exceptions and corresponding documentation needs to be made each time a facility is altered, based on the existing conditions and the scope of the proposed project.
7. **Reduction in Access:** Regardless of whether the additions or alterations involve the modification of the existing pedestrian circulation path, the resulting work cannot have the result of reducing the existing level of accessibility below the minimum requirements. For example, the installation of a bench cannot have the effect of reducing the width of the pedestrian access route to 3 feet (4 feet is the minimum). Likewise, the construction of an overlay cannot result in a street cross slope of more than 5%, nor have a lip at the curb ramp that exceeds 1/2 inch. Pedestrian facilities may be removed if they are being re-routed for safety reasons, or terminated because they do not connect to a destination or another pedestrian circulation path.

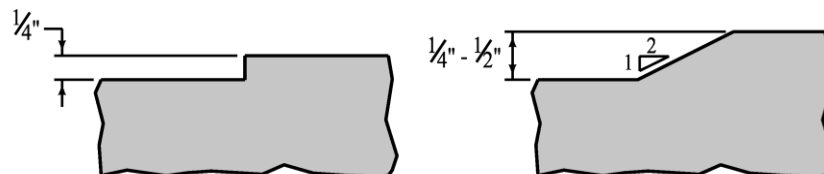
8. **Addition of Pedestrian Facilities:** If a sidewalk exists on both sides of the street, curb ramps shall be installed on both sides when the street is altered. PROWAG does not require construction of pedestrian facilities where none currently exists, although the jurisdiction's transition plan may require them.
9. **Utility Construction:** If the pedestrian circulation path is disturbed during utility construction, the requirements of this section and [Section 12A-4](#) shall apply.

E. Standards for Accessibility

The following section summarizes the design standards for the elements of an accessible pedestrian access route. The minimum and maximum values stated are taken from the PROWAG. Target values are also provided. Designing features to the target values, rather than the allowable maximum or minimum, allows for appropriate construction tolerances and field adjustment during construction while maintaining compliance with the PROWAG standards.

1. **General Requirements:** These requirements apply to all parts of the pedestrian access route.
 - a. **Surfacing:** PROWAG requires all surfaces to be firm, stable, and slip resistant (R302.7). All permanent pedestrian access routes, with the exception of some Type 2 shared use paths (see [Section 12B-2](#)), shall be paved. When crossing granular surfaced facilities, consider paving wider than the pedestrian access route; see the shared use path section.
 - b. **Vertical Alignment:** Vertical alignment (smoothness) shall be generally planar within the pedestrian access routes (R302.7.1). Although no definition for generally planar is provided, the Advisory statement for R302.7.1 indicates surfaces must be smooth and chosen for easy rollability and minimizing vibration for users of wheelchairs, scooters, and walkers. Surfaces that are heavily textured, rough, or chamfered and paving systems consisting of individual units that cannot be laid in plane should be reserved for borders and decorative accents located outside of and only occasionally crossing the pedestrian access route. Research has shown that bricks/pavers with no or narrow chamfers and narrow joint spacing between pavers can minimize vibration for all users. Bricks/pavers with sand bedding on natural soil should not be used in pedestrian access routes due to maintenance problems.
 - c. **Changes in Level:** Changes in level, including bumps, utility castings, expansion joints, etc. shall be a maximum of 1/4 inch without a bevel or up to 1/2 inch with a 2:1 bevel. Where a bevel is provided, the entire vertical surface of the discontinuity shall be beveled (R302.7.2).

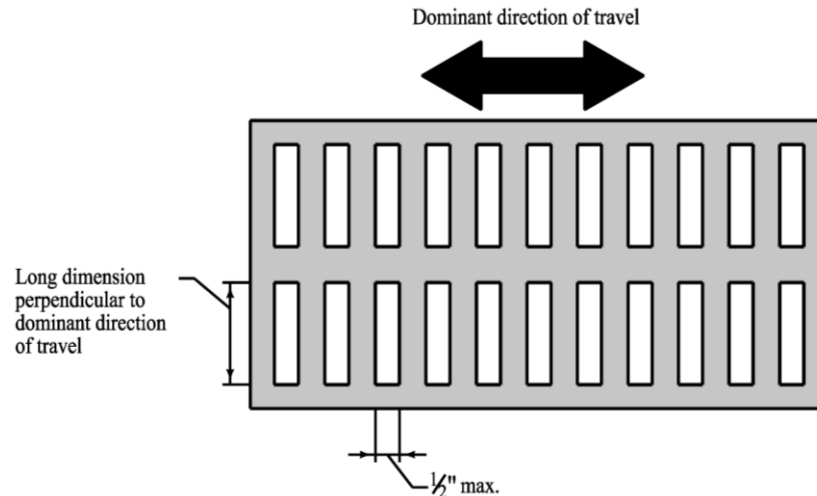
Figure 12A-2.01: Vertical Surface Discontinuities



- d. Horizontal Openings:** Horizontal openings shall not allow passage of a sphere more than 1/2 inch in diameter. Elongated openings in grates shall be placed so the long dimension is perpendicular to the dominant direction of travel. The use of grates within the pedestrian access route is discouraged; however, where necessary, the grate should be located outside of curb ramp runs, turning spaces, and gutter areas if possible. (R302.7.3)

It should be noted that none of the standard SUDAS/Iowa DOT intake grates meet the requirements for use within a pedestrian access route; therefore, a special design is required.

Figure 12A-2.02: Horizontal Openings

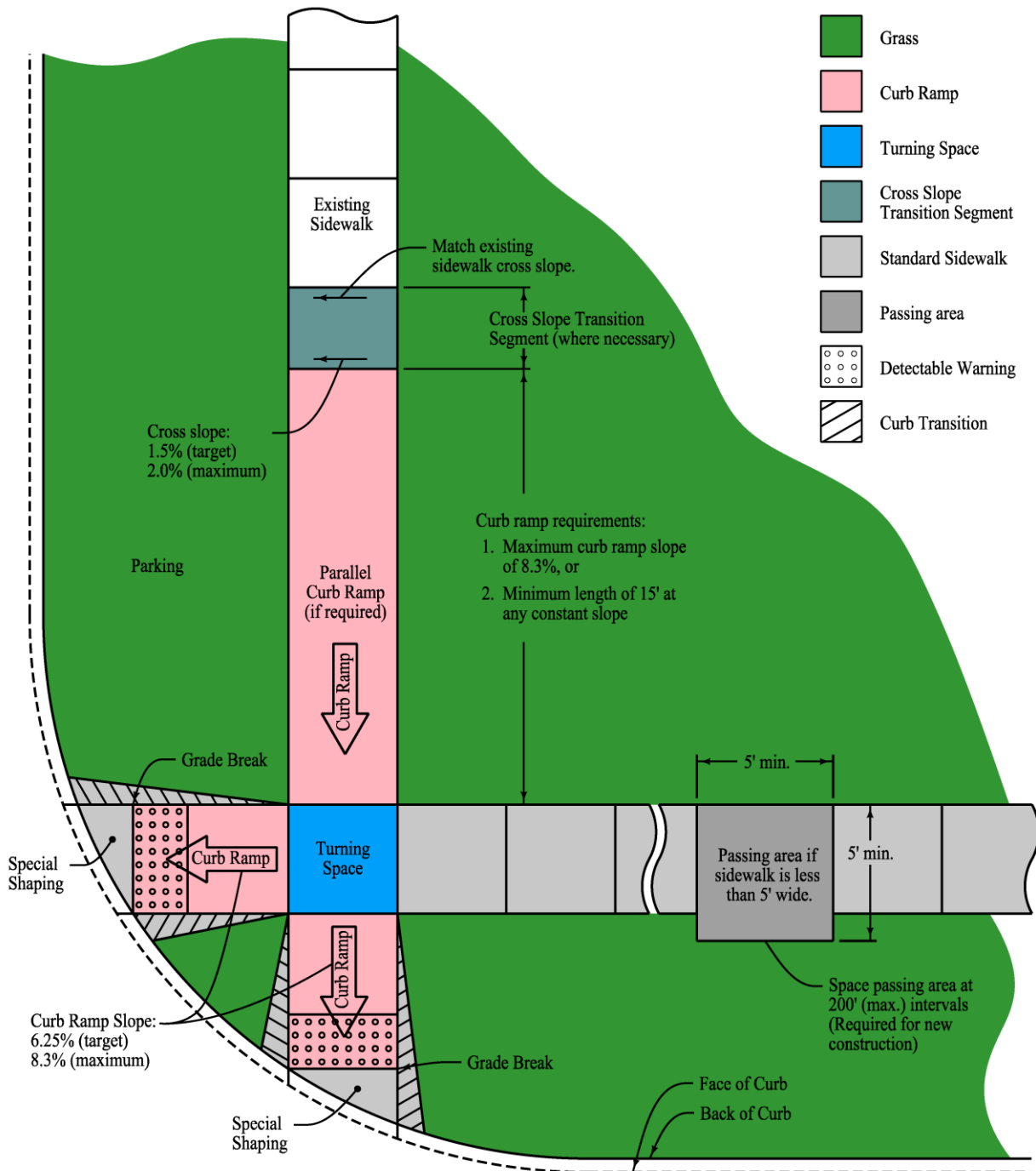


2. Standard Sidewalk:

- a. Cross Slope:** The maximum cross slope is 2.0% with a target value of 1.5% (R302.6).
- b. Running Slope:** Sidewalks with a running slope of 5% or less are acceptable. However, where the sidewalk is contained within the street right-of-way, the grade of the sidewalk shall not exceed the general grade of the adjacent street (R302.5). For design, consider the general grade of the adjacent street to be within approximately 2% of the profile grade of the street.
- c. Width:** The minimum width of the pedestrian access route is 4 feet. Five foot sidewalks are encouraged and may be required by the Jurisdiction. Iowa DOT will design 5 foot sidewalks unless otherwise requested. (R302.3)
- d. Passing Spaces:** Where the clear width of the pedestrian access route is less than 5 feet, passing spaces are required at maximum intervals of 200 feet. The passing space shall be 5 foot minimum by 5 foot minimum. Passing spaces may overlap with the pedestrian access route. (R302.4). Driveways may be used as passing spaces, as long as the 2.0% maximum cross slope is not exceeded.

Note: Sidewalks solely serving private residences are not required to follow requirements a, b, c, and d above.

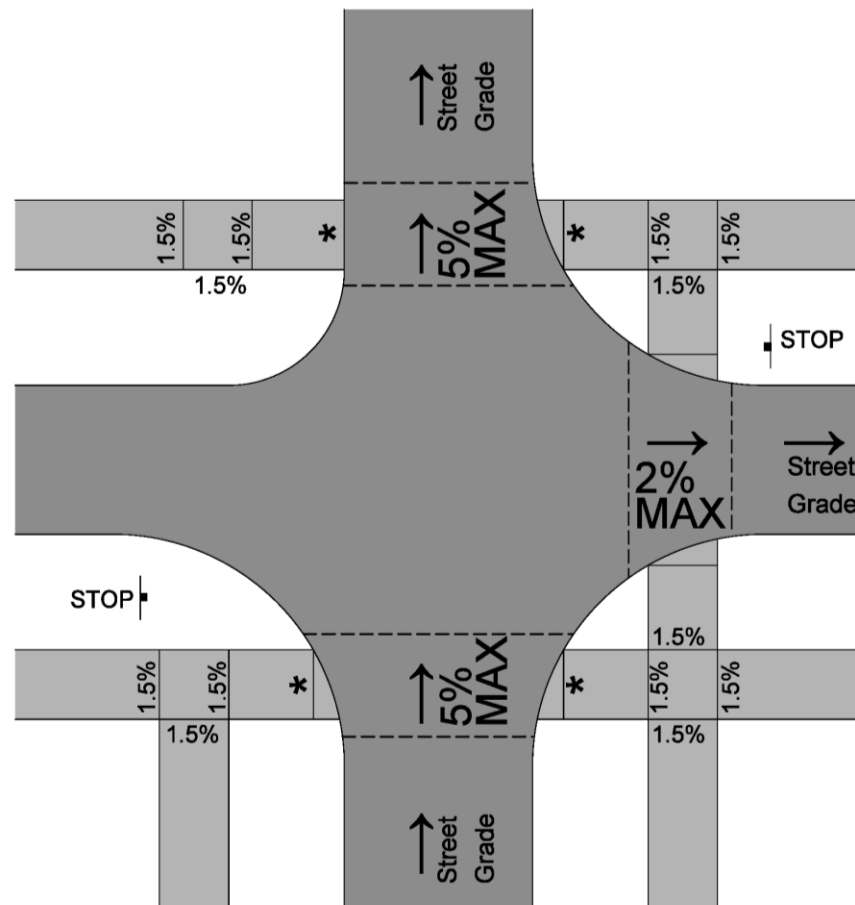
Figure 12A-2.03: Standard Sidewalk and Curb Ramp Elements



3. Pedestrian Street Crossings:

- a. **Cross Slope:** The longitudinal grade of a street becomes the cross slope for a pedestrian street crossing. PROWAG has maximum limits for the cross slope of pedestrian street crossings, which vary depending on the location of the crossing and the type of vehicular traffic control at the crossing. These requirements, in effect, limit the longitudinal grade of a street, or require a “tabled crosswalk” at the intersection. (R302.6)
- 1) **Intersection Legs with Stop or Yield Control:** For pedestrian street crossings across an intersection leg with full stop or yield control (stop sign or yield sign), the maximum cross slope is 2.0% (maximum 2.0% street grade through the crossing).
 - 2) **Intersection Legs without Stop or Yield Control:** For pedestrian street crossings across an intersection leg where vehicles may proceed without slowing or stopping (uncontrolled or signalized), the maximum cross slope of the pedestrian street crossing is 5.0% (maximum 5.0% street grade through the crossing).
 - 3) **Midblock Pedestrian Street Crossings:** At midblock crossings, the cross slope of the pedestrian street crossing is allowed to equal the street grade.

Figure 12A-2.04: Example Street Intersection

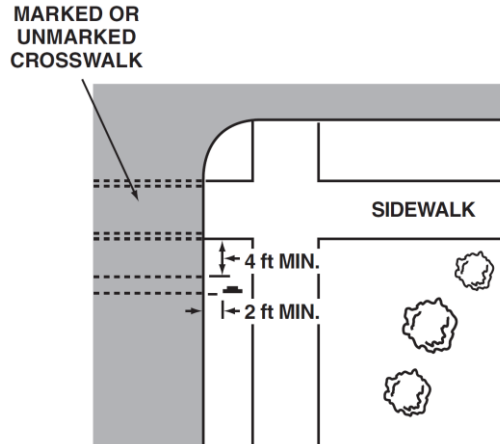


* Match pedestrian street crossing cross slope or flatter

- b. **Running Slope:** The running slope of the pedestrian street crossing is limited to a maximum of 5.0% (maximum street cross slope or superelevation of 5.0%) (R302.5.1).

- c. **Location:** Driver anticipation and awareness of pedestrians increases as one moves closer to the intersection. Therefore, curb ramps and pedestrian street crossings should be located as close to the edge of the adjacent traveled lane as practical. Where a stop sign or yield sign is provided, MUTCD requires the pedestrian street crossing, whether marked or unmarked, be located a minimum of 4 feet from the sign, between the sign and the intersection. It is recommended stop and yield signs be located no greater than 30 feet from the edge of the intersecting roadway; however, MUTCD allows up to 50 feet. Consult MUTCD for placement of curb ramps and pedestrian street crossings at signalized intersections.

Figure 12A-2.05: Pedestrian Street Crossing Location



Source: MUTCD, FHWA

- d. **Medians and Pedestrian Refuge Islands:** Medians and pedestrian refuge islands in pedestrian street crossings shall be cut through level with the street or complying with the curb ramp requirements. The clear width of pedestrian access routes within medians and pedestrian refuge islands shall be 5.0 feet minimum (R302.3.1). If a raised median is not wider than 6 feet, it is recommended the nose not be placed in the pedestrian street crossing.

4. Curb Ramps:

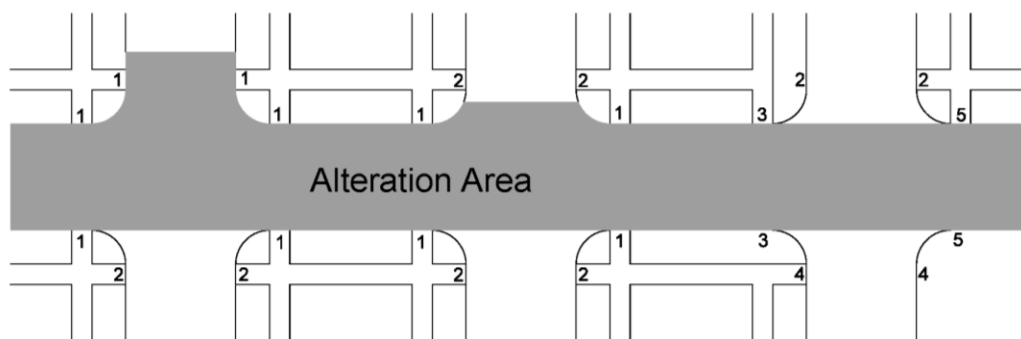
- a. **General:** There are two types of curb ramps: perpendicular and parallel. Perpendicular curb ramps are generally perpendicular to the traffic they are crossing with the turning space at the top. Parallel curb ramps have the turning space at the bottom. Parallel curb ramps may be used where the sidewalk begins at or near the back of curb and there is little or no room between the sidewalk and curb for a perpendicular curb ramp.

A separate curb ramp is required at each pedestrian street crossing for new construction. Parallel ramps with a large turning space, as shown in Figure 12A-2.08, are allowed. For alterations, follow the new construction requirements if possible; however, a single diagonal curb ramp is allowed but not recommended where existing constraints prevent two curb ramps from being installed.

For transitions into and out of driveways, curb ramp requirements may be used.

For curb ramps within and near an alteration area, see Figure 12A-2.06. It is critical to provide a new ramp opposite an existing ramp if the existing ramp is maintained so a positive exit point from the street is provided.

Figure 12A-2.06: Curb Ramps for Alterations



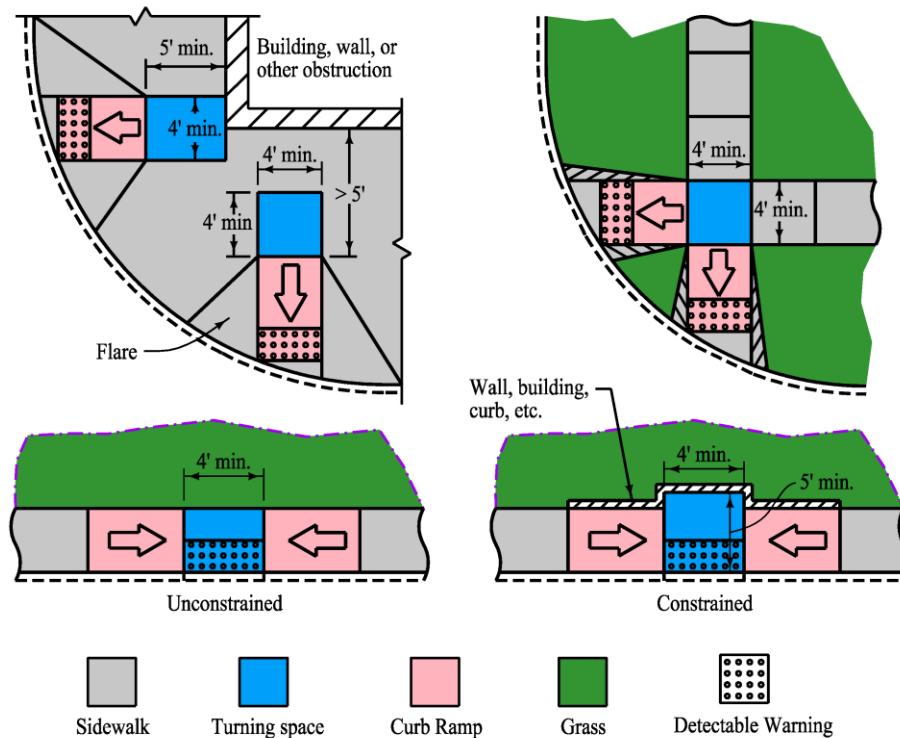
1. Required.
2. Strongly recommended.
3. Required due to barriers in the path of travel between the sidewalk on one side of the street to the sidewalk on the other side of the street.
4. Recommended, but not required because it is outside the alteration area. Consider based on pedestrian usage, safety, and land development.
5. Install both sides or remove the existing one, based on pedestrian usage, safety, and land development.

b. Technical Requirements:

- 1) **Cross Slope:** The maximum cross slope is 2.0% with a target value of 1.5%; however, for intersection legs that do not have full stop or yield control (i.e. uncontrolled or signalized) and at mid-block crossings, the curb ramp cross slope is allowed to match the cross slope in the pedestrian street crossing section. See “pedestrian street crossings” for additional details. (R304.5.3)
- 2) **Running Slope:** Provide curb ramps with a target running slope of 6.25% and a maximum slope of 8.3%; however, curb ramps are not required to be longer than 15 feet, regardless of the resulting slope. (R304.2.2 and R304.3.2)
- 3) **Width:** The minimum width of a curb ramp is 4 feet, excluding curbs and flares. If the sidewalk facility is wider than 4 feet, the target value for the curb ramp is equal to the width of the sidewalk. (R304.5.1)
- 4) **Grade Breaks:** Grade breaks at the top and bottom of curb ramps must be perpendicular to the direction of the curb ramp run. Grade breaks are not allowed on the surface of curb ramp runs and turning spaces. (R304.5.2)
- 5) **Flared Sides:** For perpendicular curb ramps on Class A sidewalks, or configurations where the pedestrian circulation path crosses the curb ramp, PROWAG requires the flares along the sides of the curb ramp to be constructed at 10% or flatter. (R304.2.3) This allows pedestrians to approach the curb ramp from the side and prevents a tripping hazard. It is recommended to design these flares at a slope between 8% and 10%, which will clearly define the curb ramp from the sidewalk.
- 6) **Clear Space:** At the bottom of perpendicular curb ramps, a minimum 4 foot by 4 foot area must be provided within the width of the pedestrian street crossing, but wholly outside of the parallel vehicle travel lanes. (R304.5.5)
- 7) **Turning Space:** Turning spaces allow users to stop, rest, and change direction on the top or bottom of a curb ramp (R304.2.1 and R304.3.1).
 - a) **Placement:** A turning space is required at the top of perpendicular curb ramps and at the bottom of parallel curb ramps.
 - b) **Slope:** The maximum cross slope and running slope is 2.0% with a target value of 1.5% (R304.2.2 and R304.3.2). When turning spaces are at the back of curb, cross slopes may be increased to match allowable values in the pedestrian street crossing section (R304.5.3).

- c) **Size:** The turning space shall be a minimum of 4 feet by 4 feet. Where the turning space is constrained on one or more sides, provide 5 feet in the direction of the pedestrian street crossing.
- 8) **Special Shaping Area:** Transition area between the back of curb and the grade break. The longest side cannot exceed 5 feet.

Figure 12A-2.07: Curb Ramp Turning Spaces

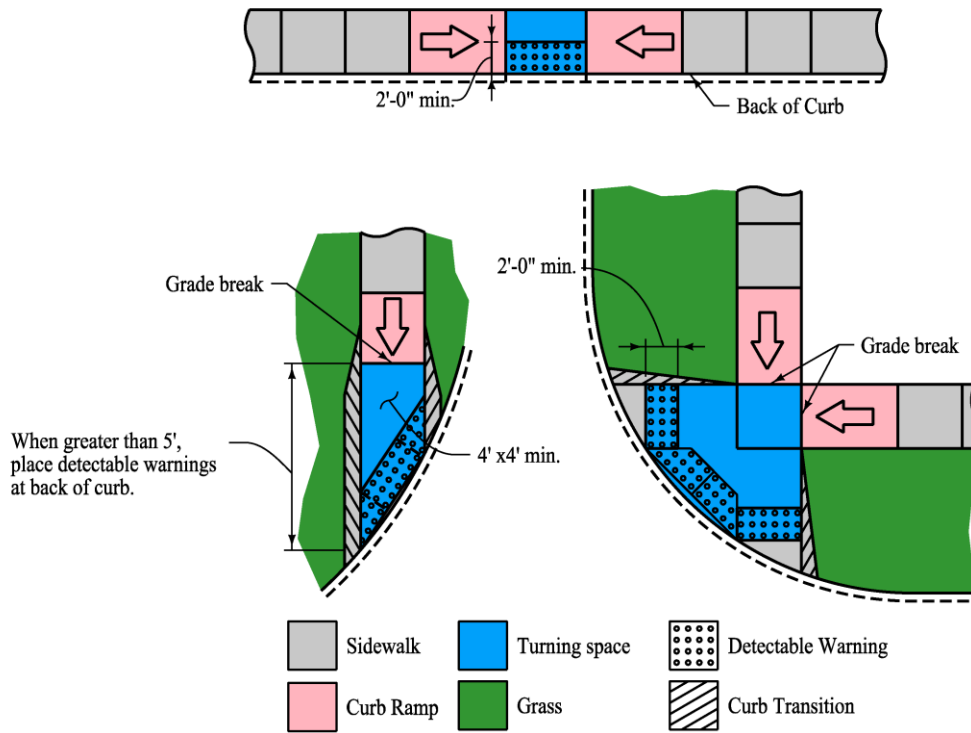


c. **Curb Ramp Design Considerations:**

- 1) **Combination Curb Ramps:** For many intersection configurations, a perpendicular curb ramp will not provide enough length to establish the top turning space at the sidewalk elevation; in these situations, a parallel curb ramp is often required to transition from the turning space up to the sidewalk elevation. The use of a perpendicular curb ramp from the curb to the turning space in conjunction with a parallel curb ramp between the turning space and the sidewalk elevation is referred to as a combination curb ramp. When transitioning from a turning space to sidewalk elevation on a steep street, it is not necessary to chase the grade. As noted in the technical requirements above, a parallel curb ramp is not required to exceed 15 feet in length, regardless of the resulting curb ramp slope. In practice, the parallel curb ramp should be extended to the next joint beyond 15 feet.
- 2) **Cross Slope Transition Segment:** When connecting to existing construction that is out of cross slope compliance, the cross slope transition should be completed beyond the parallel curb ramp or turning space; this recommendation eliminates the need to list this curb ramp in the transition plan. It is recommended this cross slope transition take place at 1% or less per foot. Typically, this can be accomplished in a single panel.
- 3) **Parking Slope:** In situations where the length of the perpendicular curb ramp is insufficient to bring the turning space up to sidewalk elevation, consider lowering the sidewalk and flattening the parking slope.

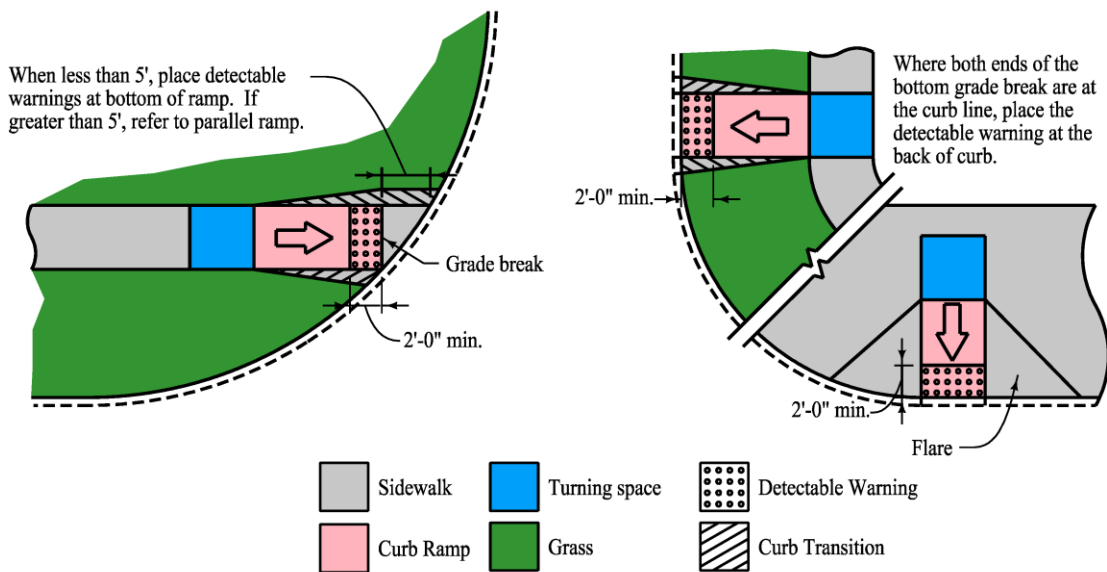
5. **Blended Transitions:** A blended transition is allowed but not recommended. Design and constructability is difficult to meet compliance requirements. In lieu of a blended transition, a curb ramp or standard sidewalk should be used.
6. **Detectable Warnings:**
 - a. **General:** Detectable warning surfaces are detected underfoot or with a cane by blind and low vision individuals. The warnings indicate the location of the back of curb. Detectable warnings also provide a visual queue to pedestrians with low vision and aid in locating the curb ramp across the street. For these reasons, the detectable warning shall contrast visually (light on dark or dark on light) from the surrounding paved surfaces (R305.1.3).
 - b. **Location:** Detectable warnings shall be installed at all pedestrian street crossings and at-grade rail crossings (R208.1). Detectable warning surfaces should not be provided at crossings of residential driveways since the pedestrian right-of-way continues across the driveway. Where commercial driveways are provided with yield control, stop control, or traffic signals at the pedestrian access route, detectable warnings should be installed at the junction between the pedestrian access route and the driveway (Advisory R208.1).
 - c. **Size:** Detectable warning surfaces shall extend a minimum of 2 feet in the direction of pedestrian travel and extend the full width of the curb ramp or pedestrian access route (R305.1.4).
 - d. **Dome Orientation:** On curb ramps, the rows of truncated domes should be aligned perpendicular to the grade break so pedestrians in wheelchairs can track their wheels between the domes. On surfaces less than 5% slope, dome orientation is less critical.
 - e. **Parallel Curb Ramps:** On parallel curb ramps, detectable warning shall be placed on the turning space at the back of curb (R305.2.2).

Figure 12A-2.08: Detectable Warnings on Parallel Curb Ramps



f. **Perpendicular Curb Ramps:** Placement of detectable warning varies based upon location of grade break as shown in Figure 12A-2.09.

Figure 12A-2.09: Detectable Warnings on Perpendicular Curb Ramps



- g. Refuge Islands:** Where refuge islands are 6 feet wide or greater from back of curb to back of curb, detectable warning shall be placed at the edges of the pedestrian island and separated by a minimum 2 foot strip without detectable warnings. Where the refuge island is less than 6 feet wide, a 2 foot strip without detectable warnings cannot be installed. In these situations, detectable warnings shall not be installed at the island and the pedestrian signal must be timed for full crossing. (R208.1 and R208.2)
- h. Rural Cross-section:** Detectable warnings should be placed similar to urban layouts, except at the edge of shoulder instead of the back of curb.

F. Bus Stop

- 1. Bus Stop Pads:** New and altered bus stop pads shall meet the following criteria.
 - Provide a firm, stable, and slip resistant surface (R308.1.3.1).
 - Provide a minimum clear length of 8 feet (measured from the curb or roadway edge) and minimum clear width of 5 feet (measured parallel to the roadway) (R308.1.1.1).
 - Connect the pad to streets, sidewalks, or pedestrian circulation paths with at least one accessible route (R308.1.3.2).
 - The slope of the pad parallel to the roadway will be the same as the roadway to the maximum extent practicable (R308.1.1.2).
 - Provide a desirable cross slope of 1.5% up to a maximum cross slope of 2.0% perpendicular to the roadway (R308.1.1.2).
- 2. Bus Shelters:** Where new or replaced bus shelters are provided, install or position them to allow a wheelchair user to enter from the public way. An accessible route shall be provided from the shelter to the boarding area. (R308.2)
- 3. Safe Street Crossings:** Most bus users need to cross streets when traveling to or from transit stops. Safe street crossings should be provided near bus stops, typically within 100 feet (FHWA Pedestrian Safety Guide for Transit Agencies). Where bus stops are near to a signalized intersection, designers should evaluate the signal to ensure appropriate pedestrian intervals, cycle lengths, and equipment are present.

G. Accessible Pedestrian Signals

An accessible pedestrian signal is an integrated device that communicates information about the WALK and DON'T WALK intervals at signalized intersections in a non-visual format (i.e. audible tones and vibrotactile surfaces) to pedestrians who have visual disabilities. Consistency throughout the pedestrian system is very important. Contact the Engineer regarding the standards and equipment types that should be incorporated into the design of the accessible pedestrian system. Where new or altered pedestrian signals and pushbuttons are provided they shall comply with MUTCD 4E.08 through 4E.13. Operable parts shall comply with R403. (R209.1)

- 1. New Pedestrian Signals:** Each new traffic signal project location should be evaluated to determine the need for accessible pedestrian signals. An engineering study should be completed that determines the needs for pedestrians with visual disabilities to safely cross the street (MUTCD 4E.09). The study should consider the following factors:
 - Potential demand for accessible pedestrian signals.
 - Requests for accessible pedestrian signals by individuals with visual disabilities.
 - Traffic volumes when pedestrians are present, including low volumes or high right turn on red volumes.

- The complexity of the signal phasing, such as split phasing, protected turn phases, leading pedestrian intervals, and exclusive pedestrian phases.
- The complexity of the intersection geometry.

If a pedestrian accessible signal is warranted, audible tones and vibrotactile surfaces should be included. Pedestrian pushbuttons should have locator tones for the visually impaired individual to be able to access the signal.

2. **Existing Pedestrian Signals:** Excluding routine maintenance or repairs due to accidental damage, when the existing pedestrian signal controller and software are altered, or the pedestrian signal head is replaced, the pedestrian signals shall include accessible pedestrian signals and pushbuttons. (R209.2)

If pedestrian signals are non-compliant, upgrades are recommended but not required when alterations are being made to the pedestrian circulation path.

H. On-Street Parking

- When on-street parking is marked or metered, provide accessible parking spaces according to Table 12A-2.01 (R214 and R309.1).

Table 12A-2.01 On-Street Accessible Parking Spaces

Total Number of Marked or Metered Parking Spaces on the Block Perimeter	Minimum Required Number of Accessible Parking Spaces
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 and over	4% of total

- Identify accessible parking spaces by displaying signs with the International Symbol of Accessibility (R411).
- Comply with R403 Operable Parts for parking meters and pay stations that serve accessible parking spaces.
- Locate accessible parking spaces where the street has the least crown and grade (R309.1).
- Accessible parking spaces located at the end of the block can be served by the curb ramps or blended transitions at the pedestrian street crossing (R309.4).
- Keep sidewalks adjacent to parallel accessible parking spaces free of signs, street furniture, and other obstructions. Locate curb ramps or blended transitions so the van side-lift or ramp can be deployed to the sidewalk (R309.2).
- At parallel accessible parking spaces, locate parking meters at the head or foot of the parking space (R309.5.1). Ensure information is visible from a point located 3.3 feet maximum above the center of the clear space in front of the parking meter or parking pay station (R309.5.2).
- For areas where the sidewalk width or available right of way exceeds 14 feet, provide an access aisle 5 feet wide at street level the full length of the parallel parking space and connect it to a pedestrian access route (R309.2.1). When an access aisle is not provided due to the sidewalk or right-of-way not exceeding 14 feet, locate the accessible parallel parking space at the end of the block face (R309.2.2).

- Provide an 8 foot wide access aisle the full length of the parking space for perpendicular or angled accessible parking spaces. Two accessible parking spaces are allowed to share a common access aisle (R309.3).
- For perpendicular or angled spaces, connect the access aisle to the pedestrian access route with a curb ramp. Do not locate curb ramps within the access aisle (R309.4).

Protruding Objects

A. Introduction

This section provides guidance to comply with section R402 of the Public Right-of-Way Accessibility Guidelines (PROWAG). The pedestrian area is any prepared area available for pedestrians (equivalent to the pedestrian circulation path as defined in PROWAG). A protruding object is any obstacle that reduces the clearance width and/or the clearance height within a pedestrian area. The pedestrian area is not limited to the sidewalk or the pedestrian access route intended by the designer. The pedestrian area includes any areas that may be perceived as a pedestrian walking space, including adjacent parking lots and paved frontage.

Common protruding objects include:

- Signs and Sign poles
- Landscaping and branches
- Utility boxes or poles and their stabilizing wires
- Mailboxes (public and private)
- Trash cans
- Transit shelters
- Bike racks
- Planters
- Fire hydrants
- Parking meters
- Benches
- Public Art

B. Protruding Object Locations

1. **Outside the Pedestrian Area:** A protruding object can result in narrow passing spaces, reduced access, and injury. Therefore, protruding objects should be placed completely outside of the pedestrian area whenever possible.
2. **Within the Pedestrian Area:** Ideally, the full width of the pedestrian area should be free of protruding objects and the pedestrian access route would be clearly separated from other paved surfaces. However, if some obstacles must be located within the pedestrian area, they should all be placed either right or left of center to provide a consistent pedestrian access route. Figure 12A-3.01 shows an acceptable pedestrian area with obstacles aligned, providing a consistent pedestrian access route. Figure 12A-3.02 shows an undesirable pedestrian area with a poorly defined pedestrian access route. The pedestrian access route within the pedestrian area must meet guidelines defined in this chapter. Special sidewalk treatments (such as brick pavers or stamped concrete) are recommended to provide a different surface texture to differentiate between the object corridor and the pedestrian access route.

Figure 12A-3.01: Acceptable Pedestrian Area



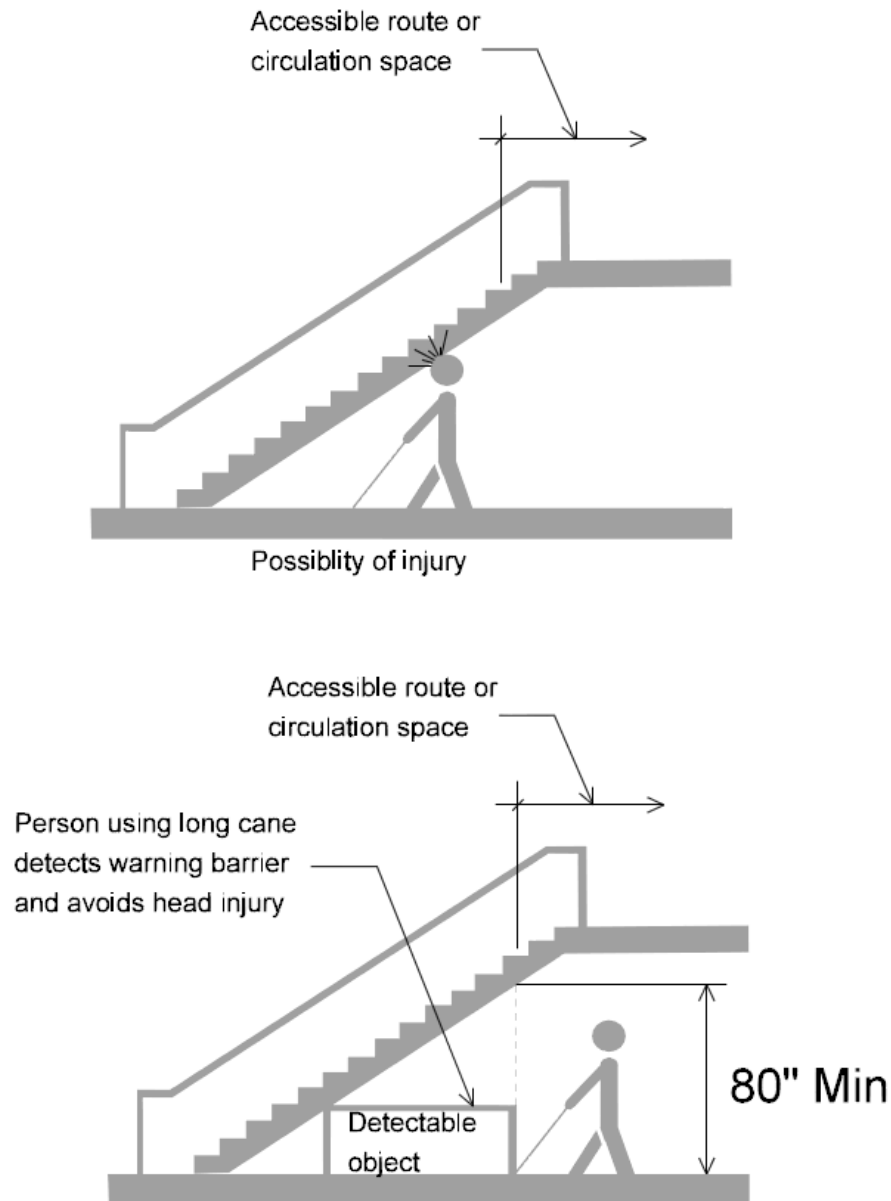
Figure 12A-3.02: Undesirable Pedestrian Area



C. Clearance

1. **Vertical Clearance:** Vertical clearance is minimum unobstructed vertical passage space required along the entire width of the pedestrian corridor. A minimum vertical clearance of 80 inches must be provided or the object must be shielded with a barrier. The leading edge of the barrier shall be a maximum of 27 inches above the finished surface. See Figure 12A-3.03.

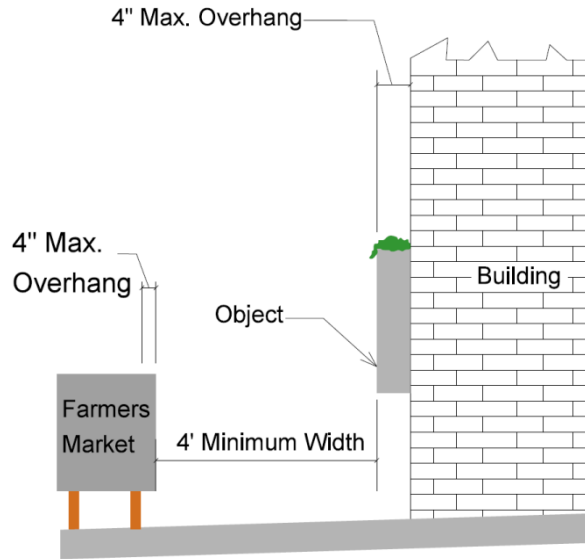
Figure 12A-3.03: Shielding for Vertical Clearance Obstacles



2. **Horizontal Clearance:** Objects mounted at or below 27 inches may extend from a fixed structure into the pedestrian area, provided the remaining sidewalk width complies with [Section 12A-2](#). Objects that extend below 27 inches are easily detectable by most pedestrians.

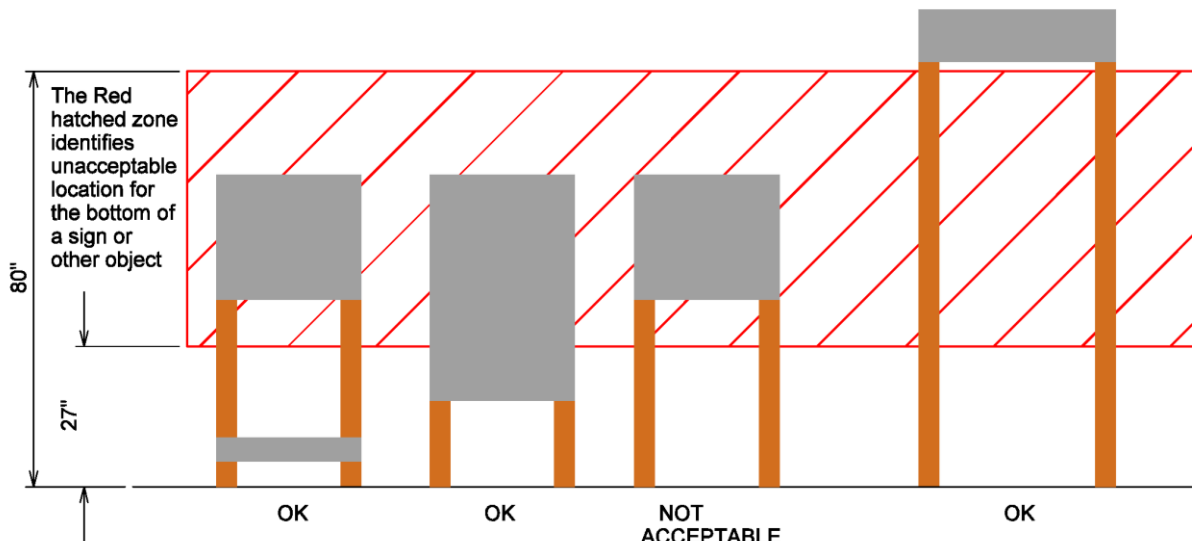
Objects that extend into the pedestrian area at a height above 27 inches are not easily detected with a cane and pedestrians may walk into them. This type of object cannot extend into the pedestrian corridor more than 4 inches from its base. The base shall be at least 2.5 inches in height. See Figure 12A-3.04.

Figure 12A-3.04: Horizontal Clearance



- 3. Objects Mounted Between Posts:** Where an object is mounted between posts or pylons and the clear distance between the posts or pylons is greater than 12 inches, the lowest edge of the object shall be between 0 and 27 inches or 80 inches or more above the ground (see Figure 12A-3.05). For objects mounted on posts closer than 12 inches, follow the requirements for horizontal clearance defined above.

Figure 12A-3.05: Height Restriction for Signs Mounted Between Posts



Pedestrian Facilities During Construction

A. Introduction

When projects impact pedestrians, it is important for the engineer to develop a temporary traffic control plan for pedestrians, including those with disabilities. For Iowa DOT projects, see [Iowa DOT Design Manual Section 9A-5](#) for temporary traffic control plans. The applicable guidelines for the temporary traffic control plan are the Public Right-of-Way Accessibility Guidelines (PROWAG) and Manual on Uniform Traffic Control Devices (MUTCD).

According to PROWAG, when a pedestrian circulation path is temporarily closed for construction or maintenance activities, an alternate pedestrian access route complying with [Sections 6D.01, 6D.02, and 6G.05](#) of the MUTCD shall be provided (R205). However, MUTCD ([Section 6D.01](#)) also requires knowledgeable persons to conduct appropriate evaluations or use engineering judgment in determining temporary traffic controls for pedestrian circulation paths. This section includes guidance on conducting the evaluation when an alternate pedestrian access route may not be practical.

B. Evaluating Pedestrian Needs

The initial design activity should be to determine the level of the accessibility of the current pedestrian circulation path within the area of the project and the adjacent areas. The impact to the pedestrian circulation path, including transit stops, from the construction or maintenance activity needs to be determined. Develop pedestrian accommodations to provide the best accessibility practical through all stages of work. Consider obtaining local input through a public meeting or contact with residents or public officials to see where additional accessibility needs should be addressed (e.g. senior centers, medical facilities, schools, public facilities, etc.).

Whenever possible, the work should be done in such a manner that does not create a need to detour pedestrians from existing routes. Pedestrians rarely observe detours and the cost of providing accessibility and detectability might outweigh the cost of maintaining a continuous route through the construction zone ([MUTCD 6D-01](#)). All methods should be given consideration, including providing alternate means of traversing the construction zone. If pedestrians are to be directed through the construction zone, safety as well as accessibility must be addressed. If a pedestrian detour is developed, it should replicate the accessibility of the existing route. If possible, stage construction to keep one side of the street open to pedestrian travel.

C. Facility Options

To address the impacts to the pedestrian circulation path, including transit stops, consider the following:

- Develop a temporary traffic control plan to guide the pedestrians through the construction zone.
- Close the pedestrian circulation path through the construction zone.
- Close the pedestrian circulation path through the construction zone; develop a detour route consistent with the accessibility features present in the pedestrian circulation path being closed.
- Provide alternate means for pedestrians to traverse the construction zone, such as free accessible shuttles or other forms of assistance.

D. Barricades, Channelizing Devices, and Signs

Pedestrian barricades and channelizing devices shall comply with sections [6F.63](#), [6F.68](#), and [6F.71](#) of the MUTCD. Do not allow post-mounted signs to encroach on sidewalks, shared use paths, or bicycle lanes. Do not place portable signs or barricades on sidewalks unless those facilities are officially closed.

1. **Barricades:** Barricades are used for pedestrian circulation path closures. See [Iowa DOT Specifications Section 2528](#).
2. **Channelizing Devices:** The designer should consider the safety of pedestrians and vehicles when choosing channelizing devices.
 - a. **Type A:** Type A devices are redirective barriers designed for highway applications. These devices are suitable when pedestrians are routed into the travel way and allow for the most protection for pedestrians from vehicular intrusion.
 - b. **Type B:** Type B devices are crashworthy but do not redirect vehicles. These devices are designed to minimize risks associated with flying debris.
 - c. **Type C:** Type C devices include any device that meets ADA requirements for channelizing pedestrians and may not be crashworthy. These devices are for locations where vehicular intrusions are unlikely (e.g. closed roads, when there is a separation between pedestrians and vehicular traffic, or where vehicular traffic is at low speeds).
3. **Signs:** See [Iowa DOT Standard Road Plan TC-601](#) and [TC-602](#).

E. Temporary Pedestrian Facilities

Temporary pedestrian facilities should comply with the other sections within this chapter to the extent practical. It is strongly recommended that detour routes be on paved surfaces.

Temporary pedestrian facility surfaces must be firm, stable, and slip resistant. Granular surfacing for short term, temporary pedestrian facilities is acceptable. The granular surfacing material should be well graded, such as Class A road stone ([Iowa DOT Specifications Section 4109, Gradation No. 8](#)) or special backfill ([Iowa DOT Specifications Section 4109, Gradation No. 30](#)). Maintenance of the temporary pedestrian facility surface to meet the firm, stable, slip resistant, and minimum width is required at all times. The temporary pedestrian facility surface must be removed and a permanent pedestrian facility must be replaced prior to the end of the construction season.

F. Utility Construction

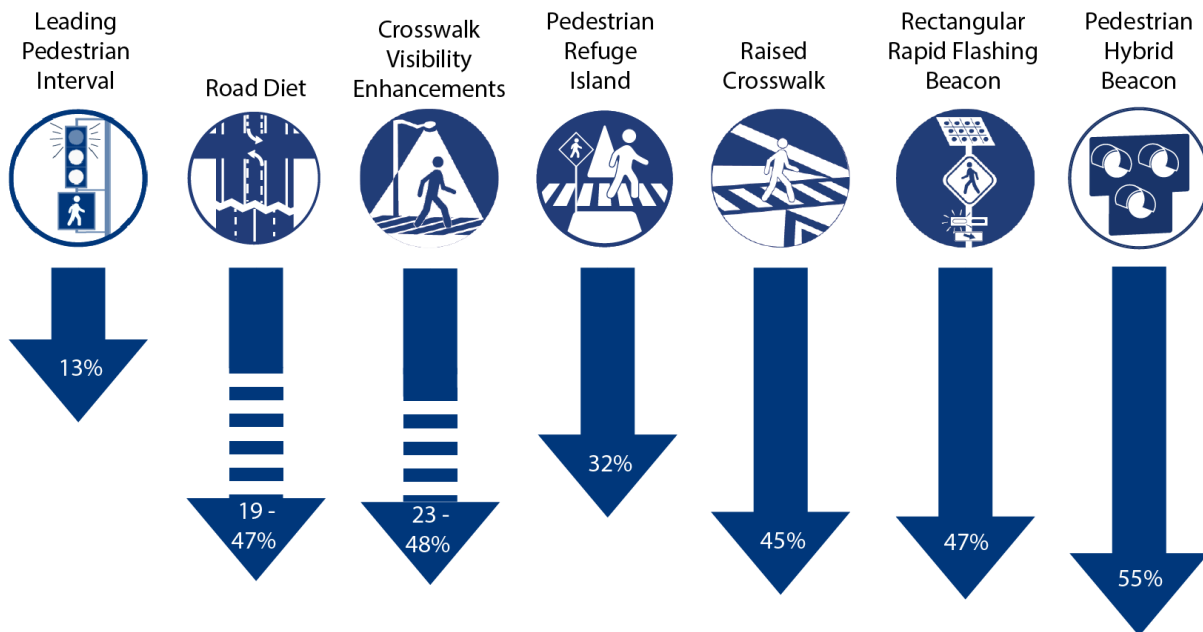
If the pedestrian circulation path is disturbed during utility construction, the requirements of this section and [Section 12A-2](#) shall apply.

Pedestrian Safety Measures at Crossings

A. Safe Transportation for Every Pedestrian (STEP)

FHWA’s Safe Transportation for Every Pedestrian (STEP) program produces technical assistance and design guidance on proven countermeasures for improving pedestrian safety. The purpose of this section is to provide guidance on how to select and implement these measures. The pedestrian safety measures and their crash mitigation reduction factor (CRF) are shown on Figure 12A-5.01.

Figure 12A-5.01: Crash Reduction Factors for Pedestrian Safety Measures



Source: Based on FHWA STEP Countermeasure Tech Sheets

B. Selecting Crossing Locations for Pedestrian Safety Measures

The provision of pedestrian safety crossing measures should be assessed along any road where pedestrians are allowed. In rural town, suburban, and urban land uses, pedestrians are expected and a well-connected pedestrian network is necessary for safe travel. However, agencies should prioritize implementing pedestrian safety measures in areas more likely to result in serious or fatal crashes. Ideally, an agency would engage in a systemic safety evaluation to identify roadway safety problems and select safety improvements. A systemic safety evaluation analyzes crash data in conjunction with other roadway data to understand the combination of conditions possibly creating high crashes, and allows planners and engineers to identify high risk crossing locations, even if no crash has occurred. When using crash data, it is important to review at least 5 years of data to analyze anomalies that might occur in a single year.

In the absence of a systemic safety analysis, enhanced pedestrian crossing safety measures should be considered at crosswalks with intersecting traffic volumes of 9,000 vehicles/day, where vehicle speeds exceed 30 mph, or the number of travel lanes to be crossed exceeds 2 lanes. In these instances, designers should consider enhanced crossings treatments at currently uncontrolled intersections or midblock where signalized crossings exceed 600 feet.

Crossings should be located where there is a desire to cross due to existing or future land use.

Examples include:

- Schools, public parks, libraries, post offices, or community centers.
- Commercial centers, government centers, and a hospital or school/university campus spanning across a street.
- Transit stops.
- Shared use path crossings.
- Existing pedestrian demand demonstrates a need (as determined by counts, or a parking lot and an office building on opposite sides of the roadway).

When evaluating a corridor to determine appropriate pedestrian safety measures at crossings, it is important to consider land uses, destinations directly on the corridor, and the areas immediately adjacent to the corridor. For example, a commercial street may have parks and schools located within several blocks of the street. Considering pedestrian circulation to those destinations within neighborhoods will help identify key crossings serving the larger area as well as land uses along the street.

To promote and achieve high compliance, mid-block crossings should be located where intersection spacing is greater than 600 feet and there is a natural desire line for the pedestrian's path of travel. Mid-block crosswalks should not be installed within the functional area of intersections. They should be located a minimum of:

- 200 feet from signalized intersections.
- 120 feet to 200 feet or more from unsignalized intersections.

Engaging the public is an important aspect of crossing location and pedestrian safety measure selection process. It can build public trust in the process, improve the overall quality of the work, ensure the project aligns with local needs and priorities, and encourage community ownership of the final result. People who walk and bike in the community have the best knowledge of current conditions at different times of day, special events, and even weather. Designers can also consider hosting walk and bike audits with local stakeholders to better understand safety issues through both local knowledge and professional expertise. The demographic characteristics of participants in public engagement should reflect the demographics of the community being served to ensure the full needs of the community are being met.

C. Design for Safe Pedestrian Crossings

A safe and intuitive pedestrian crossing incorporates the proper layout of design elements such as curb ramps, traffic control devices, intersection corner radii, and sight distance to accommodate all users. The following discusses the intersection elements and recommendations to provide effective crossing for pedestrians.

- 1. Characteristics of Safe, Accessible, and Convenient Crossings:** Whether marked or unmarked, crosswalks exist at all legs of all intersections represented by the extension of curb lines or edge of the traversable roadway through the intersection including T-intersections, except where pedestrians are prohibited. Motorists are required to yield to pedestrians crossing the roadway within any marked or unmarked crosswalk. The following are characteristics of safe, accessible, and convenient pedestrian crossings:

- a. Proper Visibility Between Approaching Motorists and Crossing Pedestrians:** It is critical for pedestrians to have adequate visibility of motorists approaching within travel lanes and for motorists in the travel lanes to easily see pedestrians waiting at intersections and mid-block crossings. Elements such as parked vehicles, buildings, hedges, and walls can impede the visibility between motorists and pedestrians. When possible, these elements should be restricted or relocated to provide proper visibility. Curb extensions or bump outs can increase visibility at intersections and mid-block crossing locations particularly for shorter pedestrians, such as people using wheelchairs and children.

Visibility is also impacted by large corner radii, which by design place curb ramps and sidewalks farther back from the intersection.

- b. Appropriate Frequency of Crossing Opportunities:** Pedestrians will generally not travel out of direction and will cross at the most convenient location. In general, the frequency of crossing opportunities should be approximately the same spacing as the street grid in the surrounding area. In locations where the street grid results in block lengths over 600 feet in length, and adjacent land uses generate pedestrian traffic, mid-block crossings may be desirable to improve walkability.
- c. Minimal Exposure to Conflicts with Motorists:** Short street crossings improve pedestrian safety and comfort by reducing exposure time and reducing the potential of vehicle-pedestrian conflicts. Depending on signal timing phasing, short street crossings may also reduce vehicle delay. Short pedestrian crossing distances may be achieved through smaller curb radii, building curb ramps aligning directly with crosswalks, curb extensions, pedestrian refuge islands, realignment of crosswalks at offset intersections, reducing lane widths, and reducing the number of vehicle lanes through road diets. At signalized intersections, pedestrian exposure to motor vehicle traffic may also be reduced or eliminated using signal phasing strategies including right turn on red restrictions, leading pedestrian intervals, protected pedestrian phasing, and exclusive pedestrian phases.
- d. Minimal Delay to Pedestrians Waiting to Cross at Both Signalized and Unsignalized Crossings:** When pedestrians experience delays, they are more likely to cross the street against a signal or without a sufficient gap in traffic. At signalized intersections, pedestrian delay can be minimized by maintaining short signal cycles. At uncontrolled crossings, designers should evaluate the crossing conditions to understand if pedestrians will have a sufficient frequency and length of gaps in traffic.
- e. Low Speeds and Improved Visibility for Turning Vehicles:** At both signalized and unsignalized intersections, steps should be taken to ensure that turning speeds are kept low and that adequate sight distance is provided for roadway users and pedestrians. This is critical given that the chance of severe injuries for the pedestrian is higher as vehicle speeds increase. Low turning speeds and improved visibility can be achieved through smaller curb radii, turning restrictions, pedestrian refuge islands, and raised crosswalks.
- f. High Motorist Yielding Rates at Uncontrolled Crossings:** At intersections without a stop sign or traffic signal, where street conditions are not conducive to motorists yielding, and where pedestrians or bicyclists are likely to be present, additional design treatments may be necessary in order to encourage motorists to yield to pedestrians waiting to cross. To encourage motorist yielding at uncontrolled crossings, consider traffic calming treatments such as raised crosswalks or curb extensions to slow motor vehicle speeds, and signs and markings that remind motorists of their obligation to yield to pedestrians such as Rapid rectangular flashing beacons and advance yield markings. At certain speed and volume

thresholds, motorists cannot be expected to yield and a traffic control device such as a pedestrian hybrid beacon may be necessary.

- Selecting Pedestrian Safety Measures at Uncontrolled Crossings:** Uncontrolled pedestrian crossings, including those crossings shared with bicyclists such as shared use paths, should be designed with appropriate treatments and countermeasures to improve motorist yielding. Table 12A-5.01 summarizes countermeasures which have been found to be effective at improving pedestrian safety based on research related to the number of motorist lanes, volumes, and operating speeds.

Table 12A-5.01: Application of Pedestrian Safety Measures at Uncontrolled Crossings by Roadway Speed, Volume, and Configuration

Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	① 2 4 5 6	① 5 6 7 9	① 5 6 7 9	① 4 5 6 7 9	① 5 6 7 9	① 5 6 7 9	① 4 5 6 7 9	① 5 6 7 9	① 5 6 9
3 lanes with raised median (1 lane in each direction)	① 2 3 4 5	① ③ 5 7 9	① ③ 5 7 9	① 3 4 5 7 9	① ③ 5 7 9	① ③ 5 7 9	① ③ 4 5 7 9	① ③ 5 7 9	① ③ 5 9
3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)	① 2 3 4 5 6 7 9	① ③ 5 6 7 9	① ③ 5 6 9	① 3 4 5 6 7 9	① ③ 5 6 7 9	① ③ 5 6 9	① ③ 4 5 6 7 9	① ③ 5 6 9	① ③ 5 6 9
4+ lanes with raised median (2 or more lanes in each direction)	① ③ 5 7 8 9	① ③ 5 7 8 9	① ③ 5 8 9	① ③ 5 7 8 9	① ③ 5 7 8 9	① ③ 5 8 9	① ③ 5 7 8 9	① ③ 5 8 9	① ③ 5 8 9
4+ lanes w/o raised median (2 or more lanes in each direction)	① ③ ① ③ 5 6 7 8 9	① ③ ① ③ 5 6 7 8 9	① ③ ① ③ 5 6 8 9	① ③ ① ③ 5 6 7 8 9	① ③ ① ③ 5 6 7 8 9	① ③ ① ③ 5 6 8 9	① ③ ① ③ 5 6 7 8 9	① ③ ① ③ 5 6 8 9	① ③ ① ③ 5 6 8 9
<p>Given the set of conditions in a cell,</p> <ul style="list-style-type: none"> # Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location. ● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location. ○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.* <p>The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.</p>		<ul style="list-style-type: none"> 1 High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs 2 Raised crosswalk 3 Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line 4 In-Street Pedestrian Crossing sign 5 Curb extension 6 Pedestrian refuge island 7 Rectangular Rapid-Flashing Beacon (RRFB)** 8 Road Diet 9 Pedestrian Hybrid Beacon (PHB)** 							

Source: FHWA STEP *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations*

Table 12A-5.01 should not be used to evaluate crossings and select measures without first establishing at which intersections or mid-block locations pedestrians desire to cross. Section 12A-5, C provides guidelines for determining existing and potential pedestrian crossing locations. Designers should recognize that the consideration of pedestrian accommodations and safety measures is not based on a pedestrian volume threshold, but instead recognizes that if there is a desire for pedestrians to cross then these features should be considered.

The FHWA STEP *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations* provides additional guidance on when each of the pedestrian safety measures are appropriate, including the safety issues, the surrounding land context, and planning level costs.

A marked crosswalk is useful to show pedestrians and drivers preferred crossing locations. However, for multilane roadway crossings where vehicle AADTs are in excess of 10,000, a marked crosswalk alone is typically not sufficient. Under such conditions, more substantial crossing improvements are also needed to prevent an increase in pedestrian crash potential. Examples of more substantial treatments include the refuge island, PHB, and RRFB. Refer to the symbols used in Table 12A-5.01 for when a marked crosswalk should be paired with one or more of the other countermeasures described. To further increase visibility of pedestrian crossings, agencies often integrate multiple countermeasures. For example, the pedestrian hybrid beacon is often installed in conjunction with advance stop markings and signs. Also, road diets present opportunities for adding pedestrian refuge islands and curb extensions at key crossing locations. Agencies should consider roadway geometry and the MUTCD when integrating multiple countermeasures.

3. **Additional Considerations at Mid-block Crossings:** Mid-block pedestrian crossings may be appropriate in a variety of contexts based on pedestrian desire lines, transit stop locations, land use context, and intersection spacing. Motorists are more likely to expect pedestrians at intersection locations and often are driving at higher speeds in mid-block locations. Because of this, the use and design of mid-block crossings should be deliberate to address pedestrian safety and improve motorist compliance. Given the differences between intersection and mid-block crossings, there are several key considerations designers must keep in mind:
 - The crosswalk must be marked to establish a crossing.
 - The crossing location should be convenient for pedestrians. Pedestrians have a strong desire to stay on their path of travel and do not want to go unnecessarily out of their way to utilize a crossing, so crossing locations should be placed at or near the pedestrian's desired path of travel.
 - Motorists should be alerted of the crossing as they approach it.
 - Pedestrians must be able to assess opportunities to cross.
 - All users must be aware of their responsibilities and obligations at the crossing and designers should ensure to provide opportunities to meet those responsibilities and obligations.

D. Design of Pedestrian Safety Measures

A safe and intuitive pedestrian crossing incorporates proper layout of design elements. A summary of most of the pedestrian safety measures in Table 12A-5.01 is provided below.

1. Crosswalk Visibility Enhancement Markings:

- a. **Crosswalk Markings:** Crosswalk markings are a basic tool for directing pedestrians across the street and alerting motorists and bicyclists of crossing pedestrians. Engineering judgement should be used to determine when to mark a crosswalk. In general, marked crosswalks and other safety treatments should be prioritized at locations where pedestrians are vulnerable to conflicts with vehicles due to:
 - High pedestrian and vehicle volumes, typical in town centers, at major bus stops, or near schools including universities.
 - Vulnerable populations such as children, senior citizens, people with disabilities, or hospital are frequently present.
 - Difficult roadway conditions for pedestrians to cross, such as wide crossing distances, high traffic speeds, complex intersection geometry.

There are two types of standard crosswalks:

- **Standard (Transverse) Crosswalk Markings:** A standard crosswalk consists of two transverse (parallel) lines, each a minimum of 6 inches in width.
- **High-Visibility (Longitudinal) Crosswalk Markings:** A high visibility crosswalk consists of longitudinal lines striped parallel to the direction of travel. The longitudinal lines may be used alone or in addition to the transverse lines, thus creating a ladder-style crossing.

In general, longitudinal markings are more visible than the two transverse lines to drivers. The FHWA *STEP Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations* strongly recommends providing high-visibility crosswalks at all established midblock pedestrian crossings. NCHRP Report 926 *Guidance to Improve Pedestrian and Bicyclist Safety at Intersections* notes that transverse crosswalk markings are only appropriate at stop-controlled or signalized intersections and should not be used for uncontrolled locations without supplemental treatments. In addition, local jurisdictions may have established policies that require high-visibility crosswalks near schools, other pedestrian generators, or at all intersections meeting certain thresholds.

Refer to the Iowa DOT [Traffic and Safety Manual](#) (TAS), [Sections 3B-1](#) and [3B-2](#); and MUTCD, [Section 3B.18](#) for line widths and spacing criteria for both standard and high-visibility crosswalks. At any marked crosswalk, curb ramps and other sloped areas should be wholly contained within the crosswalk markings. The crosswalk lines should extend the full length of the crossing. Longitudinal markings require more pavement marking material than transverse markings, and as a result have higher installation costs. Staggered spacing on longitudinal markings to avoid vehicle wheel paths can, however, reduce maintenance costs.

- b. Parking Restriction on Crosswalk Approach:** Iowa state law prohibits stopping, standing, or parking within 10 feet of the approach to any flashing beacon, stop sign, or traffic-control signal. (Iowa Code §321.358). Ten feet will usually be insufficient to permit proper visibility between approaching motorists and crossing pedestrians. Agencies should consider implementing parking restrictions on the crosswalk approach at all established pedestrian crossings (both approaches) so there is adequate sight distance for motorists on the approaches to the crossings and ample sight distance for pedestrians attempting to cross. The minimum setback is 20 feet where speeds are 25 mph or less, and 30 feet between 26 mph and 35 mph. If this cannot be achieved, curbs should be “bulbed out” to allow the pedestrian to see past the parked vehicle along the street.
- c. Adequate Nighttime Lighting:** It is best to place streetlights along both sides of arterial streets and provide a consistent level of lighting along a roadway. This includes lighting pedestrian crosswalks and approaches to the crosswalk. A single luminaire placed directly over the crosswalk does not adequately illuminate the pedestrian for the approaching motorist. To achieve the illumination necessary for motorists to detect a pedestrian in the crosswalk, the lights should be placed 10 to 15 feet in advance of the crosswalk on both sides of the street and on both approaches to better light the front of the pedestrian and avoid silhouette lighting (where possible).
- d. Crossing Warning Signs:** Consider supplementing high-visibility crosswalks with pedestrian crossing warning signs (sign W11-2 in the MUTCD) on each approach to the crosswalk. MUTCD [Section 2C.50 - Non Vehicular Warning Signs](#) and [Section 3B.18 - Crosswalk Markings](#) provide additional information.

- 2. Raised Crosswalk:** Raised crosswalks or raised intersections are ramped speed tables spanning the entire width of the roadway or intersection. Raised crosswalks are often placed at midblock crossing locations and only the width of a crosswalk. The crosswalk is demarcated with paint and/or special paving materials, and curb ramps are eliminated because the pedestrians cross the road the same level as the sidewalk. Raised crossings make the pedestrian more prominent in the driver's field of vision. Additionally, approach ramps may reduce vehicle speeds and improve motorist yielding.

The crosswalk table is typically at least 10 feet wide and designed to allow the front and rear wheels of a passenger vehicle to be on top of the table at the same time. Detectable warnings (truncated domes) and curb ramps (if the raised crossing is not at sidewalk height) are installed at the street edge for pedestrians with impaired vision or mobility disabilities. In addition to their use on local and collector streets, raised crosswalks can be installed in campus settings, shopping centers, and pick-up/drop-off zones (e.g., airports, schools, transit centers).

Designers should consider the following for raised crosswalks or intersections:

- May not be appropriate for bus transit routes or primary emergency vehicle routes. These vehicles may experience issues with vertical deflection associated with raised crossings.
- Particular attention should be paid to impacts on drainage.
- May be inappropriate for crossings on curves or steep roadway grades.
- Additional markers and training for snow plow drivers may be needed.

See MUTCD [Section 3B.25 - Speed Hump Markings](#) for additional information about markings that can be used alongside raised crosswalks.

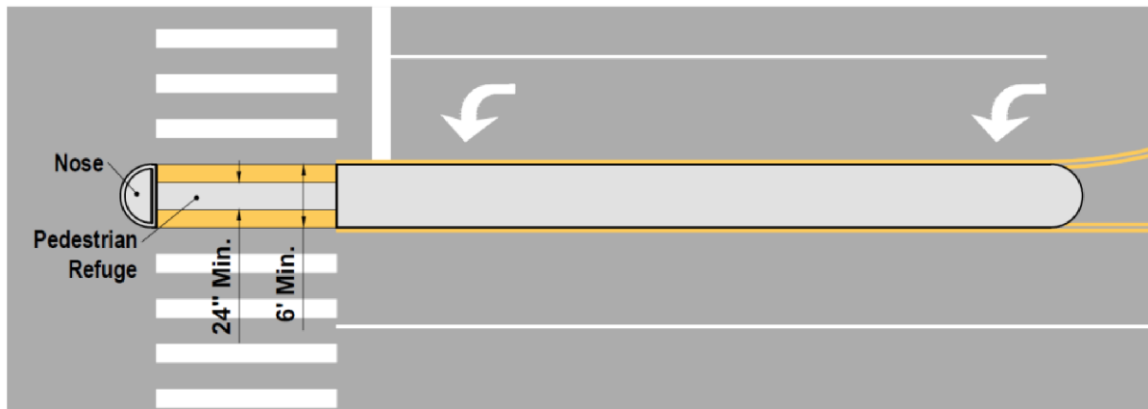
- 3. Advance Yield Here to Pedestrians sign and Yield Line:** Advance Yield Here To Pedestrians signs (sign R1-5 in the MUTCD) are placed between 30 and 50 feet in advance of the marked crosswalk along with the “shark’s teeth” yield line. Advance Yield markings and signs can greatly reduce the likelihood of a multiple-threat crash, which occurs when a motorist stopped in one lane blocks the view of a second motorist. The treatment should be strongly considered for any established pedestrian crossing on roads with four or more lanes and/or roads with speed limits of 35 mph or greater. Refer to the TAS [Sections 3B-1](#) and [3B-2](#); and MUTCD [Section 2B.11 - Yield Here To Pedestrians Signs](#) and [Section 3B.16 - Stop and Yield Lines](#) contain additional information.
- 4. In-Street Pedestrian Crossing Sign:** In-street signs are placed in the middle of the road at a crossing and are often used in conjunction with refuge islands. These signs may be appropriate on 2 lane or 3 lane roads with speed limits of 30 mph or less. On higher-speed, higher-volume, and/or multilane roads, this treatment may not be as visually prominent; therefore, it may be less effective (drivers may not notice the signs in time to stop in advance of the crosswalk). For such roadways, more robust treatments will be needed. When making the choice to use these signs, the agency should consider making a plan and securing a funding source for the maintenance and prompt replacement of damaged signs. The MUTCD permits in-street pedestrian signs for installation on centerlines and along lane lines. MUTCD [Section 2B.12 - In-Street and Overhead Pedestrian Crossing Signs](#) contains additional information about these signs.

5. **Curb Extension:** On streets with on-street parking, curb extensions can be used at both uncontrolled crossings and signalized or stop-controlled intersections to extend the sidewalk or curb line into the parking lane. Curb extensions reduce crossing distance for pedestrians and bicyclists, improve sight distance for all road users, and prevent parked cars from encroaching into the crosswalk area. At intersections, curb extensions can better control the effective turning radius and can be used in conjunction with truck aprons. Designers should consider the following for intersection and mid-block locations:
- Curb extensions are typically used where there is an on-street parking lane and the curb extension width is typically the width of, or 1 foot less than, the width of the parking lane. Curb extensions should not extend into paths of travel for bicyclists.
 - Mid-block curb extensions can be co-located with fire hydrants to maintain access to hydrants and to reduce impacts to on-street parking.
 - Curb extensions can create additional space for curb ramps, low-height landscaping, and street furniture where sidewalks are otherwise too narrow. Care should be taken to ensure that street furniture and landscaping do not block motorists' views of pedestrians.
 - Curb extension designs should facilitate adequate drainage, either by providing inlets upstream of the curb extension, providing grading that maintains drainage flows along the curb line, or by providing a drainage bypass channel beneath the sidewalk. The designer should consider factors such as maintenance in the selection of drainage facilities, as some options may be more prone to clogging and require more routine maintenance to function properly, and the ability of bicyclists or pedestrians to safely traverse the structures or grading.
 - Designers should consider providing reflective vertical elements to alert drivers and snowplow operators to the presence of curb extensions.
 - The length of curb extension should extend at least 20 feet long on both sides of the crosswalk, but can be longer depending on the use desired within the extension (e.g., stormwater management, bus loading, restricting parking) or where additional parking restrictions are desired (e.g., where "Advance Yield Here To Pedestrians Sign" and Yield Lines are provided more than 20 feet from the crosswalk).
 - Painted curb extensions may be used as an interim measure and should be paired with edge objects such as flexible delineators to create a sense of enclosure and buffer from motor vehicle traffic.
 - Approaches to curb extensions can be created as a straight taper or using reverse curves, though reverse curves are easier for snowplow operators to guide along without catching the plow edge.
6. **Pedestrian Refuge Island:** Pedestrian refuge islands are appropriate at both uncontrolled locations (i.e., where no traffic signals or stop signs exist) and signalized crossings. At uncontrolled crossings, pedestrian refuge islands allow pedestrians to focus on one direction of traffic at a time as they cross and provide space to wait for an adequate gap in oncoming traffic or for motorists to yield before finishing the second phase of a crossing. At signalized intersections where a wide intersection cannot be designed or timed to accommodate a pedestrian crossing of the intersection at one time, a pedestrian refuge island must be provided. A median refuge should be considered where crossing distances are greater than 50 feet to better accommodate slower-moving pedestrians.

Designers should consider the following for intersection and mid-block locations:

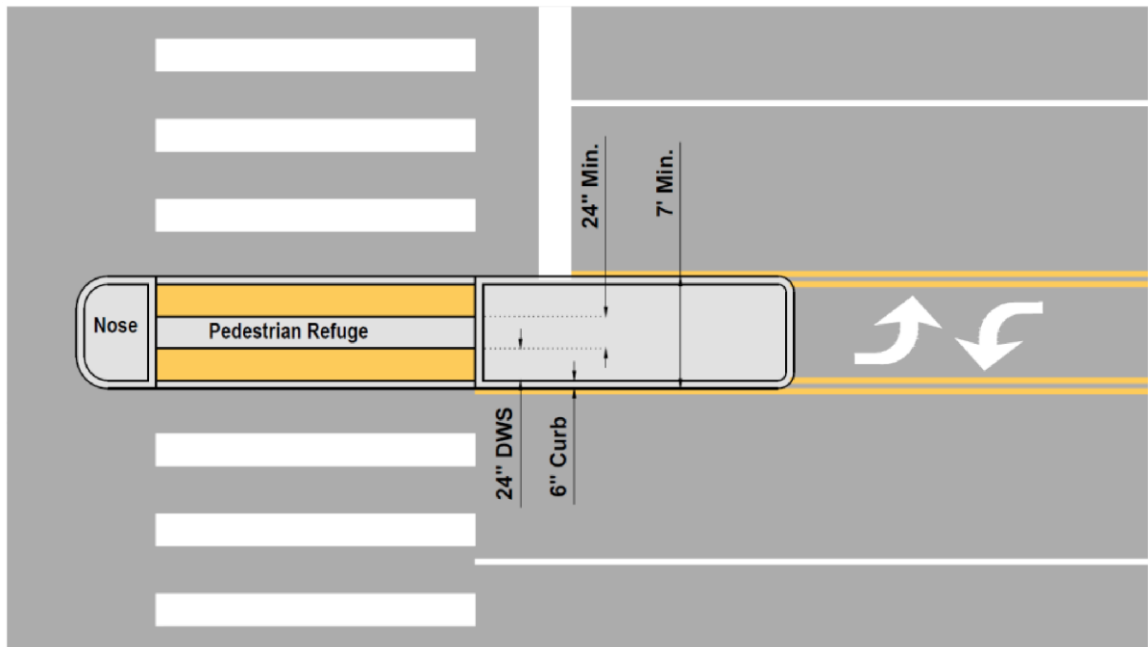
- The minimum width for a crossing island to provide an accessible refuge is 6 feet, measured from outside edge of the detectable warning surfaces, and the minimum width between detectable warning surfaces is 24 inches (Figure 12A-5.02) Where medians are constructed using curbing and the detectable warnings are placed at the back of curb, the minimum width of the island is 7 feet, measured from curb face to curb face (Figure 12A-5.03).

Figure 12A-5.02: Pedestrian Refuge Island - Detectable Warning Surface Placed in Line with Island Face of Curb



Source: Based on PROWAG figure R 305.2.4

Figure 12A-5.03: Pedestrian Refuge Island - Detectable Warning Surface Placed at Back of Curb



Source: Based on PROWAG figure R 305.2.4

- The preferred width of the crossing is 10 feet, which accommodates bicyclists with trailers and wheelchair users more comfortably. At a minimum, cut-through openings should match the width of the corresponding crosswalk and on roadways with speeds of 50 mph or greater, the minimum crossing opening width is 8 feet. A “nose” that extends past the crosswalk toward the intersection is recommended to separate people waiting on the crossing island from motorists, and to slow turning motorists. Traffic control equipment, vegetation, and other aesthetic treatments may be incorporated, but must not obscure pedestrian visibility.
- When a refuge is placed at a signalized crossing, use pedestrian recall to prevent “trapping” a pedestrian in the refuge island.
- Triangular channelization islands adjacent to right turning lanes can also act as refuge islands.
- Median refuges can be coupled with other traffic calming features, such as partial diverters and curb extensions at mid-block and intersection locations.

7. **Rectangular Rapid-Flashing Beacon (RRFB):** An RRFB is a pedestrian-actuated flashing light used in combination with a pedestrian, school, or trail crossing warning sign to improve safety at uncontrolled, marked crosswalks. The device includes two rectangular-shaped yellow indications, each with an LED-array-based light source, that flash with high frequency when activated. The RRFB design differs from the standard flashing beacon by utilizing:
- A different shape.
 - A much faster rapid-pulsing flash rate.
 - A brighter light intensity, directed at eye level of approaching drivers.

The RRFB is a treatment option at many types of established pedestrian crossings. RRFBs are particularly effective at multilane crossings with speed limits less than 40 mph. Consider the Pedestrian Hybrid Beacon (PHB) instead for roadways with higher speeds. On four to six lane streets, RRFBs produce higher driver yielding rates when mounted in the median (or overhead) as well as on the right edge of the roadway in combination with advanced stop or yield lines.

RRFBs are placed on both sides of a crosswalk below the pedestrian crossing sign and above the arrow indication pointing at the crossing. It is preferable to erect crosswalk signage on the far-side of crosswalks less than 20 feet in width. This placement helps ensure that sightlines between pedestrians and motorists are not obstructed. The flashing pattern can be activated with pushbuttons or automated (e.g., video or infrared) pedestrian detection, and should be unlit when not activated.

The Federal Highway Administration has issued interim approval for the use of the RRFB (IA-21). The Iowa Department of Transportation has applied for, and received, interim approval for all highway agencies in the state to use RRFBs under IA-21. IA-21 provides additional information about the conditions of use, including dimensions, placement, and flashing requirements. IA-21 does not provide guidance or criteria based on number of lanes, speed, or traffic volumes.

8. **Road Diet:** A road diet reconfigures the roadway. A frequently-implemented Road Diet involves converting a 4 lane, undivided roadway into a 3 lane roadway with a center turn lane. This is a candidate treatment for any undivided road with wide travel lanes or multiple lanes that can be narrowed or repurposed to improve pedestrian crossing safety.
9. **Pedestrian Hybrid Beacon (PHB):** A PHB head consists of two red lenses above a single yellow lens, and is used in conjunction with pedestrian signal heads installed at each end of a marked crosswalk. Figure 12A-5.04 shows a photo of a PHB. The PHB has also been referred to as the High-Intensity Activated crosswalk beacon (HAWK), but the MUTCD refers to this device as the PHB.

Figure 12A-5.04: Pedestrian Hybrid Beacon

Source: Toole Design

Unlike a traffic signal, the PHB rests in dark until a pedestrian activates it via pushbutton or other form of detection. When activated, the beacon displays a sequence of flashing and solid lights that control vehicular traffic while the pedestrian signal heads indicate the pedestrian walk interval and a pedestrian clearance interval.

The PHB should meet the installation guidelines - based on speed, pedestrian volume, vehicular volume, and crossing length - as provided in MUTCD [Section 4F.01](#) (see Figure 4F-1 for speeds of 35 mph or less; Figure 4F-2 for speeds greater than 35 mph). Research indicates that PHBs are most effective on roads with three or more lanes that have AADTs above 9,000. PHBs should be strongly considered for all midblock crossings where the roadway speed limits are equal to or greater than 40 mph. Refer to Table 1 for other conditions where PHBs should be strongly considered. It should be noted that the PHB and RRFB are not both installed at the same crossing location.

Designers have the flexibility to estimate future demand in the absence of a PHB (or signal) if existing conditions limit vulnerable user crossing opportunities. In some cases, people may not be crossing a street in sufficient numbers to satisfy PHB guidelines (or signal warrants) because there are not adequate gaps in traffic or they do not feel comfortable doing so, thus they avoid the crossing altogether. For these locations, it may be more appropriate to use an estimated crossing demand for analysis that assumes better crossing protection. Experience shows once a street can be crossed more safely, people will generally cross in greater numbers compared to prior conditions. Designers may also include bicyclists in the volume estimating. Depending on the crossing location, they may operate as a motor vehicle or a pedestrian.

PHBs have also been installed successfully at intersections under certain conditions. Since the current MUTCD guidance is to locate PHBs at least 100 feet away from an intersection, engineering judgment/engineering study must be carefully applied if considering an installation at an intersection.

E. Pedestrian Safety at Interchanges

Any work on the design of interchanges, including facilitating pedestrian travel, must be coordinated with Iowa DOT. This subsection is provided for informational purposes because interchanges are often a barrier and safety hazard for people walking. The challenges posed by pedestrians crossing interchanges include the following.

- 1. Multiple Crossings:** Interchanges often require pedestrians to cross several ramps and intersections in stages. This can result in complex movements, and pedestrian signal delays.
- 2. Free-flow Movements:** Where ramps are free-flowing, it can be difficult and unsafe for pedestrians to find safe gaps to cross in a motor vehicle traffic stream that is high volume, high speed, or both.
- 3. Long Crossings and Skewed Crossings:** On and off-ramps often require pedestrians to cross a channelized traffic lane at a skewed crossing angle, which results in longer crossings. In urban areas, off ramps may have several lanes of traffic to store motor vehicles exiting the freeway and turning at signalized intersections. The more lanes of traffic, the longer the crossing distance for pedestrians.

Two design guides provide detailed guidance on how to accommodate people walking through interchanges safely and accessibly:

- ITE's *Design Guidelines to Accommodate Pedestrians and Bicyclists at Interchanges* identifies specific dimensions, safety features, signage, pavement markings, design geometries, and other treatments.
- NCHRP's *Guide for Pedestrian and Bicyclist Safety at Alternative and Other Intersections and Interchanges* provides specific guidance for other alternative interchange designs such as diverging diamond interchange, restricted crossing U-turn, median U-turn, and displaced left-turn.

F. References

American Association of State Highway and Transportation Officials (AASHTO). *Guide for the Planning, Design, and Operation of Pedestrian Facilities* ("AASHTO Ped Guide"). Washington, DC. 2004.

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Federal Highway Administration (FHWA). STEP – Resources. Countermeasure Tech Sheets. <https://highways.dot.gov/safety/pedestrian-bicyclist/step/resources>. Accessed November 2023.

Institute of Transportation Engineers (ITE). *Design Guidelines to Accommodate Pedestrians and Bicyclists at Interchanges*. Washington, DC. 2016.

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Selecting Bicycle Facilities

A. Introduction

The major categories for bicycle and pedestrian facilities include sidewalks, shared use paths, on-street, and trails. Sidewalks are an integral component of the transportation system, usually used only by pedestrians. For information on designing sidewalks, see [Sections 12A-1](#) and [12A-2](#). Shared use paths are also an integral component of the transportation system and use the sidewalk standards, but must also be designed for bicycle usage. Shared use paths are generally separate from the street, but in limited instances it may be necessary to utilize an on-street facility.

Iowa DOT's Bicycle and Pedestrian Long Range Plan recommends the core of a local or regional bicycle network be a system of low-stress bikeways. Interconnected multi-use trails often serve as the foundation for this system, but it is also necessary to identify potential low-stress connections along streets. This section provides guidance on how to select the appropriate bicycle facility type based on posted speed limit, traffic volume, and other context.

The word "trail" has conflicting definitions in ADA, AASHTO, program funding, and common usage. Projects developed around the state and those let through the Iowa DOT are generally shared use paths as defined by the Access Board, not trails. Facilities with a transportation purpose cannot use the trail guidelines published by the Access Board, even though they are commonly referred to as trails. The trail information from the Access Board only applies in parks and other limited locations; therefore, they are not covered in this manual.

B. Definitions

The following definitions are from the "AASHTO Guide for the Development of Bicycle Facilities" (or AASHTO *Bicycle Guide*) and Iowa DOT's Bicycle and Pedestrian Long Range Plan. The definition for advisory bicycle lanes is from the FHWA Bikeway Selection Guide.

Advisory Bicycle Lanes: A portion of the roadway that has been demarcated with dashed lines to indicate preferred space for bicyclists and motorists on narrow streets that would otherwise be shared lanes. Unlike bicycle lanes, motor vehicle use is not prohibited in the advisory bicycle lane and is expected on occasion.

Bicycle Boulevard: A street, usually a low volume, low speed local street, that has been modified to prioritize bicycle travel. It usually includes treatments such as shared lane markings, wayfinding signs, and traffic calming features.

Bicycle Facilities: A general term denoting improvements and provisions to accommodate or encourage bicycling, including parking and storage facilities, and shared roadways not specifically defined for bicycle use.

Bicycle Lane and Buffered Bicycle Lanes: A portion of roadway that has been designated for preferential or exclusive use by bicyclists by pavement markings and, if used, signs. It is intended for one-way travel, usually in the same direction as the adjacent traffic lane, unless designed as a contra-flow lane. A buffered bicycle lane features a striped buffer (typically 18 inches to 3 feet in width) for further separation between motor vehicles and bicyclists.

Separated Bicycle Lanes: A bicycle lane physically separated by a vertical element - such as a concrete or engineered rubber curb, planter, flex post, or a parking lane - from the adjacent motor vehicle lanes. Buffered bicycle lanes without a vertical element are not considered separated bicycle lanes. Some communities refer to separated bicycle lanes as cycle tracks or protected bicycle lanes.

Bicycle Route: A roadway or bikeway designated by the jurisdiction having authority, either with a unique route designation or with BIKE ROUTE signs, along which bicycle guide signs may provide directional and distance information. Signs that provide directional, distance, and destination information for bicyclists do not necessarily establish a bicycle route.

Bikeway: A generic term for any road, street, path, or way that in some matter is specifically designated for bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes.

Electric Bicycle (e-bike): Iowa Code Section 321.1 defines ‘low-speed electric bicycle’ as a device having a saddle or seat for the use of a rider, up to 4 wheels, equipped with fully operable pedals, and an electric motor of less than 750 watts that meets the requirements of one of the following classes:

- ‘Class 1 low-speed electric bicycle’ - a low-speed electric bicycle equipped with a motor that may be used to provide assistance only when the rider is pedaling and ceases to provide assistance when the bicycle reaches a speed of 20 mph or more.
- ‘Class 2 low-speed electric bicycle’ - a low-speed electric bicycle equipped with a motor that may be used exclusively to propel the bicycle and is not capable of providing assistance when the bicycle reaches a speed of 20 mph or more.
- ‘Class 3 low-speed electric bicycle’ - a low-speed electric bicycle equipped with a motor that may be used to provide assistance only when the rider is pedaling and ceases to provide assistance when the bicycle reaches a speed of 28 mph or more.

Independent Right-of-Way: A general term denoting right-of-way outside the boundary of a conventional highway.

Roundabout: A type of circular intersection that provides yield control to all entering vehicles and features channelized approaches and geometry to encourage reduced travel speeds through the circular roadway.

Rumble Strips: A textured or grooved pavement treatment designed to create noise and vibration to alert motorists of a need to change their path or speed. Longitudinal rumble strips are sometimes used on or along shoulders or center lines of highways to alert motorists who stray from the appropriate traveled way. Transverse rumble strips are placed on the roadway surface in the travel lane, perpendicular to the direction of travel.

Shared Lane: A lane of a traveled way that is open to both bicycle and motor vehicle travel, usually a low volume local street.

Shared Lane Marking: A pavement marking or symbol that indicates an appropriate bicycle positioning in a shared lane.

Shared Use Path: (From U.S. Department of Transportation, Federal Highway Administration) The term “shared use path” means a multi-use trail or other path, physically separated from motorized vehicular traffic by an open space or barrier, either within a highway right-of-way or within an independent right-of-way, and usable for transportation purposes. Shared use paths may be used by pedestrians, bicyclists, skaters, equestrians, and other authorized users.

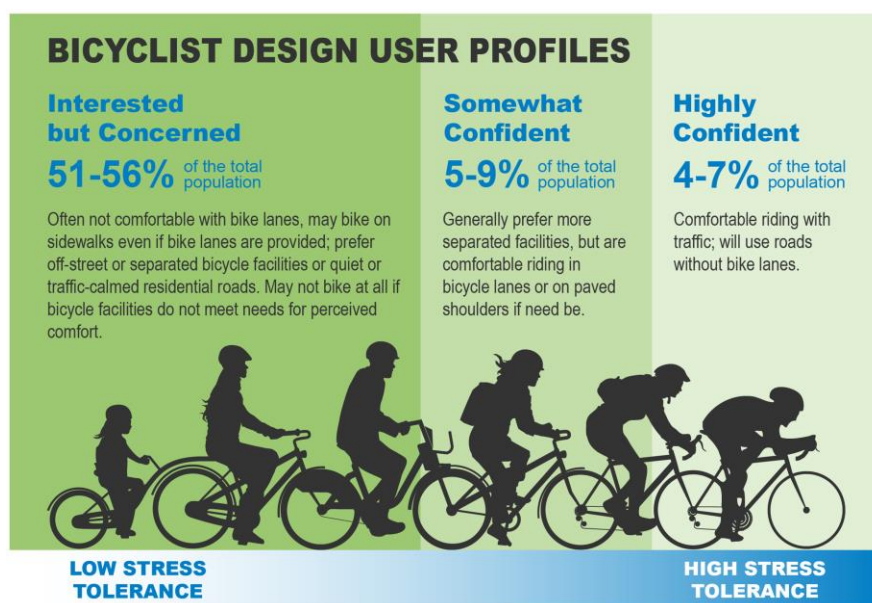
Traveled Way: The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and any bicycle lane immediately inside of the shoulder.

C. Bicycle Design User Profiles

Of adults who have stated an interest in bicycling, research has identified three types of potential and existing bicyclist profiles (see Figure 12B-1.01). These bicyclist profiles consider a person's comfort level operating a bicycle with motorized traffic, bicycling skill and experience, age, and trip purpose. These user profiles of common types of adult bicycle users and trips can be used to inform bikeway design.

The “interested but concerned” bicyclist profile should typically be used to identify the bikeway design in urban, suburban, and rural town contexts because this group represents the largest of the bicyclist profiles, consisting of 51 to 56% of the general population. Bicycling as a form of transportation by this group is underrepresented in many communities due to a lack of connected low stress bicycle networks. To maximize the potential for bicycling as a viable transportation option, it is important to design facilities to meet the needs of the “interested but concerned” bicyclist user, which will also naturally accommodate the “somewhat confident and highly confident” users.

Figure 12B-1.01: Bicycle Design User Profiles



Source: FHWA *Bikeway Selection Guide*

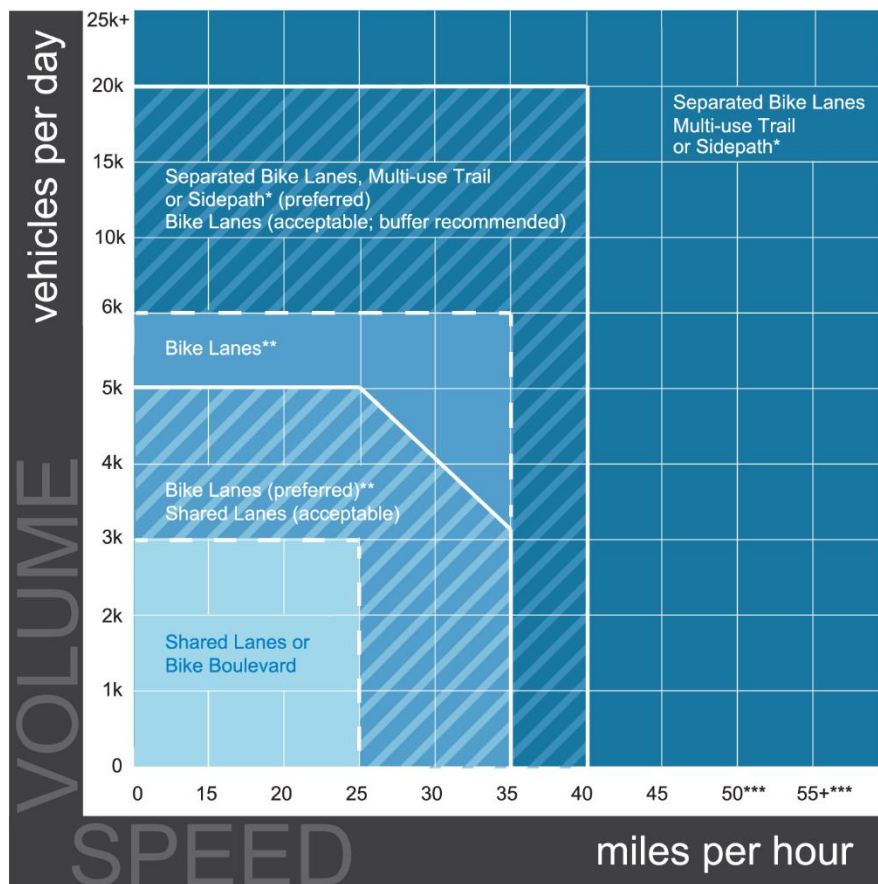
D. Bicycle Network Design Process

Chapter 4 of Iowa DOT's Bicycle and Pedestrian Long Range Plan provides guidance on planning bicycle networks and facility selection. The bicycle facility selection process is linked to the larger transportation planning process. It should be informed by a plan for a future bicycle network developed with input from agency staff and members of the public. Ideally, the facility selection process is also controlled by local bikeway selection or complete streets policies ensuring decisions are consistently and objectively applied across a jurisdiction.

Bicycle networks should be continuous, connect seamlessly across jurisdictional boundaries, and provide access to destinations. Bicycle transportation depends on access to local destinations, many of which are located along higher traffic arterial streets. Adequate, context sensitive bicycle facilities should therefore be provided along these streets. If a continuous bicycle facility is not feasible on a higher-traffic street, alternative routes along parallel lower traffic streets may be provided in the interim until the preferred facility can be implemented.

- Bikeway Facility Selection:** Motor vehicle traffic volume and speed are critical contextual considerations for bicyclist and pedestrian safety and comfort. Proximity to motor vehicle traffic is a significant source of stress, safety risks, and discomfort for bicyclists, and corresponds with sharp rises in crash severity and fatality risks for vulnerable users when motor vehicle speeds exceed 25 miles per hour. Furthermore, as motorized traffic volumes increase, it becomes increasingly difficult for motorists and bicyclists to share roadway space. Figure 12B-1.02 is provided to help determine appropriate types of bicycle (and in some cases, pedestrian) accommodations for any given context. The matrix includes preferred and acceptable values for each facility type. Designers should use forecast traffic volumes if available. Additionally, designers should default to selecting the preferred facility when possible.

Figure 12B-1.02 Urban and Suburban Bicycle Facility Selection Matrix



*To determine whether to provide a multi-use trail/sidepath or separated bike lane, consider pedestrian and bicycle volumes or, in the absence of volume, consider land use.
 **Advisory bike lanes may be an option where traffic volume < 4,000 ADT
 ***Speeds 50 mph or greater in urban areas are typically found in urban/rural transition areas.

Source: Iowa DOT Bicycle and Pedestrian Long Range Plan

- 2. Bikeway Feasibility Assessment:** Once the preferred bikeway type is identified, designers will need to assess its feasibility in the given project location against potential project constraints limiting the ability to implement the preferred bikeway. This assessment may involve determining whether additional separation between motorists and bicyclists is warranted, identifying portions of the roadway to reallocate to achieve desired widths, selecting the “next best” bikeway type, or selecting an alternative route for the bikeway. Designers have an ethical obligation to provide for the health, safety, and welfare of the public, which may require a careful evaluation of mobility and safety for each user. One user’s convenience or mobility should not be prioritized over another user’s safety. When evaluating safety trade-offs, options reducing serious injuries and fatalities should be prioritized over options reducing property damage or minor injuries.
- a. Conditions for Increasing Separation:** There are a variety of conditions indicating the need for greater separation between motorists and bicyclists, which could increase the width of the bikeway or materials used in the buffer. The conditions where greater separation may be appropriate to accommodate the selected design user include the following:
- Unusual peak hour motor vehicle volumes (more than 15% of AADT);
 - High percentage of heavy vehicles (trucks, buses, and heavy vehicles are more than 5% of traffic);
 - Motor vehicle operating speeds exceed posted speed;
 - Frequent parking turnover or heavy curbside activity;
 - High volumes of bicyclists (500 bicyclists per hour);
 - Presence of vulnerable populations (i.e. school children);
 - Network connectivity gaps;
 - Proximity to transit; and
 - Frequent driveways.
- b. Options for Reallocating Roadway Space:** When constructing new roads, bikeways should be built to the recommended preferred dimensions rather than constrained dimensions. For retrofit projects, it may be necessary to evaluate options to reallocate existing space or use minimum or constrained dimensions. The following are strategies for reallocating roadway space to accommodate a bikeway:
- Narrowing travel lanes, including medians/turn lanes;
 - Removing travel or turn lanes;
 - Removing parking on one side of street; and
 - Converting angled parking to parallel parking.
- c. Selecting the “Next Best” Bikeway Type or Parallel Routes:** Impacts on ridership, comfort/stress, safety, and overall network connectivity should be considered when evaluating alternative bikeway designs or potential parallel routes to ensure the project will still meet the purpose identified at the outset. The following trade-offs should be considered and documented in the design process:
- Reduced or suppressed ridership where the bikeway does not meet the needs of the target design user;
 - Additional length of trip when bicyclists must use a parallel route (this length should not exceed 30% more than original route and should not add excessive delay);
 - Critical gaps in the network when projects fail to provide bicycle accommodations;
 - Reduced safety where bicyclists must operate with relatively high motor vehicle speed and/or high-volume traffic in shared lanes;
 - Reduced safety where bicyclists must operate in narrow space (e.g. narrow bicycle lanes adjacent to parking lanes or narrow shared use paths with high volumes of pedestrians or bicyclists);

- Reduced safety where bicyclists improperly use facilities (e.g., ride the wrong way on shared lanes, sidewalk riding, etc.); and
- Increased sidewalk bicycling where bicyclists are avoiding low comfort/high stress roadway conditions.

If selecting a parallel route as the preferred route for the “interested but concerned” bicyclist occurs, the provision of a bikeway along the desired route should still be considered to accommodate the “highly confident” bicyclist and to provide connections for bicyclists to and from properties along the desired route. An example would be the provision of a bicycle lane or shoulder on a higher volume roadway, which can benefit the “highly confident” bicyclists while a convenient, direct parallel route on an adjacent low volume street serves the “interested but concerned” bicyclists.

Chapter 4 of Iowa DOT’s Bicycle and Pedestrian Long Range Plan provides additional guidance on facility selection, with context characteristics for each of the common facility types shown in Figure 12B-1.02, and additional guidance on facility selection and other considerations.

Shared Use Path Design

A. Accessible Shared Use Path Design

1. **General:** Applicable portions from the following draft documents were used to develop this section.
 - a. **AASHTO Bicycle Guide:** The fourth edition (2012) of the AASHTO “Guide for the Development of Bicycle Facilities” (or AASHTO *Bicycle Guide*). References made to the AASHTO *Bicycle Guide* within this section are shown in parentheses, e.g. (AASHTO *Bicycle Guide* 5.2.1).
 - b. **AGODA:** The June 20, 2007 Proposed Architectural Barriers Act “Accessibility Guidelines for Outdoor Developed Areas” (AGODA). This document is primarily used for shared use paths designed as bicycle facilities.
 - c. **PROWAG:** The Public Right-of-Way Accessibility Guidelines (PROWAG) are primarily used for shared use paths designed as sidewalks.
2. **Documenting Exceptions:** If the project cannot fully meet the minimum requirements included within this section, a document should be developed to describe why the minimum requirements cannot be met. It is recommended that this document be retained in the project file. For local agency projects administered through Iowa DOT, a certification with supporting documentation shall be submitted to the Iowa DOT administering bureau. The certification shall be as prescribed by the Iowa DOT and signed by a registered professional engineer or landscape architect licensed in the State of Iowa. For Iowa DOT projects, contact the Design Bureau, Methods Section.

B. Shared Use Path Categories

1. **Type 1:** A shared use path adjacent or in close proximity to the roadway and functions similar to a sidewalk and separated bicycle lane. Due to the proximity to the roadway, intersection crossings of type 1 shared use path should closely follow the best practices of separated bicycle lanes. In rural cross-sections, these paths would be at the top of the foreslope.
2. **Type 2:** A shared use path similar to Type 3, except they serve as a transportation route to facilities that fulfill a basic life need, provide access to a program or service, or provide a safe route for non-drivers.
3. **Type 3:** A shared use path in independent right-of-way or not in close proximity to the roadway. Although Type 3 paths may fulfill a transportation function, these paths primarily serve a recreation and fitness benefit.

One shared use path project may have different combinations of Type 1, Type 2, and/or Type 3 segments, based on location and function. If Federal or State funding is being used on a project, the funding application should identify where Type 1, Type 2, or Type 3 segments will be used.

C. Shared Use Path Design Elements

The following considerations should be used as a guide when designing shared use paths.

1. **Width:** A bicyclist requires a minimum of 4 feet and a preferred 5 feet of essential operating space based upon their profile. The typical path width is 10 to 12 feet to accommodate two-way traffic. The minimum width needed for a bicyclist to pass another path user while maintaining sufficient space for another user approaching from the opposite direction is 11 feet. Consider wider paths (12 to 15 feet) when at minimum one of the following is anticipated:
 - User volume exceeding 300 users within the peak hour.
 - Curves where more operating space should be provided.
 - Large maintenance vehicles.

Path width can be reduced to 8 feet where the following conditions prevail:

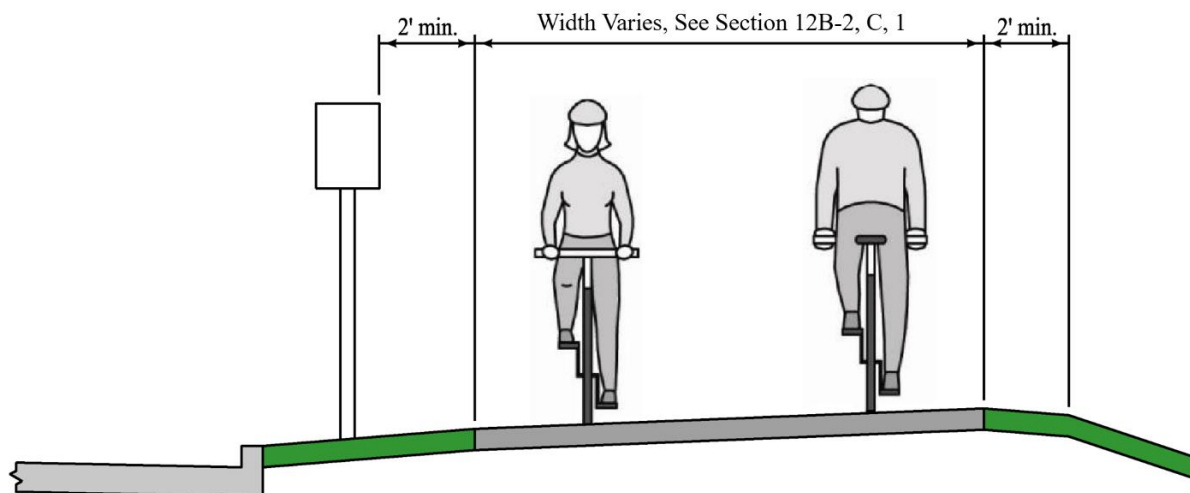
- Bicycle traffic is expected to be low.
- Pedestrian use is generally not expected.
- Horizontal and vertical alignments provide well-designed passing and resting opportunities.
- The path will not be regularly subjected to maintenance vehicle loading conditions.
- A physical constraint exists for a short duration such as a utility structure, fence, etc.
- Protection of environmental features.

Path widths between 8 and 5 feet should be avoided; paths less than 5 feet do not meet ADA requirements. If the path width is less than 8 feet, a design exception must be developed.

For Iowa DOT projects involving paths on structures, contact the Bridges and Structures Bureau to determine the structural impacts of shared use path widths.

If segregation of pedestrians and bicycle traffic is desirable, a minimum 15 foot width should be provided. This includes 10 feet for two-way bicycle traffic and 5 feet for two-way pedestrian traffic. (AASHTO *Bicycle Guide* 5.2.1).

Figure 12B-2.01: Typical Cross-Section of Two-Way Shared Use Path on Independent Right-of-Way



Source: Adapted from AASHTO *Bicycle Guide* Exhibit 5.1

2. **Minimum Surface Thickness:** For Iowa DOT projects, contact the Pavement Design Section in the Design Bureau for a pavement determination. For local agency projects administered through Iowa DOT, Iowa DOT will accept the thickness design as determined by the engineer.

For local projects, the pavement depth for both PCC and HMA pavements should have a minimum of 4 inches and a recommended thickness of 5 inches. If pavement thickness is proposed to be less than 4 inches, a pavement determination should be completed and documented.

3. **Cross Slope:** Shared use paths must have the capabilities to serve people with disabilities.
 - a. **Type 1 and Type 2:** Cross slopes shall not exceed the requirements in [Section 12A-2](#).
 - b. **Type 3:** A 1.5% cross slope is recommended, but cross slopes should be a minimum of 1% and shall not exceed 5%. Cross slopes greater than 2% should be sloped to the inside of the horizontal curve regardless of drainage conditions. On unpaved paths, cross slopes may increase up to 5% due to the need of draining water off the path. On rare bicycle only facilities, the path does not need to meet accessibility guidelines and the cross slope can be between 5% and 8%. Cross slope transition should be comfortable for the user; therefore, a minimum transition length of 5 feet for each 1% change in cross slope should be used.
4. **Separation of Roadway and Path:** A separation of 6 feet or greater between the curb or edge of roadway and the path is desirable to increase pedestrian and bicyclist comfort. Where the distance between the edge of roadway and the edge of the path is less than 5 feet, a vertical element of separation should be provided between the edge of roadway and type 1 or type 2 shared use path for the safety and comfort of path users. This is particularly important at night. For streets with curbs to provide the vertical element, a minimum 2 foot buffer should be provided between the path and the adjacent roadway. On high-speed roadways or uncurbed roadways where the separation from the edge of the traveled way to the near edge of the path 5 feet or less, a crashworthy barrier or railing is needed due to high speeds and clear zone requirements.

At uncontrolled approaches of intersections and at signalized intersections where turning vehicles and bicycle through movements are expected, designers should offset the bicycle crossing between 6 and 16.5 feet from the adjacent motor vehicle lane. This treatment creates a yielding space for motorists and has been shown to reduce crashes at uncontrolled and permissive conflict locations.

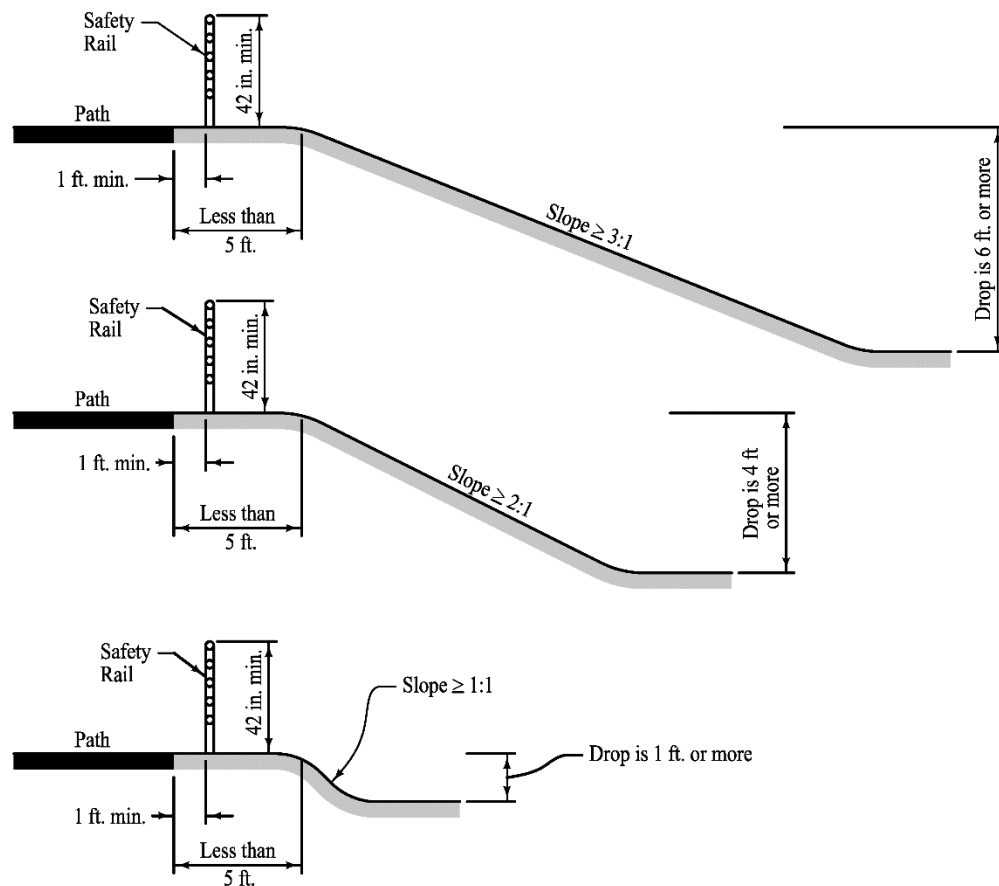
5. **Lateral and Vertical Clearance:** The provision of adequate clearance to a wide variety of potential obstructions that may be found along a prospective route is important for creating a safe and comfortable shared use path facility. Guidelines for lateral and vertical clearance are particularly important in view of the wide range of riding proficiency that is found among riders. See [Section 12B-3, B](#) for clearance values for obstructions adjacent to bikeways (including shared use paths).
 - a. **Lateral Clearances to Fixed and Movable Obstructions:** When minimum clearance in [Section 12B-3](#) cannot be achieved, refer to [Section 12A-3](#) for protruding object requirements; refer to the *AASHTO Bicycle Guide* for mitigation measures, such as pavement markings, delineation, and signing.

- b. Vertical Clearances to Overhead Obstructions:** The minimum vertical clearance is 10 feet. In some situations, such as tunnels and bridge underpasses, the vertical clearance should be greater than 10 feet in order to accommodate maintenance and emergency vehicles. In constrained areas, AASHTO allows the vertical clearance to obstructions to be a minimum of 8 feet. (AASHTO *Bicycle Guide* 5.2.1).

Refer to [Section 12A-3](#) for legal requirements in low clearance situations.

- 6. Shoulder Width and Slope:** The minimum graded shoulder width is 2 feet. The maximum shoulder area cross slope is 6:1.
- 7. Safety Rail:** Safety rail should be a minimum of 42 inches in height. Provide safety rails at the outside of a structure. On steep fill embankment as described below, provide a safety rail or widen the shoulder area to 5 feet. (AASHTO *Bicycle Guide* 5.2.1)
- Slopes 3:1 or steeper with a drop of 6 feet or greater.
 - Slopes 3:1 or steeper adjacent to a parallel body of water or other substantial obstacle.
 - Slopes 2:1 or steeper with a drop of 4 feet or greater.
 - Slopes 1:1 or steeper with a drop of 1 foot or greater.

Figure 12B-2.02: Safety Rail between Path and Adjacent Slope



See [Iowa DOT Design Manual Section 12B-10](#) for guidance on safety rails.

Source: Adapted from AASHTO *Bicycle Guide* Exhibit 5.3

8. Design Speed and Alignments:

- a. **Type 1:** Grades shall meet the requirements of [Section 12A-2](#).
- b. **Type 2:** Grades shall be less than or equal to 5% and all other Type 3 requirements should be met.
- c. **Type 3:** For most shared use paths with higher volumes of users in relatively flat areas, a design speed of 15 mph is generally sufficient due to the mixed-use operation with pedestrians on the facility. Table 12B-2.01 describes cases in which the design speed should be adjusted based on context. (AASHTO *Bicycle Guide* 5.2.4)

Table 12B-2.01: Shared Use Path Design Speed by Context

Design Speed	Shared Use Path Context	Description
12 mph	Unpaved path surfaces	On unpaved path surfaces, bicyclists tend to travel slower to compensate for reduced braking ability, so a lower design speed (12 mph) may be used.
15 mph	Paved, high volumes with diverse users	For most shared use paths with higher volumes of users in relatively flat areas, a design speed of 15 mph is generally appropriate due to the mixed-use operation with pedestrians on the facility.
18 to 30 mph	Paved, low volume of users, especially pedestrians	For shared use paths with lower volumes of users, where pedestrian volumes are low (less than 30%), where the primary purpose of the shared use path is to provide a higher speed bicycling opportunity between destinations, or on wider paths where bicycles are provided separate spaces from pedestrians, a design speed of 18 to 30 mph may be appropriate.
18 to 30 mph	Paved, rolling terrain	On shared use paths with rolling terrain and sustained steeper grades (greater than 5%), the appropriate design speed should be selected based on the anticipated travel speeds of bicyclists going downhill; however, design speed should generally not exceed 30 mph.

Source: ODOT *Multimodal Design Guide*

The minimum radius of curvature negotiable by a bicycle can be calculated using the lean angle of the bicyclist or the superelevation and coefficient of friction of the shared use path. A bicyclist must lean two wheeled bicycles while cornering to prevent falling outward due to forces associated with turning movements. A lean angle of 20 degrees is considered the typical maximum lean angle for users to continue pedaling through a turn. Lean angles greater than this typically require bicyclists to stop pedaling to avoid pedal strikes on the pavement. The minimum radii of curvature for a paved path are shown in Table 12B-2.02 based on the typical lean angle of the bicyclists.

Table 12B-2.02: Minimum Radii for Horizontal Curves at Lean Angle

Design Speed (mph)	Minimum Radius (feet)
12	27
14	36
16	47
18	60
20	74
25	115
30	166

Source: AASHTO Bicycle Guide Exhibit 5.6

The minimum radii of curvature for a paved path based on superelevation should be calculated per the equations shown in the *AASHTO Bicycle Guide*. (*AASHTO Bicycle Guide* 5.2.2, 5.2.5, 5.2.6, and 5.2.8).

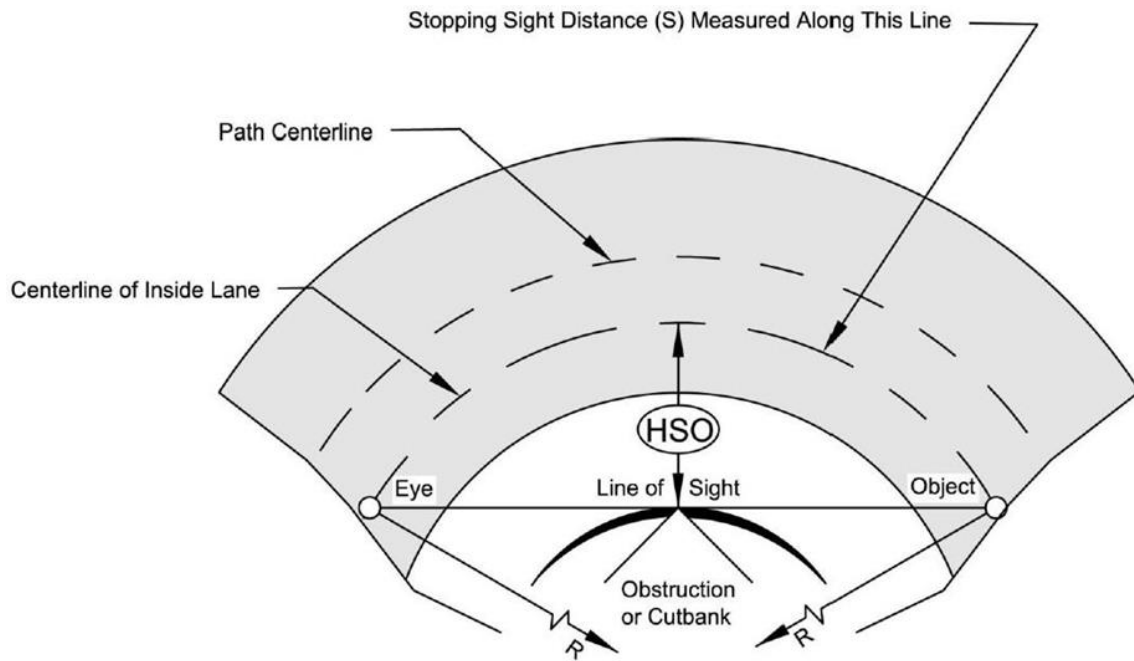
Table 12B-2.03 and Figure 12B-2.03 should be used to determine the minimum clearance necessary to avoid line-of-sight obstructions for horizontal curves. The lateral clearance (horizontal sight line offset or HSO) can be obtained from Table 12B-2.03, given the stopping sight distance from Equation 12B-2.01 and the proposed horizontal radius of curvature. Lateral clearances on horizontal curves should be calculated based on the sum of the stopping sight distances for both users traveling in opposite directions around the curve because bicyclists have a tendency to ride near the middle of narrow paths.

Table 12B-2.03: Minimum Lateral Clearance (Horizontal Sightline Offset or HSO) for Horizontal Curve

R (ft)	S= Stopping Sight Distance (ft)														
	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300
25	2.0	7.6	15.9												
50	1.0	3.9	8.7	15.2	23.0	31.9	41.5								
75	0.7	2.7	5.9	10.4	16.1	22.8	30.4	38.8	47.8	57.4	67.2				
95	0.5	2.1	4.7	8.3	12.9	18.3	24.7	31.8	39.5	48.0	56.9	66.3	75.9	85.8	
125	0.4	1.6	3.6	6.3	9.9	14.1	19.1	24.7	31.0	37.9	45.4	53.3	61.7	70.6	79.7
155	0.3	1.3	2.9	5.1	8.0	11.5	15.5	20.2	25.4	31.2	37.4	44.2	51.4	59.1	67.1
175	0.3	1.1	2.6	4.6	7.1	10.2	13.8	18.0	22.6	27.8	33.5	39.6	46.1	53.1	60.5
200	0.3	1.0	2.2	4.0	6.2	8.9	12.1	15.8	19.9	24.5	29.5	34.9	40.8	47.0	53.7
225	0.2	0.9	2.0	3.5	5.5	8.0	10.8	14.1	17.8	21.9	26.4	31.3	36.5	42.2	48.2
250	0.2	0.8	1.8	3.2	5.0	7.2	9.7	12.7	16.0	19.7	23.8	28.3	33.1	38.2	43.7
275	0.2	0.7	1.6	2.9	4.5	6.5	8.9	11.6	14.6	18.0	21.7	25.8	30.2	34.9	39.9
300	0.2	0.7	1.5	2.7	4.2	6.0	8.1	10.6	13.4	16.5	19.9	23.7	27.7	32.1	36.7
350	0.1	0.6	1.3	2.3	3.6	5.1	7.0	9.1	11.5	14.2	17.1	20.4	23.9	27.6	31.7
390	0.1	0.5	1.2	2.1	3.2	4.6	6.3	8.2	10.3	12.8	15.4	18.3	21.5	24.9	28.5
500	0.1	0.4	0.9	1.6	2.5	3.6	4.9	6.4	8.1	10.0	12.1	14.3	16.8	19.5	22.3
565		0.4	0.8	1.4	2.2	3.2	4.3	5.7	7.2	8.8	10.7	12.7	14.9	17.3	19.8
600		0.3	0.8	1.3	2.1	3.0	4.1	5.3	6.7	8.3	10.1	12.0	14.0	16.3	18.7
700		0.3	0.6	1.1	1.8	2.6	3.5	4.6	5.8	7.1	8.6	10.3	12.0	14.0	16.0
800		0.3	0.6	1.0	1.6	2.2	3.1	4.0	5.1	6.2	7.6	9.0	10.5	12.2	14.0
900		0.2	0.5	0.9	1.4	2.0	2.7	3.6	4.5	5.6	6.7	8.0	9.4	10.9	12.5
1000		0.2	0.5	0.8	1.3	1.8	2.4	3.2	4.0	5.0	6.0	7.2	8.4	9.8	11.2

Source: AASHTO Bicycle Guide Exhibit 5.10

Figure 12B-2.03: Components for Determining Horizontal Sight Distance



Source: AASHTO Bicycle Guide Exhibit 5.9

For vertical alignment, use the preferred maximum segment length shown in Table 12B-2.04 whenever possible. Using the acceptable and allowed criteria should only be done when the engineer considers the ability of the users. For example, long rural segments would generally serve more physically capable users who have selected the path and could navigate the steeper grades over longer lengths.

Table 12B-2.04: Vertical Alignment

Grade Range	Maximum Segment Length (feet)		
	Preferred	Acceptable ¹	Allowed ²
< 5%	Any length	Any Length	Any Length
≥ 5% and < 8.33%	--	50	200
≥ 8.33% and < 10%	--	30	30
≥ 10% and < 12.50%	--	--	10

¹ Derived from AGODA Section 1016 (Outdoor Recreation Access Routes)

² Derived from AGODA Section 1017 (Trails)

The minimum length of vertical curve needed to provide minimum stopping sight distance at various speeds on crest vertical curves is presented in Table 12B-2.05. The eye height of the typical adult bicyclist is assumed to be 4.5 feet. For stopping sight distance calculations, the object height is assumed to be 0 inches. (AASHTO Bicycle Guide 5.2.7). Equation 12B-2.01 can also be used to determine the minimum length of crest vertical curve necessary to provide adequate sight distance.

$$S > L \quad L = 2S - \frac{200(\sqrt{h_1} + \sqrt{h_2})^2}{A} \quad \text{Equation 12B-2.01}$$

$$S > L \quad L = 2S - \frac{200(\sqrt{h_1} + \sqrt{h_2})^2}{A}$$

$$L > S \quad L = \frac{AS^2}{100(\sqrt{2h_1} + \sqrt{2h_2})^2}$$

where:

- L= Minimum length of vertical curve (ft)
- A = Algebraic grade difference (percent)
- S = Stopping sight distance (ft)
- h₁ = Eye height (4.5 feet for a typical bicyclist)
- h₂ = Object height (0 ft)

Table 12B-2.05: Minimum Length of Crest Vertical Curve Based on Stopping Sight Distance

A (%)	S=Stopping Sight Distance (ft)														
	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300
2												30	70	110	150
3								20	60	100	140	180	220	260	300
4						15	55	95	135	175	215	256	300	348	400
5					20	60	100	140	180	222	269	320	376	436	500
6			10	50	90	130	170	210	267	323	384	451	523	600	
7			31	71	111	151	191	231	311	376	448	526	610	700	
8		8	48	88	128	168	208	248	356	430	512	601	697	800	
9		20	60	100	140	180	220	260	400	484	576	676	784	900	
10		30	70	110	150	190	230	270	444	538	640	751	871	1000	
11		38	78	118	158	198	238	278	489	592	704	826	958	1100	
12	5	45	85	125	165	205	245	285	533	645	768	901	1045	1200	
13	11	51	91	131	171	211	251	291	578	699	832	976	1132	1300	
14	16	56	96	136	176	216	256	296	622	753	896	1052	1220	1400	
15	20	60	100	140	180	220	260	300	667	807	960	1127	1307	1500	
16	24	64	104	144	184	224	264	304	711	860	1024	1202	1394	1600	
17	27	67	107	147	187	227	267	307	756	914	1088	1277	1481	1700	
18	30	70	110	150	190	230	270	310	800	968	1152	1352	1568	1800	
19	33	73	113	153	193	233	273	313	844	1022	1216	1427	1655	1900	
20	35	75	115	155	195	235	275	315	889	1076	1280	1502	1742	2000	
21	37	77	117	157	197	237	277	317	933	1129	1344	1577	1829	2100	
22	39	79	119	159	199	239	279	319	978	1183	1408	1652	1916	2200	
23	41	81	121	161	201	241	281	321	1022	1237	1472	1728	2004	2300	
24	3	43	83	123	163	203	243	283	323	1067	1291	1536	1803	2091	2400
25	4	44	84	124	164	204	244	284	324	1111	1344	1600	1878	2178	2500

The line between the shaded and un-shaded portions of the table shows when the stopping sight distance is equal to the length of the crest vertical curve.

Source: AASHTO Bicycle Guide Exhibit 5.8

- 9. Stopping Sight Distance:** Shared use paths must be designed with adequate stopping sight distance along the entire path to provide users with the opportunity to see and react to unexpected conditions. The distance needed to bring a path user to a fully controlled stop is a function of the user's perception and braking reaction time, the initial speed, the coefficient of friction between the wheels and the pavement, the braking ability of the user's equipment, and the grade. Minimum stopping sight distances can be determined using Equation 12B-2.02. Stopping sight distance must be provided along the entire length of the pathway and should be checked at all horizontal and vertical curves. (AASHTO *Bicycle Guide* 5.2.8).

$$S = \frac{V^2}{30(f \pm G)} + 3.67V \quad \text{Equation 12B-2.02}$$

where:

S = Stopping sight distance (ft)

V = Velocity (mph)

f = Coefficient of friction (use 0.16 for a typical bicycle)

G = Grade (ft/ft) (rise/run)

- 10. Accessibility Requirements:** For construction of curb ramps and placement of detectable warnings, see [Section 12A-2](#) to ensure ADA compliance.

D. Intersection Sight Distance

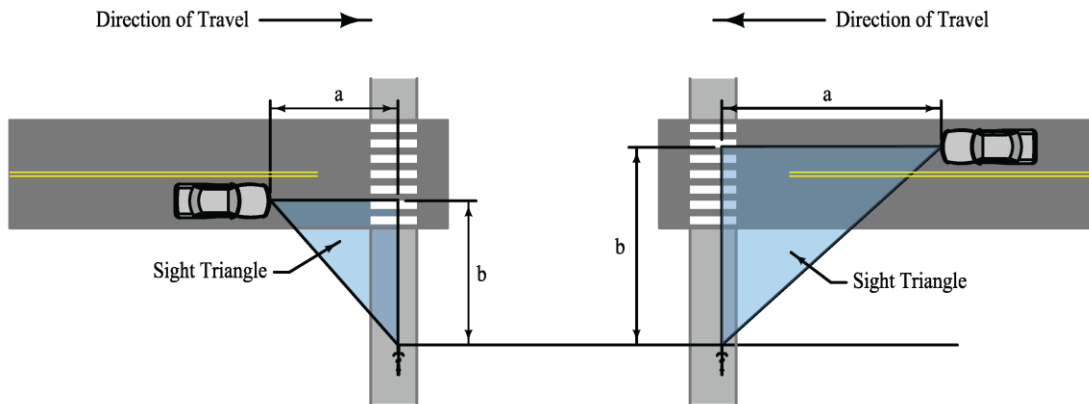
- 1. General:** Intersection sight distance is a fundamental component in the selection of appropriate control at a midblock path-roadway intersection. The least restrictive control that is effective should be used. The line of sight is considered to be 2.3 feet above the path surface.

Roadway approach sight distance and departure sight triangles should be calculated using motor vehicles, which will control the design criteria. (AASHTO *Bicycle Guide* 5.3).

- 2. Approach Sight Distance:** Pathway approach sight distance should be determined by the fastest path user, typically the adult bicyclist. If yield control is to be used for either the roadway approach or the path approach, available sight distance adequate for a traveler on the yield controlled approach to slow, stop, and avoid a traveler on the other approach is required. The roadway leg (a) of the sight triangle is based on the ability of a bicyclist to reach and cross the roadway if they do not see a conflict (see Figure 12B-2.04). Similarly, the path leg (b) of the sight triangle is based on the ability of a motorist to reach and cross the junction if they do not see a conflict (see Figure 12B-2.04). If sufficient sight distance is unable to be provided by the yield sight triangle described above, more restrictive control should be implemented.

For Type 1 shared use paths crossing a roadway near an intersection, refer to [Section 12B-3, F, 3](#) for additional geometric design treatments.

Figure 12B-2.04: Yield Sight Triangles



Source: Adapted from AASHTO *Bicycle Guide* Exhibit 5.15

$$a = 1.47V_{Road} \left(\frac{S}{1.47V_{Path}} + \frac{w + L_a}{1.47V_{Path}} \right)$$

Equation 12B-2.03
Length of Roadway Leg of Sight Triangle

$$b = V_{Path} \left(\frac{1.47V_e - 1.47V_b}{a_i} + \frac{w + L_a}{0.88V_{Road}} \right)$$

Equation 12B-2.04
Length of Path Leg of Sight Triangle

where:

a = Length of leg of sight triangle along the roadway approach (ft)

b = Length of leg of sight triangle along the path approach (ft)

w = Width of the intersection to be crossed (ft)

L_a = Design vehicle length

For Equation 12B-2.03: Typical bicycle length = 6 ft

For Equation 12B-2.04: Design vehicle length (ft)

V_{Path} = Design speed of the path (mph)

V_{Road} = Design speed of the road (mph)

S = Stopping sight distance for the path user traveling at design speed

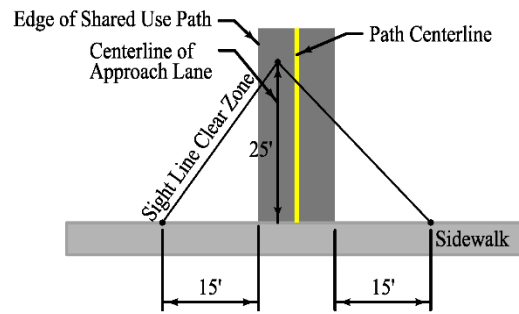
V_e = Speed at which the motorist would enter the intersection after decelerating (mph)
(assumed 0.60 x road design speed)

V_b = Speed at which braking by the motorist begins (mph) (same as road design speed)

a_i = motorist deceleration rate (ft/s²) on intersection approach when braking to a stop is not initiated (assume -5.0 ft/s²)

- 3. Path-Sidewalk Intersection:** At an intersection of a shared use path and a sidewalk, a clear sight triangle extending at minimum 15 feet along the sidewalk must be provided. Refer to Figure 12B-2.05. If two shared use paths intersect, the same process for the roadway-path intersection should be used.

Figure 12B-2.05: Minimum Path-Sidewalk Sight Triangle



Source: Adapted from *AASHTO Bicycle Guide* Exhibit 5.16

E. Surface

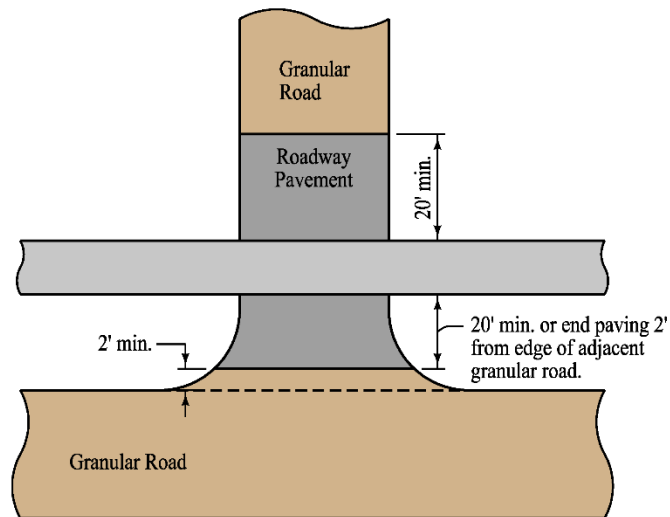
It is important to construct and maintain a smooth riding surface on shared use paths. Shared use path pavements should be machine placed. Surface texture is needed but care must be exercised not to cause operational problems with too little or too much texture. Broom finish or burlap drag concrete surfaces are preferred over trowel finishes. Joints shall be sawed, not hand tooled.

1. **Type 1 and Type 2:** Type 1 and Type 2 shared use paths shall be paved.
2. **Type 3:** Hard, all-weather pavement surfaces are preferred to unpaved surfaces due to the higher service quality and lower maintenance. Type 3 shared use paths should be paved; however, a granular surface may be allowed. If a granular surface is used, it must be maintained to be firm, stable, and slip resistant.

F. Crossings at Unpaved Surfaces

When crossing an unpaved roadway, alley, or driveway, a minimum of 20 feet in addition to the path width should be paved on each side of the path to reduce the amount of gravel tracked onto the path. If edge of parallel unpaved roadway is less than 20 feet from the closest edge of the path, only pave to within 2 foot of edge of the parallel unpaved roadway. The thickness of the path and adjacent roadway paving should be designed to accommodate vehicular traffic and meet the requirements of the agency responsible for the roadway.

Figure 12B-2.06: Crossing at Unpaved Surface



G. At-grade Railroad Crossing

Whenever it is necessary to cross railroad tracks with a bicycle, special care must be taken. The crossing should be at least as wide as the approaches of the shared use path. Whenever possible, the crossing should be straight and between 90 and 60 degrees to the rails. The greater the crossing angle deviates from being perpendicular, the greater the chance that a bicyclist's front wheel may be trapped in the flangeway causing a loss of control. (AASHTO *Bicycle Guide* 4.12).

H. Drainage

Drainage structures underneath paths should typically be designed to the same design year storm as the roadway drainage structures. When a Type 3 shared use path is built on a berm, consider the drainage needs of that path. For shared use paths constructed on slopes, drainage design should take into account control of the runoff from the slope. For higher flows it may be necessary to develop parallel ditches and culverts under the path. Drainage designs should also provide for low flows and seepage from the slope. Due to the potential for accidents from buildup of algae from low flows and side hill seepage, the need for subdrains or other treatments on the high side of the path should be evaluated.

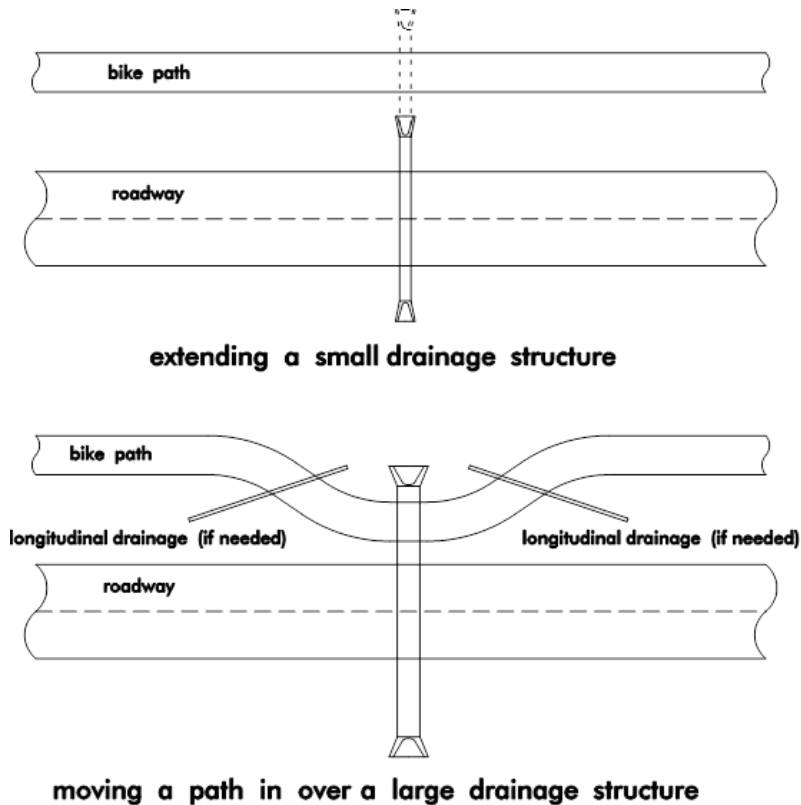
1. **Urban Areas:** The minimum recommended pavement cross slope of 1% usually provides enough slope for proper drainage. Sloping in one direction, usually toward the street, instead of crowning is preferred and usually simplifies the drainage and surface construction. However, care must be exercised not to trap water on the high side of the shared use path, particularly in curved areas. (AASHTO *Bicycle Guide* 5.2.11).
2. **Rural Areas:** The best way to accomplish drainage underneath a shared use path is by extending smaller structures under the path or moving the path closer to the roadway to cross larger structures, see Figure 12B-2.07.

For paths placed on the backslope, smaller drainage structures (normally pipes less than 60 inches and box culverts less than 5 feet by 4 feet) should be extended through the path. For larger culverts, the path should be moved in to cross the structure and then moved back out to the backslope. If this is done, longitudinal drainage will have to be provided where the path crosses

the ditch. Depending upon how close the path comes to culvert openings, safety railing may be needed on the culverts.

For paths on the foreslope, culverts should be extended as necessary.

Figure 12B-2.07: Accommodating Drainage Structures



I. Structure Design

The preferred bridge width for shared use path is equal to the width of the path plus 4 feet, which provides 2 feet of clearance on each side, according to the AASHTO *Bicycle Guide*. It is acceptable to provide bridge widths equal to the width of the path plus 2 feet, which provides 1 foot of clearance on each side. In constrained situations, the bridge width may equal the path width so long as the landings are adequately tapered from the clear zone to the bridge. For a 10 foot wide path, the resulting specified bridge widths are:

- 14 feet (preferred)
- 12 feet (acceptable)
- 10 feet (in constrained conditions)

For Iowa DOT administered projects, the designer should contact the Design Bureau and the Traffic and Safety Bureau for further assistance if considering a narrowed path across a bridge.

J. Pavement Markings

Ladder or zebra pavement markings per MUTCD are recommended at crosswalks. Other pavement markings are not required, except as mitigation strategies. (AASHTO *Bicycle Guide* 5.4).

K. Signing

All signs should be retroreflective and conform to the color, legend, and shape requirements described in the MUTCD. In addition, guide signing, such as to indicate directions, destinations, distances, route numbers, and names of crossing streets should be used. In general, uniform application of traffic control devices, as described in the MUTCD, should be used and will tend to encourage proper bicyclist behavior. (AASHTO *Bicycle Guide* 5.4).

L. Lighting

Fixed-source lighting reduces conflicts along shared use paths and at intersections. In addition, lighting allows the bicyclist to see the shared use path direction, surface conditions, and obstacles. Lighting for paths is important and may be considered where heavy nighttime riding is expected (e.g., paths serving college students or commuters) and at roadway intersections. Lighting should be considered through underpasses or tunnels and when nighttime security could be a problem. Where special security problems exist, higher illumination levels may be considered. Light standards (poles) should meet the recommended horizontal and vertical clearances. (AASHTO *Bicycle Guide* 5.2.12).

On-Street Bicycle Facilities

A. General

Except where prohibited, bicycles may operate on all roadways. This section describes the different types of bicycle facilities located on the roadway, along with their design criteria.

Bicyclists have similar access and mobility needs as other transportation users. However, bicyclists must use their own strength and energy to propel the bicycle or use e-bike. Even then, a bicyclist is generally slower than other vehicles operating on the roadway. Additionally, bicyclists are more vulnerable to injury during a crash and are of any age group. With these factors in mind, it is imperative to design bicycle facilities with great care.

The fourth edition (2012) of the AASHTO “Guide for the Development of Bicycle Facilities” (or AASHTO *Bicycle Guide*) was used as a reference for developing this section. References made to the AASHTO *Bicycle Guide* within this section are shown in parentheses, e.g. (AASHTO *Bicycle Guide* 4.2).

B. Elements of Design

Since bicyclists usually have a higher eye height and are slower than the adjacent traffic, the roadway design elements for motor vehicles usually meet or exceed the minimum design elements required for bicyclists. Additional considerations and exceptions are described below.

- 1. Bicyclist Design Speed:** Where bicyclists are operating on roadways (bicycle lanes, shared lanes, bicycle boulevards, and paved shoulders), designing streets meeting basic geometric design guidelines for motor vehicles will result in a facility generally accommodating bicyclists in terms of grades, stopping sight distance, horizontal and vertical alignment, and cross slopes.

Where separated bicycle lanes are present and geometric elements such as shifting tapers are introduced specifically for bicyclists, a design speed for the typical bikeway user is appropriate. Using the typical adult bicyclist to establish design speeds ensures the geometric design accommodates slower users, including children, seniors and less confident adult bicyclists, pedestrians, and others. The typical adult bicyclist travels at speeds of less than 15 mph on flat level terrain, with average speeds closer to 10 mph. Consideration should also be given to higher speed e-bikes, which are allowed to reach speeds of 28 mph.

Speeds slower than the design speed should be considered for some elements of design, such as using 8 mph for signal timing to account for slower bicyclists (e.g., children and seniors) who need more time to cross intersections.

- 2. Stopping Sight Distance:** Bicycle stopping sight distance is the distance needed to bring a bicycle to a fully controlled stop. It is a function of the user’s perception and brake reaction time, the initial speed, the coefficient of friction between the wheels and the pavement, the braking ability of the user’s equipment, and the grade. See AASHTO *Bicycle Guide* 5.2.8 for calculating stopping sight distance.

- 3. Intersection Sight Distance:** Roadway approach sight distance and departure sight triangles should be calculated according to procedures in AASHTO’s *A Policy on Geometric Design of Highways and Streets* because motor vehicles will control the design criteria.

Where a stop controlled roadway intersects an uncontrolled roadway, bicyclists must judge the speed of, and gaps in, approaching motor vehicle traffic from their location at the edge of the roadway (see Figure 12B-3.01). Providing the minimum stopping sight distance for the motorist on the uncontrolled roadway approach will allow the motorist sufficient time to exercise due care to slow or stop for the crossing bicyclist who may still be in the intersection. Table 12B-3.01 provides the length of the departure sight triangle along the roadway to allow the bicyclist enough time to judge a gap in traffic and complete a full crossing of the roadway without a motorist needing to slow or stop. The table assumes a bicyclist with a:

- design acceleration of 2.5 square feet,
- maximum speed of 8 mph to account for a slow bicyclist, and
- bicycle length of 6 feet.

Figure 12B-3.01: Bicyclist Crossing from a Minor Road

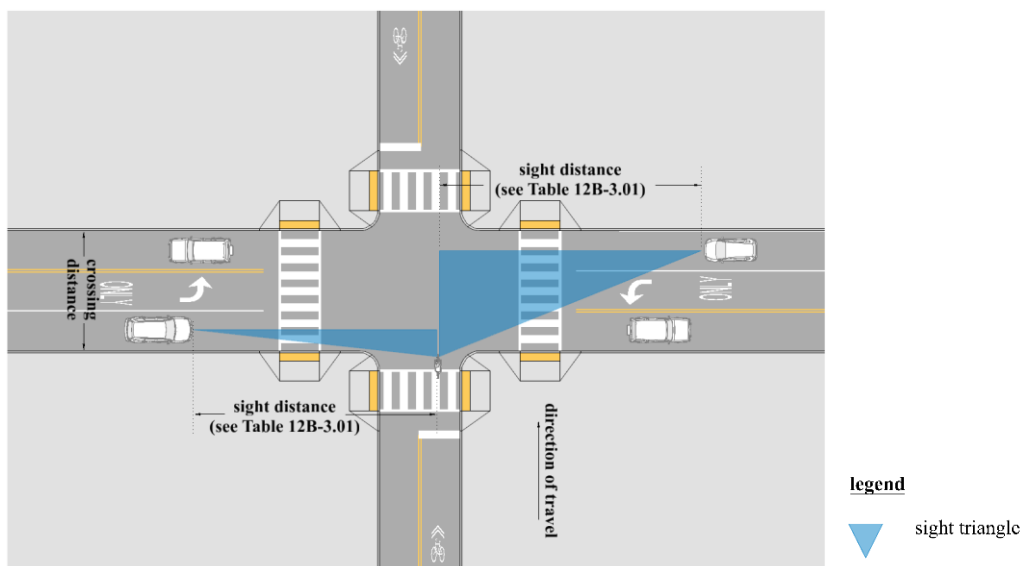


Table 12B-3.01: Bicyclist Sight Distance Crossing from a Minor Road

Bicyclist Sight Distance (ft) Crossing from a Minor Road						
Crossing Distance (ft)	Speed of Roadway to be Crossed (mph)					
	20	25	30	35	40	45
10	149	187	224	261	299	336
15	165	206	247	288	329	370
20	178	223	267	312	356	401
25	191	238	286	333	381	429
30	202	252	303	353	404	454
35	216	270	324	378	431	485
40	228	285	342	399	456	514
45	241	301	361	421	481	542
50	253	317	380	443	506	570
55	266	332	399	465	531	598
60	278	348	417	487	556	626

Based on Standing Bicycle Crossing Time and Motor Vehicle Stopping Sight Distance

4. **Bicyclist Operating Space and Shy Space:** As stated in [Section 12B-2, C](#), a bicyclist requires a minimum of 4 feet operating space. To maintain comfort and safety of bicyclists, it is preferable to provide shy spaces (lateral clearances for vertical elements or obstructions adjacent to bikeways) outside the operating space of the bicyclist. However, for bikeways within the roadway, it may not be practicable to provide shy space to parked and moving motor vehicles. Where minimum shy spaces are not provided, the usable width intended for bicycle travel, and the level of comfort for the facility, is likely to be reduced. Table 12B-3.02 provides guidance for determining an appropriate clearance distance to common vertical elements.

Table 12B-3.02: Bicyclist Shy Space

Vertical Element	Shy Space (in)	
	Preferred	Acceptable
Bicycle Traffic	12	6
Intermittent (tree, flex post, pole, etc.)	12	0
Continuous (fence, railing, planter etc.)	24	12
Vertical Curb*	12	6
Mountable / Sloping Curb	0	0

* Vertical curb without gutter 3 inches or greater. Where a gutter is provided, the shy space is equal to the width of the gutter.

Source: Adapted from *Minnesota Bicycle Facility Design Manual*

In addition to fixed objects, bicyclists have the potential to collide into other bicyclists or pedestrians (on shared use paths) where a bikeway width limits their ability to operate side-by-side, to pass other bicyclists, or to pass pedestrians. Bikeways should be constructed to serve the expected volume of users to minimize this crash risk. Table 12B-3.02 describes the preferred shy space for “bicycle traffic,” which accommodates passing or side-by-side bicycling. Where it is desired to accommodate side-by-side bicycling or frequent passing, shy space should be provided between the operating spaces of each bicyclist. Where it is not desired to encourage bicyclists to ride side-by-side, shy space should still be provided between the physical spaces of each bicyclist to accommodate the occasional passing of bicyclists.

5. **Bicycle Tapers:** Tapers may occur where designers wish to slow bicyclists in advance of an intersection or where a bicycle lane must be shifted to introduce a turn lane. Tapers should generally occur gradually, with a minimum length as calculated using Equation 12B-3.01. If the bikeway is delineated by paint only, and if the off tracking of a bicycle pulling a trailer would not put the trailer into a motor vehicle lane, a maximum taper ratio of 2:1 (longitudinal: lateral) may be considered, see Figure 12B-3.02.

$$L = \frac{WS^2}{60}$$

Equation 12B-3.01

where:

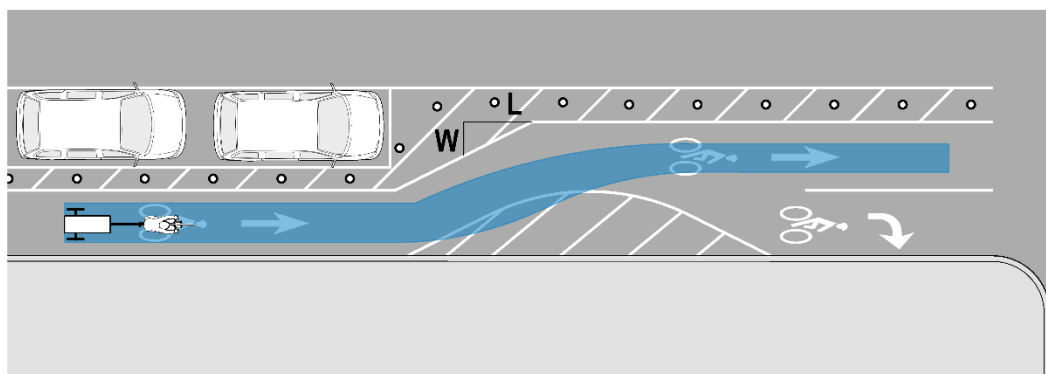
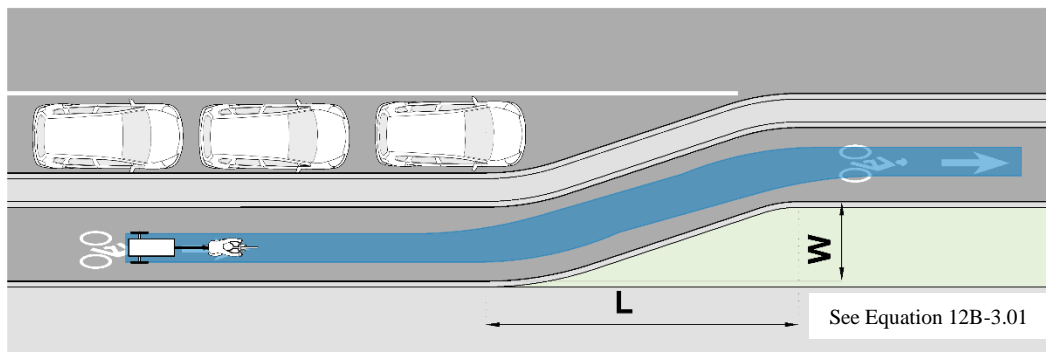
L = Lane shift, ft (minimum 20 feet)


W = Width of offset, ft

S = Target bicyclist operating speeds, mph

Source: MUTCD for speeds less than 45 mph

Figure 12B-3.02: Shifting Taper Equation

**legend**

 bicycle trailer envelope

Source: Adapted from MUTCD Figure 3B-14

- Pavement Conditions:** Surface conditions affect bicyclists more significantly than motor vehicles. Therefore, when establishing bicycle lanes and routes, it is important that the roadway surface is in good condition and is free of potholes, bumps, cracks, loose gravel, etc. If the roadway is not in good bicycle riding condition, it should be repaired either with resurfacing or reconstruction. Chip-sealed surfaces prove to create difficult riding conditions. (AASHTO *Bicycle Guide* 4.2).

C. Shared Lanes

Shared lanes already exist on local neighborhoods and city streets. Shared lanes may be identified with signage and markings or be left unmarked. They are not recommended for roadways with speeds over 35 mph or traffic volumes over 5,000 AADT. In addition, shared lanes on roadways with speeds greater than 25 mph or volumes over 3,000 AADT are unlikely to accommodate the “interested but concerned” bicyclist but could accommodate the “highly confident” bicyclists (see [Section 12B-1](#)).

The designs and dimensions for shared lanes differ by location, but attention to design features can make the lanes more comfortable for all bicyclists. This includes good pavement quality, adequate sight distance, lower motor vehicle speeds, appropriate signal timing and detection systems, bicycle-compatible drainage grates, bridge expansion joints, railroad crossings, etc. (AASHTO *Bicycle Guide* 4.3).

Where bicyclists are operating in shared lanes, travel lane widths should generally be the minimum widths appropriate for the context of the roadway. In the past, it was common practice to provide wider outside lanes (14 feet or greater) under the assumptions motorists in such a lane could pass a person riding a bicycle without encroaching into the adjacent lane and this practice would improve operating conditions and safety for both bicyclists and motorists. However, research finds this configuration does not adequately provide safe passing distance and motorists generally do not recognize this additional space is intended for bicyclists. Wider travel lanes are also associated with increases in motor vehicle speeds, which reduce comfort and safety for bicyclists. Wide lanes are therefore not recommended as a strategy to accommodate bicycling. Where wide lanes exist, roadways should at a minimum be restriped to reduce wide lanes to minimum lane widths. Additional space may be reallocated to other purpose such as bicycle lanes, wider sidewalks, etc.

The use of constrained width bicycle lanes (see Section 12B-3, C, 3) is preferable to a wide outside lane. However, the use of minimum constrained width bicycle lanes should be limited to constrained roadways where preferred minimum bicycle lane widths cannot be achieved after all other travel lanes have been narrowed to minimum widths appropriate for the context of the roadway.

1. **Shared Lane Markings:** In areas that need to provide enhanced guidance for cyclists, shared lanes may be marked with pavement marking symbols. This marking should be provided in locations where there are insufficient widths to provide bicycle lanes or shared use paths. This pavement marking not only lets the cyclists know where to be located within the lane but also the direction of travel.

Shared lane markings are not appropriate for paved shoulders or bicycle lanes, and should not be used on roadways that have a speed limit above 35 mph. Markings should be placed immediately after an intersection and spaced not greater than 250 foot intervals. Refer to both the MUTCD and AASHTO *Bicycle Guide* 4.4.

2. **Shared Lane Signs:** Along with pavement markings, signage is very useful to reinforce to motorists the legal right of bicyclists about shared operating along a roadway.

The recommended sign for use in shared lane conditions is the “BICYCLES MAY USE FULL LANE” sign (R4-11). This sign is used on roadways without bicycle lanes or usable shoulders where travel lanes are too narrow for bicyclists and motorists to operate side by side within a lane (typically less than 14.5 feet). Use of the “SHARE THE ROAD” sign (W16-1P) is not recommended due to the ambiguous message it sends. Refer to both the MUTCD and AASHTO *Bicycle Guide* 4.3.2.

Figure 12B-3.03: Shared Roadways



R4-11

D. Paved Shoulders

“Highly confident” or “somewhat confident” bicyclists are most likely to travel long distances on rural roadways between towns and cities and are often assumed as the default design user profiles. Paved shoulders can improve these bicyclists’ safety and comfort along higher speed and higher volume roadways. This will not only benefit the cyclists and motorists by giving the bicyclists a place to ride that is located outside of the travel lane, but it also can extend the service life of roads by reducing edge deterioration.

Paved shoulders should meet the standards set forth in Iowa DOT’s Bicycle and Pedestrian Long Range Plan and shown in Table 12B-3.04, which vary depending on Average Daily Traffic of the roadway. Also, they should include shy space for guardrails or vertical obstructions, as set forth in Table 12B-3.02. Additionally, the width may be increased in areas of heavy truck traffic.

Table 12B-3.04: Paved Shoulder Standards

Design Year Average Daily Traffic (ADT) Thresholds	Preferred Paved Shoulder Width (ft)	Acceptable Paved Shoulder Width (ft)
ADT > 5,000 (Bicycle Routes*)	10	6
ADT > 5,000	6	5**
2,000-5,000 ADT (Bicycle Routes*)	6**	5**
2,000-5,000 ADT	5**	4**
1,000-2,000 ADT (Bicycle Routes*)	5**	4**
1,500-2,000 ADT	3**	2**

*On roadways where a higher level of bicycle traffic is expected (e.g. bicycle routes identified by municipalities or other agencies).

**Paved width exclusive of rumble strips

Source: Iowa DOT Bicycle and Pedestrian Long Range Plan

It is preferred to have paved shoulders on both sides of a two-way roadway; however, in constrained locations and where pavement widths are limited, it may be preferable to provide a wider shoulder on one side of the roadway and a narrower shoulder on the other. This is beneficial in uphill roadway sections to provide slow-moving bicyclists additional maneuvering space and sections with vertical or horizontal curves that limit sight distance over crests and on the inside of horizontal curves.

Paved shoulders can be designated as bicycle lanes by installing bicycle lane symbol markings and must follow the criteria in Section 12B-3, E. Along rural roads with higher speeds (45 mph or greater) it is preferable to provide a shared use path separated from the road if the road segment:

- is a well used and important bicycle route,
- is located in an area that attracts larger volumes of bicycling due to scenic views, and
- serves as a key bicycle connection between major destinations.

In locations where unpaved driveways or roadways meet a paved shoulder, it is recommended to pave at least 10 feet of the driveway and 20 feet or to the right-of-way line, whichever is less, of the unpaved public road. This will help minimize loose gravel from spilling onto the travel way and affecting the bicyclists. Additionally, raised pavement markers should not be used, unless they are beveled or have tapered edges.

Rumble strips may be used on paved shoulders that include the bicycle traffic. A bicyclist requires a minimum of 4 feet and a preferred 5 feet of essential operating space based upon their profile. When rumble strips are used, a minimum clear path 4 feet from the rumble strip to the outside edge of paved shoulder or 5 feet to the adjacent curb or other obstacle should be provided, with wider clear paths preferred. Gaps of 12 to 15 feet and a recommended distance of 40 to 60 feet for the rumble strips should also be provided in order to allow room for bicyclists to leave or enter the shoulder without crossing the rumble strip. A 15 foot gap allows approximately half a second for a bicyclist to cross the rumble strip at an operating speed of 20 mph or less. Designers should consider increasing the gap length to a range of 15 to 20 feet or shifting the rumble strip to the right side of the shoulder in locations where bicyclists are traveling at speeds over 20 mph and likely need to traverse the rumble strip into the travel lane. Rumble strips should have the following design and meet NCHRP Report 641:

- Width: 7 inches
- Depth: 0.375 inches
- Spacing: 11 to 12 inches (may be reduced to 6 inches)
- Length: 6 to 12 inches

E. Bicycle Lanes

Bicycle lanes are a portion of the roadway that is designated for bicycle traffic. The following sections discuss several types of bicycle lanes including buffered bicycle lanes, separated bicycle lanes, and contraflow bicycle lanes. For guidance on how to select one of these bicycle facilities, refer to [Section 12B-1](#). Public information and education programs may be necessary when a specific type of bicycle lane is introduced into a community. Programs should include a focus for drivers, as well as for bicyclists. Paved shoulders can be designated as bicycle lanes by installing bicycle lane symbol markings, yet marked shoulders will still need to meet the criteria listed herein.

Bicycle lanes should have a smooth surface with utility and grate covers flush with the surface of the lane. Additionally, bicycle lanes should be free of ponding water, washouts, debris accumulation, and other potential hazards. (*AASHTO Bicycle Guide* 4.6). Designers need to be aware that pavement joints, especially near curb and gutter sections, could impact the usability of the bicycle lane.

- 1. Bicycle Lane Widths:** The widths prescribed in Table 12B-3.05 accommodate a bicyclist operating space, occasional passing, and shy distances to vertical elements as presented in Table 12B-3.02. The bicycle lane should be a hard and smooth rideable surface, clear of defects, joints, and other potential obstructions. The gutter should not be included in the measurement of the bicycle lane width because it is not a rideable surface and the gutter presents a potential crash hazard. The only exception is locations where the gutter is incorporated into the full width of the bicycle lane. In those instances, the gutter should be designed to provide a smooth rideable surface with no longitudinal joints or seams parallel to the bicyclist's line of travel.

Table 12B-3.05: One-Way Bicycle Lane Width Criteria

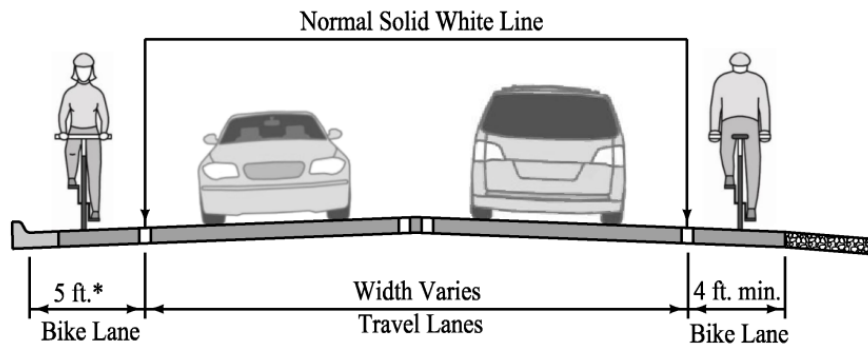
Bicycle Lane Description	Preferred Width (ft)	Minimum Width (ft)
Adjacent to curb ¹ or edge of pavement	5 to 7	4
Between travel lanes or buffers	5 to 7	4
Adjacent to parking ²	6 to 7	5
Intermediate or sidewalk level raised bicycle lane	5.5 to 7.5	5
To allow side-by-side bicycling or passing	8 to 10	7

¹ Exclusive of the gutter unless the gutter is integrated into the full width of the bicycle lane.

² Raised bicycle lanes adjacent to parking should have a minimum width of 7 feet.

Source: Adapted from *Minnesota Bicycle Facility Design Manual*

Where a bicycle lane is adjacent to a curb with no gutter, the bicycle lane width should be measured from the face of curb to the center of bicycle lane line. For streets with on-street parking, the bicycle lane width should be measured from the center of the parking lane or buffer line to the center of the bicycle lane line.

Figure 12B-3.04: Conventional Bicycle Lane Cross-sections - Parking Prohibited

* On extremely constrained, low-speed roadways with curbs but no gutter, where the preferred bicycle lane width cannot be achieved despite narrowing all other travel lanes to their minimum widths, a 4 foot wide bicycle lane can be used.

Source: Adapted from AASHTO *Bicycle Guide* Exhibit 4.13

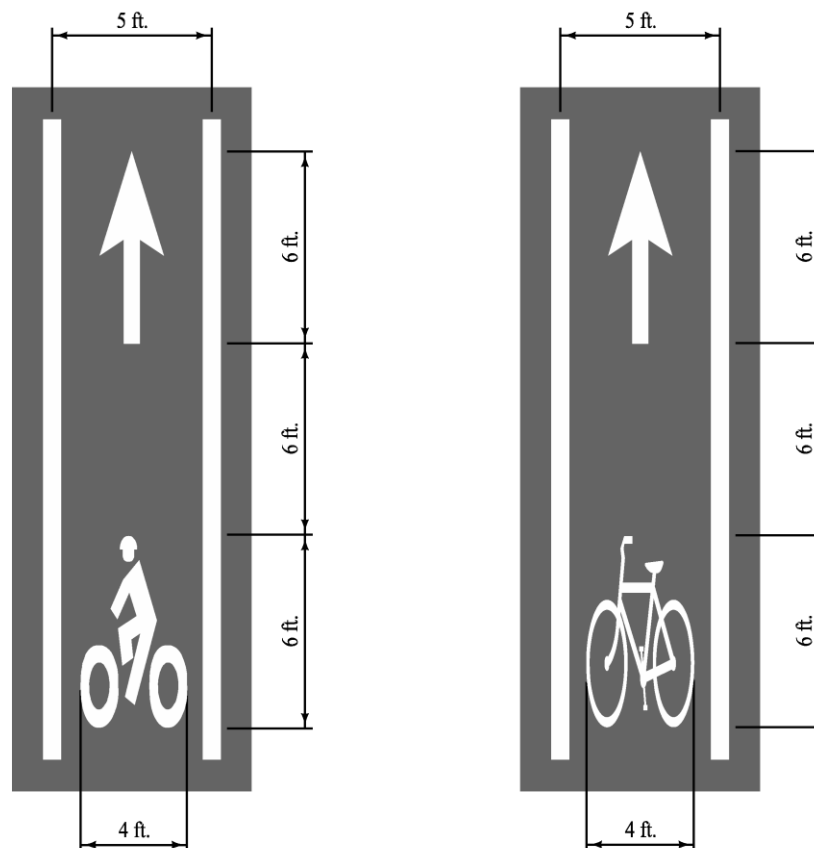
The width of a bicycle lane and buffer (if provided) have a significant impact on a bicyclist comfort and their operating position within a bicycle lane. As the adjacent motorized traffic volume and speed increases, bicyclists will try to move away from vehicles operating in the adjacent travel lane, positioning themselves closer to parked vehicles or the edge of roadway, which can increase their crash risk. Bicycle lanes should therefore be built to preferred widths to address the comfort and safety of bicyclists operating within the lane adjacent to the motorized traffic. While bicycle lanes wider than 7 feet may be provided, they should be complemented by a buffer to minimize their appearance as a travel or parking lane for motorists (see Section 12B-3, E, 7).

Example conditions where wider bicycle lanes or buffered bicycle lanes may be preferable include:

- Locations with high parking turnover.
- Locations where it is desirable to allow bicyclists to travel side-by-side or pass each other.
- On roadways with posted speeds over 30 mph or 6,000 vehicles/day.
- On roadways with more than 5% heavy vehicles/trucks.
- Locations where bicycle lanes are located between two moving travel lanes such as between a through lane and turning lane.

2. **Markings for Bicycle Lanes:** Bicycle lanes are designated for preferential use by bicyclists with a white lane line and one of the two standard bicycle lane symbols, which should be supplemented with a directional arrow marking indicating the correct direction of travel in the bicycle lane. The lane line may be a normal width (4 to 6 inches wide) or it may be a wide width (8 to 12 inches wide) to add emphasis, see Figure 12B-3.5. Bicycle lane signs may be used to supplement the pavement markings. All bicycle lane markings should be retroreflective. Refer to both the MUTCD and *AASHTO Bicycle Guide* 4.7 for bicycle lane markings and Section 12B-3, F for bicycle lane markings at intersections.

Figure 12B-3.05: Conventional Bicycle Lane Symbol Markings



Source: Adapted from *AASHTO Bicycle Guide* Exhibit 4.17

- 3. Bicycle Lanes on One Side of a Two-way Street:** It is recommended that bicycle lanes are provided on both sides of two-way streets. Bicycle lanes on only one side may encourage wrong-way use. The following scenarios note when it may be acceptable to provide a bicycle lane on one side and how to select which side:
- On streets where downhill grades are long enough to result in bicycle speeds similar to typical motor vehicle speeds, then a bicycle lane may be provided only in the uphill direction, with shared lane markings in the downhill direction. This design can be especially advantageous on streets where fast downhill bicycle speeds have the potential to increase the likelihood of crashes with fixed objects, particularly in locations with on-street parking.
 - Where a roadway narrows on one side of a roadway for a short segment with an otherwise continuous bicycle lane.
 - Where an adjacent parallel roadway of similar width provides a bicycle lane in the opposing direction.

When a bicycle lane is only provided in one direction, shared lane markings should be added in the opposing direction if the roadway speed is 35 mph or below.

- 4. Bicycle Lanes on One-way Streets:** On one-way streets, the bicycle lane should be on the right-hand side of the roadway. A bicycle lane may be placed on the left side of the roadway if there are a significant number of right turn lanes, or if left sided bicycle lanes will reduce conflicts with bus traffic, on-street parking, and/or heavy right-turn movements, etc. Left side bicycle lanes may increase crash risks for bicyclists because it is generally an unexpected location for bicyclists. To mitigate this risk, left side bicycle lanes should be restricted to streets with posted speeds below 30 mph and implemented on a consistent basis in a community. Consideration should be given to increasing the conspicuity of the bicycle lane through the use of wider bicycle lane lines, additional bicycle lane markings, green colored pavement, and additional regulatory or warning signs notifying motorists of the left side placement.

Bicycle lanes should also be provided on both streets of a one-way couplet as to provide a more complete network and discourage wrong-way riding. If width constraints are in effect, shared lane markings should be considered.

- 5. Counterflow Bicycle Lanes:** Bicycle lanes should typically be provided on both streets of a one-way couplet. If a one-way roadway pair in the opposite direction does not exist or would significantly increase bicyclist travel time due to out of direction travel, there may be an increase in wrong way riding. If sufficient width exists, a counterflow bicycle lane can also be added to provide for two-way bicycle travel on a one-way street. A bicycle lane should be provided for bicyclists traveling in the same direction as motor vehicle traffic. If there is insufficient room to provide a bicycle lane in the dominant flow direction of the street, shared lane markings should be considered to emphasize that bicyclists must share the travel lane on this side of the street.

To mitigate potential safety challenges associated with counterflow bicycle travel, the following should be considered:

- The bicycle lane should be marked according to normal rules of the road so bicyclists using the lane are traveling on the right-hand side of the roadway, with opposing traffic on their left.
- Bicycle lane symbols and directional arrows should be used on both the approach and departure of each intersection, to remind bicyclists to use the bicycle lane in the appropriate direction, and to remind motorists to expect two-way bicycle traffic.
- Because counterflow bicycle travel can be unexpected by motorists when entering, exiting or crossing the roadway, additional treatments including signs and green colored conflict markings (see Section 12B-3, F) should be considered at intersections, alleys, grade crossings, and driveways.

- At intersecting streets, alleys, and major driveways, “DO NOT ENTER” signs and turn restriction signs should include a supplemental “EXCEPT BICYCLES” plaque to establish that the street is two-way for bicyclists.
- At traffic signals, signal heads should be provided for counterflow bicyclists, as well as suitable bicycle detection measures. A supplemental plaque that says “BICYCLE SIGNAL” may be needed beneath the signal to clarify its purpose. See Section 12B-3, L, 1 for information on signal options for controlling bicyclists.
- A solid double yellow center line should be used to separate the counterflow bicycle lane from opposite direction traffic. Medians or traffic separators should be considered to provide more separation between motorists and bicyclists traveling in opposing direction, particularly at intersections. This treatment is required when posted speeds exceed 35 mph.

- 6. Bicycle Lanes Adjacent to On-street Parking:** Where on-street parking facilities are present, bicycle lanes should be located between the general purpose travel lane and the parking lane, unless designated as a separated bicycle lane. Delineating the bicycle lane with two stripes, one along the street side and one along the parking side, is preferable to a single stripe between the bicycle lane and travel lane.

When parallel parking lanes are narrow or there is a high parking turnover, it is preferable to provide a separated bicycle lane to reduce conflicts with the vehicles. When a separated bicycle lane is not feasible or an interim solution is needed, a buffered bicycle lane should be provided, see Section 12B-3, E, 7. It is preferable that the combined width of the parking lane and buffer be at least 10.5 feet wide to allow the opening of motor vehicle doors.

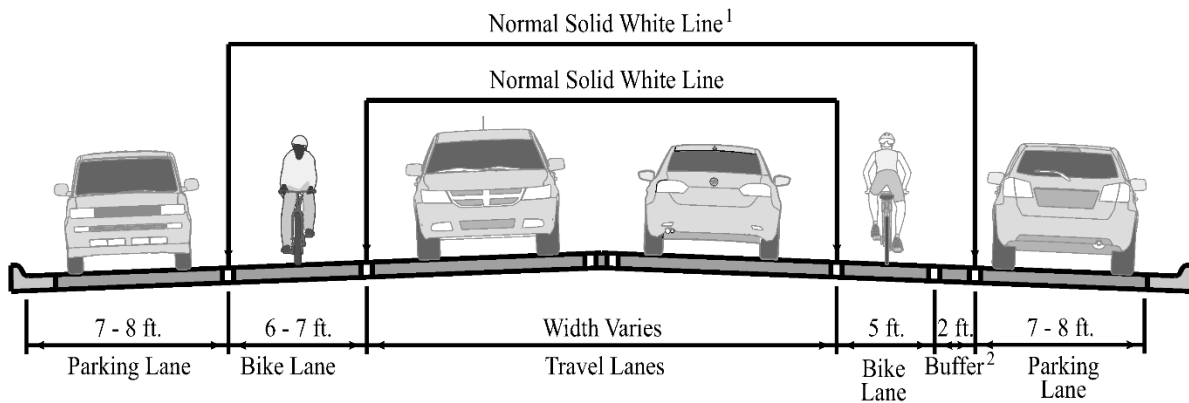
If a striped buffer is not desired, the bicycle lane width may be increased to provide bicyclists with more operating space to ride out of the area of opening vehicle doors; however, as bicycle lane widths increase, they may appear more like travel lanes and may result in instances of double parking. Designers may consider the use of green pavement to discourage motorists using the bikeway. If a buffered bicycle lane is not feasible, designers should consider the following options in the order stated:

- Evaluate the reduction of travel lane widths and parking lane widths to accommodate the design widths for buffered bicycle lanes. For parallel on-street parking, the recommended width of a marked parking lane is 8 feet to encourage vehicles to stay within the parking lane. A parking lane of 9 feet may be preferable in areas where trucks are routinely present.
- Evaluate if parking can be consolidated to one side of the street or removed to provide the additional space necessary to accommodate the design widths for buffered bicycle lanes.
- On constrained streets where it is not feasible to eliminate parking, or to narrow or remove a travel lane, in order to achieve the minimum dimensions, research indicates there is a slightly reduced risk of dooring in bicycle lanes as compared to shared lanes. The bicycle lane may be narrowed to a minimum width of 4 feet to provide a buffer within the door zone area. The door zone buffer may vary from 2 feet to 4 feet. The buffer markings will encourage bicyclists to ride farther from parked vehicles and encourage motorists to park closer to the curb.
- The minimum combined bicycle lane and parking lane width is 12 feet. All other travel lanes should be narrowed to the allowable constrained width before the minimum combined bicycle and parking lane width is considered. Diagonal pavement markings may be used within the bicycle lane to identify the potential door zone area by extending parking tees or diagonal pavement markings into the bicycle lane up to 3.5 feet from the parking lane line.
- When insufficient widths are available, providing a shared lane in lieu of a bicycle lane is unlikely to accommodate the “interested but concerned” bicyclist, but could accommodate the “highly confident” bicyclist. An alternative route should be considered if the target design user is the “interested but concerned” user.

For the scenarios listed above, green colored pavement may be used within the bicycle lane to improve the visibility of the bicycle lane adjacent to parking or loading areas.

Bicycle lanes should not be placed adjacent to head-in angled parking, since drivers backing out of parking spaces have poor visibility of bicyclists in the bicycle lane. The use of back-in angled parking can help mitigate the conflicts normally associated with bicycle lanes adjacent to head-in angled parking (AASHTO *Bicycle Guide* 4.6.5).

Figure 12B-3.06: Bicycle Lane Cross-sections Adjacent to On-street Parking



¹ The normal (4 to 6 inch) solid white line is preferred to make the presence of a bicycle lane more evident. Parking stall markings may also be used.

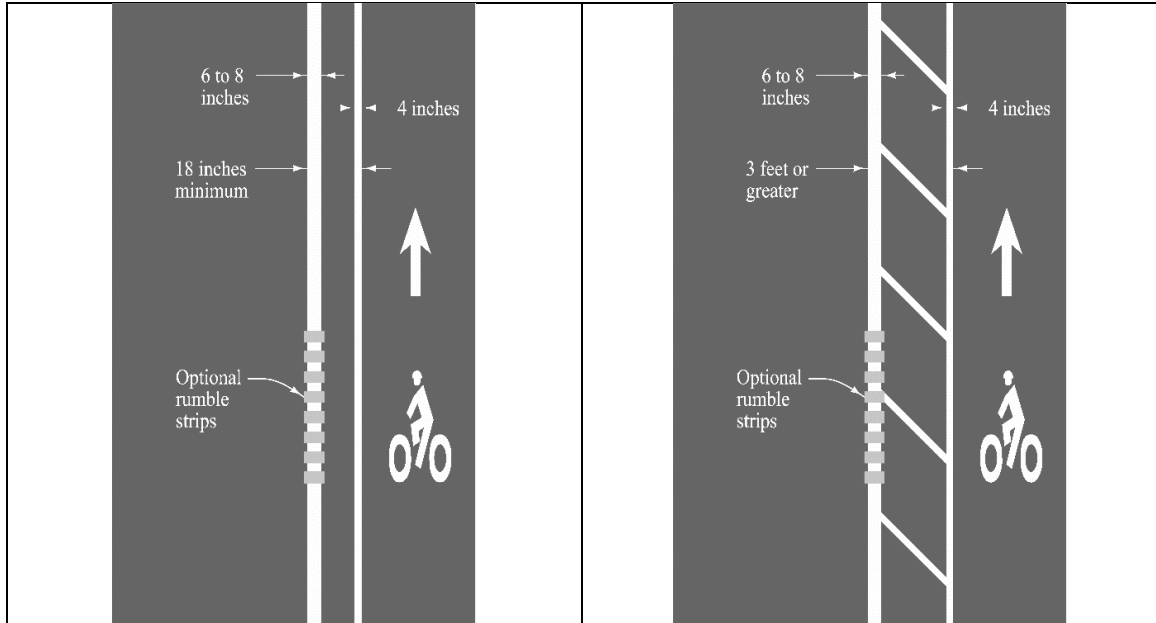
² Buffers are preferred where parking turnover is high.

Source: Adapted from AASHTO *Bicycle Guide* Exhibit 4.13

- 7. Buffered Bicycle Lanes:** Where space is available, bicycle lanes can be improved through the provision of a painted buffer between the bicycle lane and the adjacent motor vehicle lanes and/or a parking lane. They are generally used when traffic volumes include high percentages of trucks or buses and higher travel speeds or to reduce the risk of dooring where bicycle lanes are adjacent to on-street parallel parking.

The lane widths are the same as those set forth in Table 12B-3.05. The buffered bicycle lane provides a greater space for cycling without making the bicycle lane appear so wide that it might be mistaken for a travel or parking lane. The buffer should be a minimum of 18 inches wide and marked with two solid white lines with diagonal hatching or chevron markings if the width is 3 feet or greater. Typical spacing of the chevron markings is 20 feet. The maximum spacing should not exceed the equivalent of the speed limit. Colored markings may be used at the beginning of each block to discourage motorists from entering the buffered lane. The combined width of the buffer(s) and bicycle lane should be considered the “bicycle lane width.” For buffered lanes between travel lanes and on-street parking, the bicycle lane should be a minimum of 7 feet wide (inclusive of buffer width) to encourage bicyclists to ride outside the door zone. Rumble strips may be added to the painted buffer area as an additional indicator for vehicles to remain clear of the bicycle lane. Placement of rumble strips should comply with Iowa DOT requirements. Rumble strips can present a hazard to bicyclists and should not be used in areas where bicyclists are likely to merge in the adjacent general purpose lane to complete turns.

Figure 12B-3.05: Buffered Bicycle Lane Markings

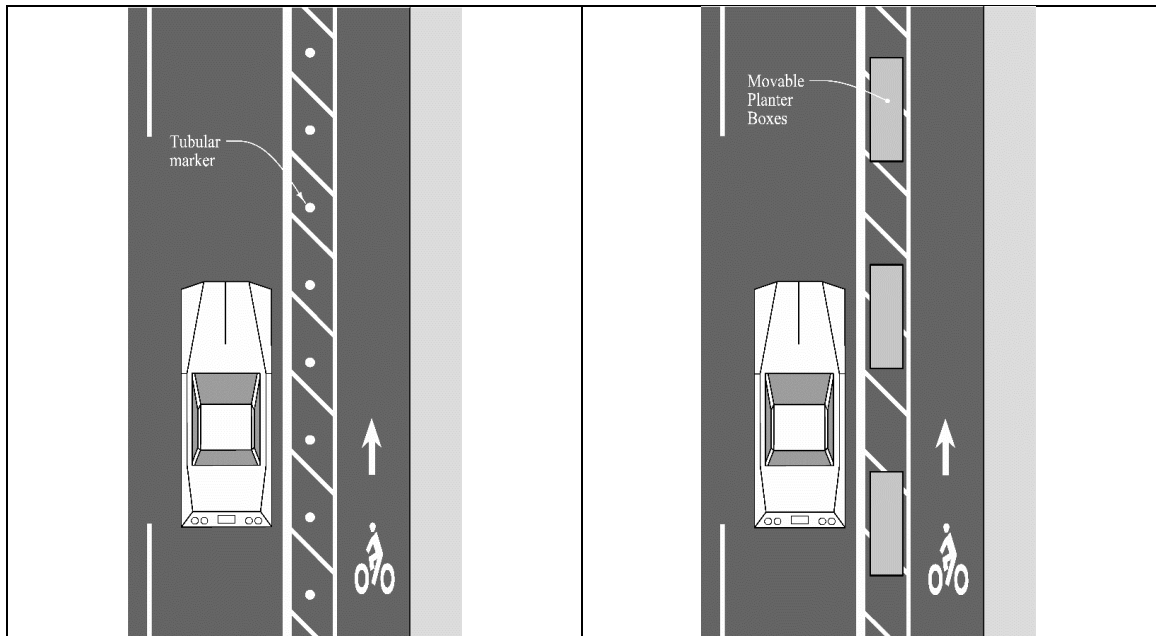


Note: Buffered bicycle lane markings should be measured from the middle of the lane line.

Source: Adapted from *Urban Bikeway Design Guide*, NACTO

8. **Separated Bicycle Lanes:** In order to feel comfortable riding on high speed and high-traffic streets, most bicyclists prefer separation from motor vehicle traffic, see [Section 12B-1](#). Separated bicycle lanes provide an exclusive space that is physically separated from motor vehicle or parking lanes by a vertical element. Examples of vertical separation include delineators, bollards, curbs, medians, planters, concrete barriers, and on-street parking, see Figure 12B-3.08. Where on-street parking is present, designers may need to evaluate parking restrictions to ensure adequate sight distance, see Section 12B-3, E, 9.

Figure 12B-3.08: Separated Bicycle Lane



Source: Adapted from *Urban Bikeway Design Guide*, NACTO

If the separated bicycle lane is parking protected, parking should be prohibited a minimum of 30 to 50 feet from the crosswalk of an intersection. Make sure to provide ADA access across the separated bicycle lane from parking spaces.

Separated bicycle lanes may be located at street elevation, sidewalk elevation, or an intermediate elevation in between the sidewalk and street. When built at sidewalk level, care must be taken to ensure they are distinct from the sidewalk to discourage pedestrian encroachment and to provide a detectable edge for persons with vision disabilities.

Separated bicycle lanes may be installed in one-way and two-way configurations, each of which present opportunities and challenges that must be considered during the design process. Two-way separated bicycle lanes might be appropriate where key destinations exist along one side of the road, where driveways and intersections are sparse along one side of road but frequent along the other side, or for other context-based reasons. If used, signings and markings at intersections, driveways, and other conflict points should be employed as appropriate to ensure people walking and driving are aware of the two-way operations. At signalized intersections, additional equipment and phasing adjustments may be necessary, see Section 12B-3, L.

Separated bicycle lane width should be selected based on the desired elevation of the bicycle lane, adjacent curb type(s), anticipated volume of users, likelihood of passing maneuvers, and one-way vs. two-way operation. Bicyclists typically do not have the option to pass each other by moving out of a separated bicycle lane as they would in a standard bicycle lane because of the vertical elements between the bikeway and the motor vehicle travel lane. It is therefore preferable for the width of the separated bicycle lane to accommodate passing and potentially allow side-by-side bicycling. The preferred, minimum, and constrained bicycle lane widths for one-way and two-way separated bicycle lane(s) are provided in Table 12B-3.6. When designing separated bicycle lane widths, consideration should also be given to the following factors:

- Shy distances to different curb types and vertical elements (see Table 12B-3.02).
- The equipment that will be needed to perform sweeping and snow removal maintenance. Unobstructed widths of less than 8 feet will likely require specialized maintenance equipment. If a solid median is used as the means of vertical separation, drainage may also be impacted. Separation devices such as delineators or planters may be removed during the winter months to facilitate snow plowing and removal activities.
- Tactile warning devices when level with adjacent sidewalk.

Table 12B-3.06: Separated Bicycle Lane Widths

Bikeway Operation and Context	Separated Bicycle Lane Widths (ft) ¹		
	Preferred Width	Acceptable Width	Constrained Condition ²
One-way, Adjacent to One Vertical Curb	8	6	4
One-way, Between Sloped Curbs or at Sidewalk Level	7.5	5.5	3.5
Two-way, Adjacent to One Vertical Curb	11.5	9.5	8
Two-way, Between Sloped Curbs or at Sidewalk Level	11	9	7.5

¹ The widths shown are for separated bicycle lanes where the peak bicycle activity is less than 150 bicycles per hour. Where volumes exceed this, additional width should be provided.

² In constrained conditions, the minimum widths for separated bicycle lanes will not accommodate passing maneuvers between bicyclists. As such, constrained minimum widths are not recommended for long distances. However, they may be appropriate adjacent to accessible parking spaces, loading zones, or transit stops if sufficient width is not available to accommodate the preferred widths.

Source: Adapted from *Minnesota Bicycle Facility Design Manual*

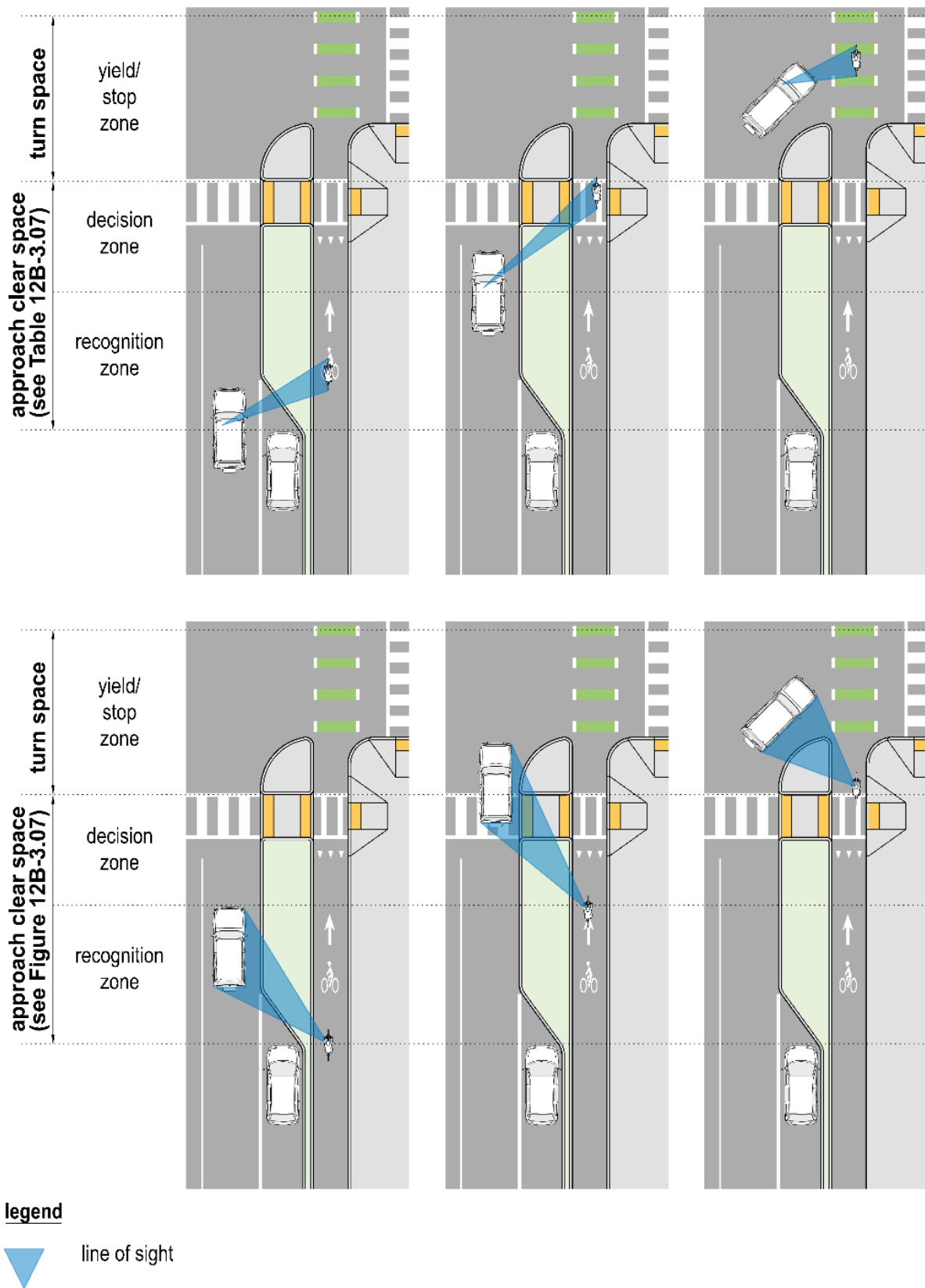
Interaction between transit stops and separated bicycle lanes can be difficult. When possible, the bicycle lane should be routed behind the bus platform. Where on-street parking is present, a floating bus stop may be provided, see NACTO's *Transit Street Design Guide*. If bus traffic is infrequent (less than four buses per hour), bus stops can utilize the bicycle lane space. When buses are present, bicyclists may merge left and pass the stopped bus.

9. **Separated Bicycle Lane Parking Buffer Design for Intersection Sight Distance:** When a separated bicycle lane is located adjacent to a parking lane, it may be necessary to restrict parking and other vertical obstructions in the vicinity of a crossing to ensure adequate sight distance are provided for both bicyclists and motorists. To determine parking restrictions near the crossing, it is necessary to know the approach speed of the bicyclist and the turning speed of the motorist. The overall objective of the design is to provide adequate sight distances for each user to detect a conflicting movement of another user and to react appropriately. The approach to the conflict point consists of these three zones:
- **Recognition Zone:** The approaching bicyclist and motorist have an opportunity to see the other and evaluate their respective approach speeds.
 - **Decision Zone:** The bicyclist or motorist identifies who is likely to arrive at the intersection first and adjusts their speed to yield or stop if necessary.
 - **Yield/Stop Zone:** A space for the motorist or bicyclist to yield or stop, if necessary.

At intersections with permissive turning movements where bicyclists and motorists are traveling in the same direction, there are two yielding scenarios that occur depending upon who arrives at the crossing first. The two scenarios are described below and illustrated in Figure 12B-3.09.

- **Right Turning Motorist Yields to Through Bicyclist:** This scenario occurs when a through moving bicyclist arrives at the crossing prior to a turning motorist, who must stop or yield to the through bicyclist. Parking must be set back sufficiently for the motorist to see the approaching bicyclist
- **Through Bicyclists Yields to Turning Motorist:** This scenario occurs when a turning motorist arrives at the crossing prior to a through moving bicyclist. Again, parking must be set back sufficiently to enable bicyclists and motorists to see and react to each other.

Figure 12B-3.09: Yielding Scenarios Illustrating Intersection Sight Distance Case A



Source: Adapted from *MassDOT Separated Bike Lane Planning & Design Guide*

The following provides sight distance considerations for situations where motorists turn right, left, or cross separated bicycle lanes. The recommended approach clear space assumes the bicyclist is approaching the intersection at a constant speed of 15 mph. Clear space recommendations are provided for various turning speeds of motorists that may vary based on the geometric design of the corner and the travel path of the motorist. The recommended clear space allows 1 second of reaction time for both parties as they approach the intersection. If bicyclists' speeds are slower (such as on an uphill approach) or motorists' turning speeds are slower than 10 mph, the clear space can be reduced. Where either party may be traveling faster, such as on downhill grades, the clear space may benefit from an extension.

- a. Bicycle Case A - Right-Turning Motorist Across Separated Bicycle Lane:** In this case, the motorist will be decelerating for the right turn approaching the intersection. Table 12B-3.07 identifies the minimum approach clear space, measured from the point of curvature of the motorist's effective turning radius, which represents the location where the motorist will have decelerated to the turning speed; this location may or may not be the curb line point of curvature. For locations with two-way separated bicycle lanes, additional approach clear space is not typically required because the recognition zone between the counterflow bicyclist movement and the right-turning motorists should exceed the recommended sight distances. Approach clear space may be increased to account for steeper slopes or higher speeds for bicyclists.

Table 12B-3.07: Intersection Approach Clear Space by Vehicular Turning Design Speed

Effective Vehicle Turning Radius	Target Vehicular Turning Speed	Approach Clear Space
<18 ft	<10 mph ¹	20 ft
18 ft	10 mph	40 ft
25 ft	15 mph	50 ft
30 ft	20 mph	60 ft
≥50 ft	25 mph	70 ft

¹ Most low volume driveways and alleys

Source: Adapted from MassDOT *Separated Bicycle Lane Planning & Design Guide*

- b. Bicycle Case B - Left-Turning Motorist Across Separated Bicycle Lane:** This case applies when a motorist is making a permissive left turn at a traffic signal or from an uncontrolled approach (e.g., a left turn from an arterial onto a local street or driveway). On one-way streets with a left-side separated bicycle lane, this case has the same operational dynamics and approach clear space requirements as Bicycle Case A since the left-turning motorist will be turning adjacent to the separated bicycle lane. On two-way streets with a left-side separated bicycle lane, there are two sight lines that should be maintained. A left-turning motorist approaching a turn needs a line of sight to bicyclists approaching from the same direction. Table 12B-3.07 identifies the minimum approach clear space based on the effective turning radius for the left-turning motorist. The provision of Bicycle Case A for motorists making a right-turn across a two-way bikeway will already provide the necessary line of sight between a left-turning motorist and a bicyclist approaching from the opposite direction.

On streets with two-way traffic flow, the operational dynamic of a motorist looking for gaps in traffic creates unique challenges that cannot be resolved through improving sight distance. This is a challenging maneuver because the motorist is primarily looking for gaps in oncoming motor vehicle traffic and is less likely to scan for bicyclists approaching from behind. Unlike for Bicycle Case A or Bicycle Case B on one-way streets where the motorist is decelerating towards the crossing, the motorist in this case will be accelerating towards the

crossing once they perceive a gap in traffic. This creates a higher potential for conflicts on roads with the following:

- High traffic volumes and multiple lanes.
- Higher operating speeds.
- High left turn volumes.

Where it is not feasible to eliminate high speed and high volume conflicts through signalization, turn prohibitions, or other traffic control, it may be necessary to reevaluate whether a two-way separated bicycle lane is appropriate at the location, or provide an adequate motorist yield zone that allows the motorist to complete the turn while still yielding to crossing pedestrians or bicyclists, see Section 12B-3, F, 5.

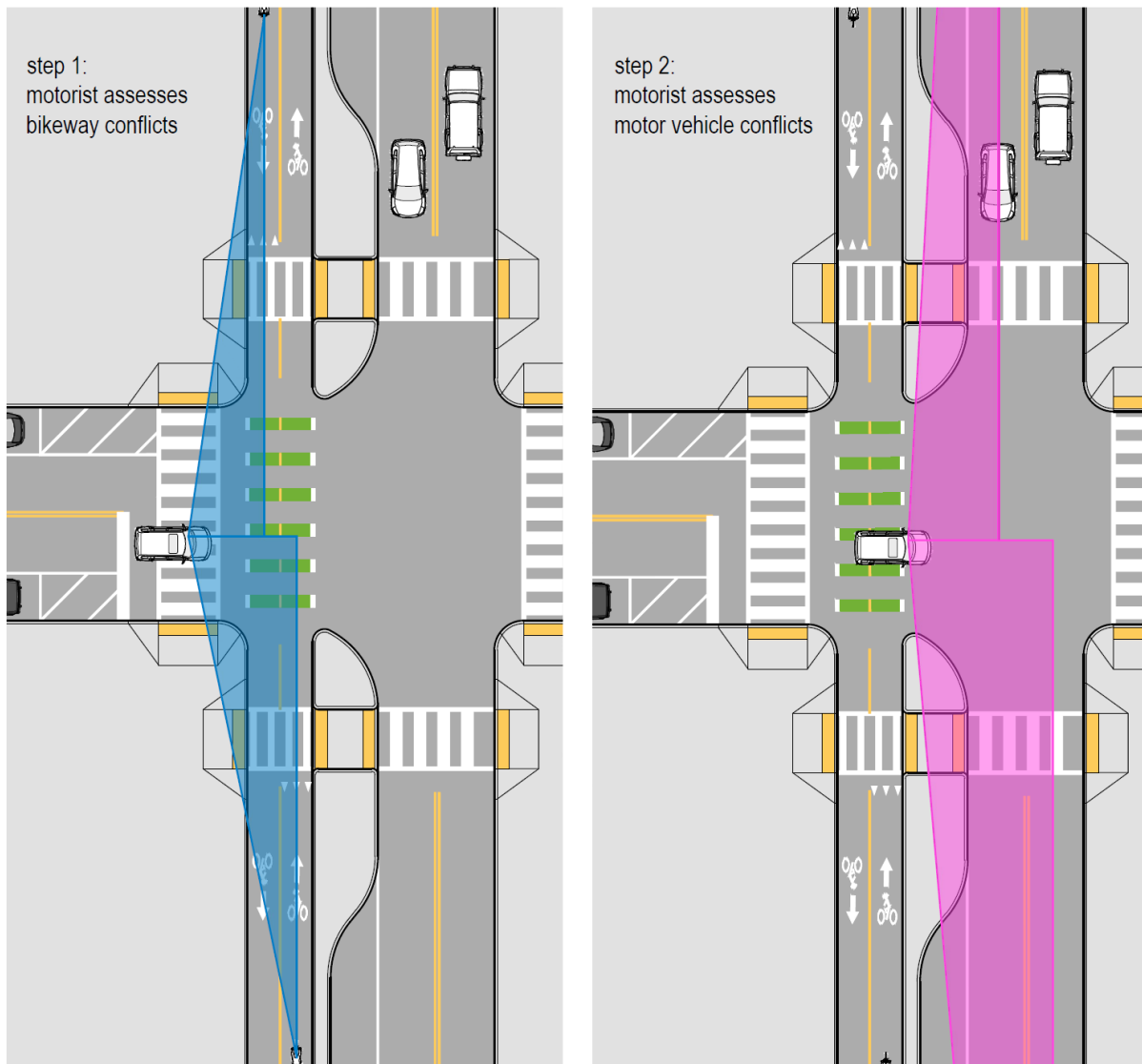
c. Bicycle Case C - Motorist Crossing of a Separated Bicycle Lane or Shared Use Path:

This case applies when a motorist crosses a separated bicycle lane and is similar to the cases in the AASHTO *Bicycle Guide* where a motorist crosses a bicycle lane or a mid-block path. The bicycle lane case is expanded upon below, including near-side and far-side intersection scenarios.


1) Bicycle Case C1 - Near-Side Crossing: This case applies when a motorist crosses a near-side separated bicycle lane before continuing straight or turning at an intersection. The two potential design scenarios are as follows:


- **Two-Stage Crossing:** In this scenario, the motorist will first assess the bicycle conflicts, then move forward and assess motor vehicle conflicts (i.e., designers should perform two calculations from two different locations) as shown in Figure 12B-3.10. Similar to when a motorist moves forward after assessing pedestrian conflicts, when the motorist moves forward, they might block the bikeway to look for gaps in traffic. The equation in Table 12B-3.08 should be used to calculate the departure sight triangle between a passenger vehicle and the bikeway using a time gap (t_g) of 5.5 seconds for the motorist to clear the bikeway. This time gap uses an assumption that the vertex (decision point) of the departure sight triangle is 10 feet from the edge of bikeway and the bikeway width is no wider than 14 feet. The appropriate sight distance from AASHTO Green Book Case B should then be used to calculate departure sight triangle between the motorist and the intersecting motorist travel lanes.

Figure 12B-3.10: Bicycle Case C1 - Two-Stage Crossing Scenario



legend

 bike case C1 sight triangles

 AASHTO Green Book Case B sight triangles

Use the following equation to determine the Bicycle Case C intersection sight distance.

$$ISD_{bike} = 1.47V_{bike}t_g \tag{Equation 12B-3.01}$$

where:

ISD_{bike} = Intersection sight distance (length of the leg of sight triangle along the bikeway) (ft)

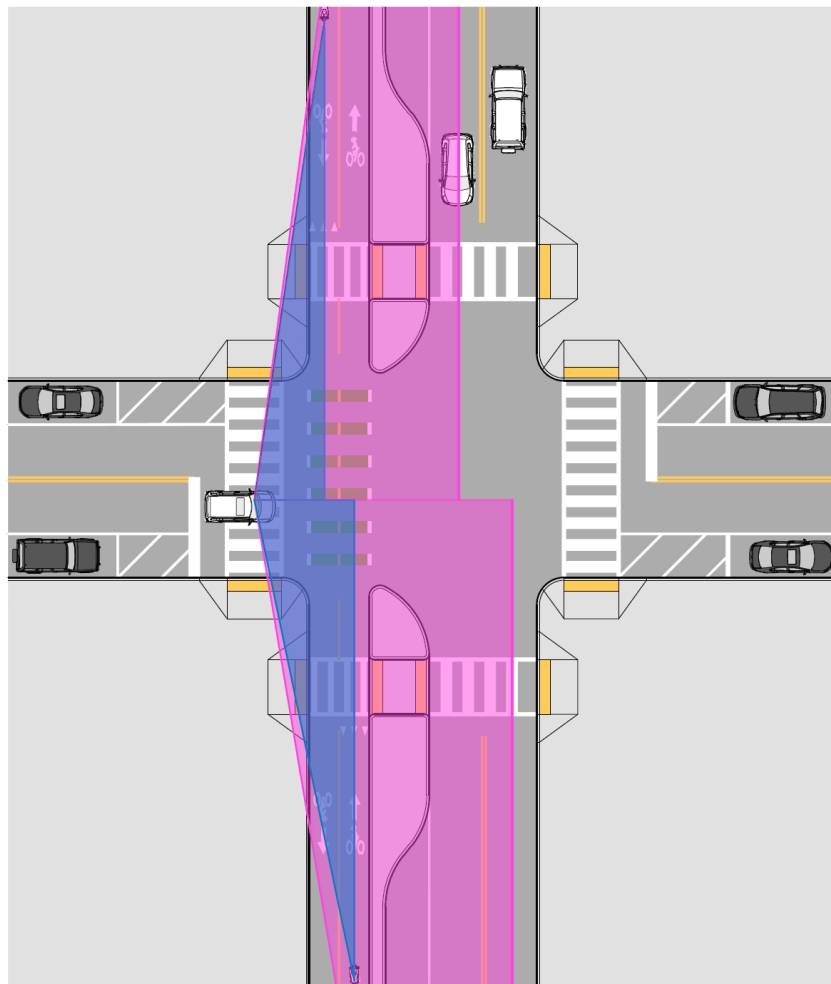
V_{bike} = Design speed of bikeway (mph)

t_g = Time gap for passenger vehicle to cross bikeway(s)


Source: AASHTO Green Book


- Single Crossing:** In this scenario, the motorist assesses both the bikeway conflicts and motor vehicle conflicts from one stopped location, then performs the turning movement when there is a sufficient gap in both the bikeway and motor vehicle traffic (Figure 12B-3.11). This scenario may be appropriate in locations where the motorist would otherwise block the bicycle facility for extended periods of time or where bicycle volumes or motorist volumes are anticipated to be high. The equation in Table 12B-3.08 should be used to calculate the departure sight triangle between a passenger vehicle and the bikeway using a time gap (t_g) of 4 seconds for the motorist to clear the bikeway. This time gap uses an assumption that the vertex (decision point) of the departure sight triangle is 10 feet from the edge of bikeway and the bikeway width is no wider than 14 feet. The vertex of the departure triangle between the motorist and the intersecting motorist travel lanes will remain the same, but designers will need to adjust the typical time gap for the appropriate sight distance from AASHTO Green Book Case B to account for the longer distance the motorist will traverse. As shown in Figure 12B-3.11, the provision of the motorist intersection sight distance will often accommodate the sight distance along the bikeway.

Figure 12B-3.11: Case C1 - Single-Stage Crossing Scenario



legend

 bike case C1 sight triangles

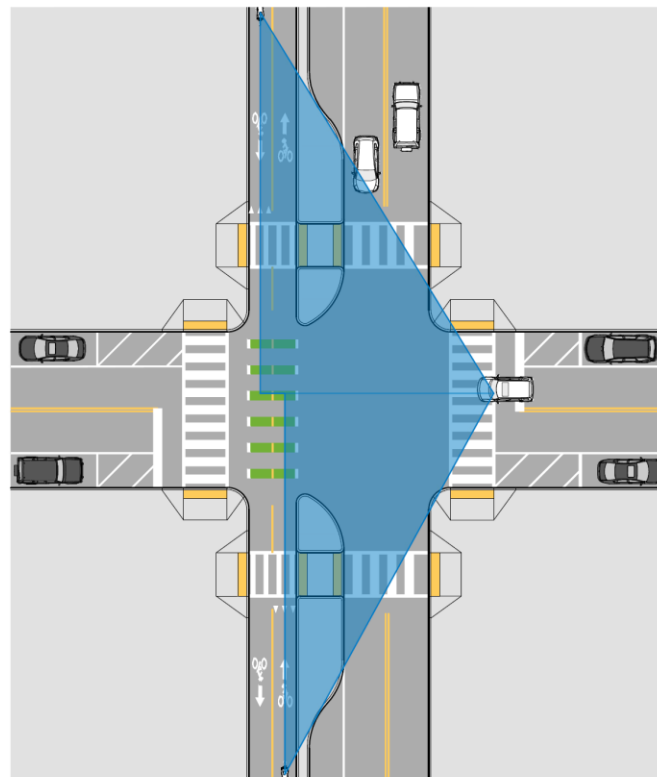
 AASHTO Green Book Case B sight triangles

- 2) **Bicycle Case C2 - Far Side Crossing:** This case applies when a motorist crosses a far side separated bicycle lane, see Figure 12B-3.12. Where both the motorist and bikeway approaches are stop-controlled, providing a line of sight between the stopped motorist and the stopped bikeway user is appropriate.

Where the motorist approach is stop-controlled and the bikeway crossing is uncontrolled, the intersection sight distance described in AASHTO Green Book Case B3 should be used to calculate departure sight triangle between the motorist and the intersecting bikeway. The bikeway design speed should be used in the intersection sight distance triangle calculation. The bikeway width and street buffer width should be converted to equivalent lane widths to adjust the time gap (t_g) for the crossing of the roadway and the bikeway. In constrained situations, at a minimum, the stopping sight distance for bicyclists should be provided to allow a bicyclist to slow or stop if a vehicle encroaches into the bikeway.

As with Bicycle Case B, this case creates a challenging dynamic that is often difficult to resolve by increasing the size of the sight triangle. In urban areas, it may be difficult to increase the sight triangle enough to provide the intersection sight distance to judge gaps that allow a motorist to cross all the travel lanes as well as the separated bicycle lane on the opposite side of the road. As such, designers should consider the frequency of through movements at these types of intersections and provide either traffic control devices or adequate sight distance (i.e. minimum stopping sight distance) for bicyclists to see and react to a crossing vehicle and stop if necessary. It may be appropriate to restrict these through motorist movements where traffic control devices or sight distances are inadequate.

Figure 12B-3.12: Bicycle Case C2 - Single-Stage Crossing Scenario



legend

 sight triangles

10. Curbside Management, Accessible Parking, and Loading Zones: At locations where vehicles frequently stop or stand in the bicycle lane, in addition to the signing strategies noted above, it may be beneficial to implement curbside management strategies to result in increased parking and loading space availability during peak periods and to address various curbside uses. Where on-street parking is present, loading zones may be delineated within the parking lane, and the bicycle lane may be preserved alongside them. See the ITE *Curbside Management Practitioners Guide* for more information.

Accessible parking and loading spaces require additional space adjacent to parking stalls for vans with ramps to allow passenger boarding and alighting, and to ensure an accessible route is provided to and from the sidewalk. This can present a unique challenge when separated bicycle lanes are present between the on-street parking and sidewalk. In constrained locations where accessible parking is provided, the protected bicycle lane may be narrowed to a minimum constrained width adjacent to the parking. It is preferable to use a raised crossing such that the separated bicycle lane is an intermediate or sidewalk level thus reducing the risk of pedal strikes. In addition, this may slow bicyclists down and reinforce that pedestrians will be crossing at this location. At locations without on-street parking but where an accessible parking or loading area is desired, a lateral deflection (bend-out) of the separated bicycle lane will often be required to accommodate the accessible space. Bicycle lane deflection should occur gradually but should not exceed the shifting taper guidelines to maintain bicyclist safety and comfort

F. Intersection Design

Due to the vulnerability of bicyclists as well as the low visibility the bicyclists have in relationship to the motorists, good intersection bicycle lane design and intersection pavement marking design is crucial to the success of an intersection that incorporates bicycle lanes. As a bicycle lane approaches an intersection, designers should provide a continuous and direct route through the intersection, driveway, or alley that is legible to all users of the roadway. Designers should minimize or eliminate conflict areas between bicyclists and motor vehicles, where possible. To minimize the potential for conflicts, designers should adhere to the following design principles:

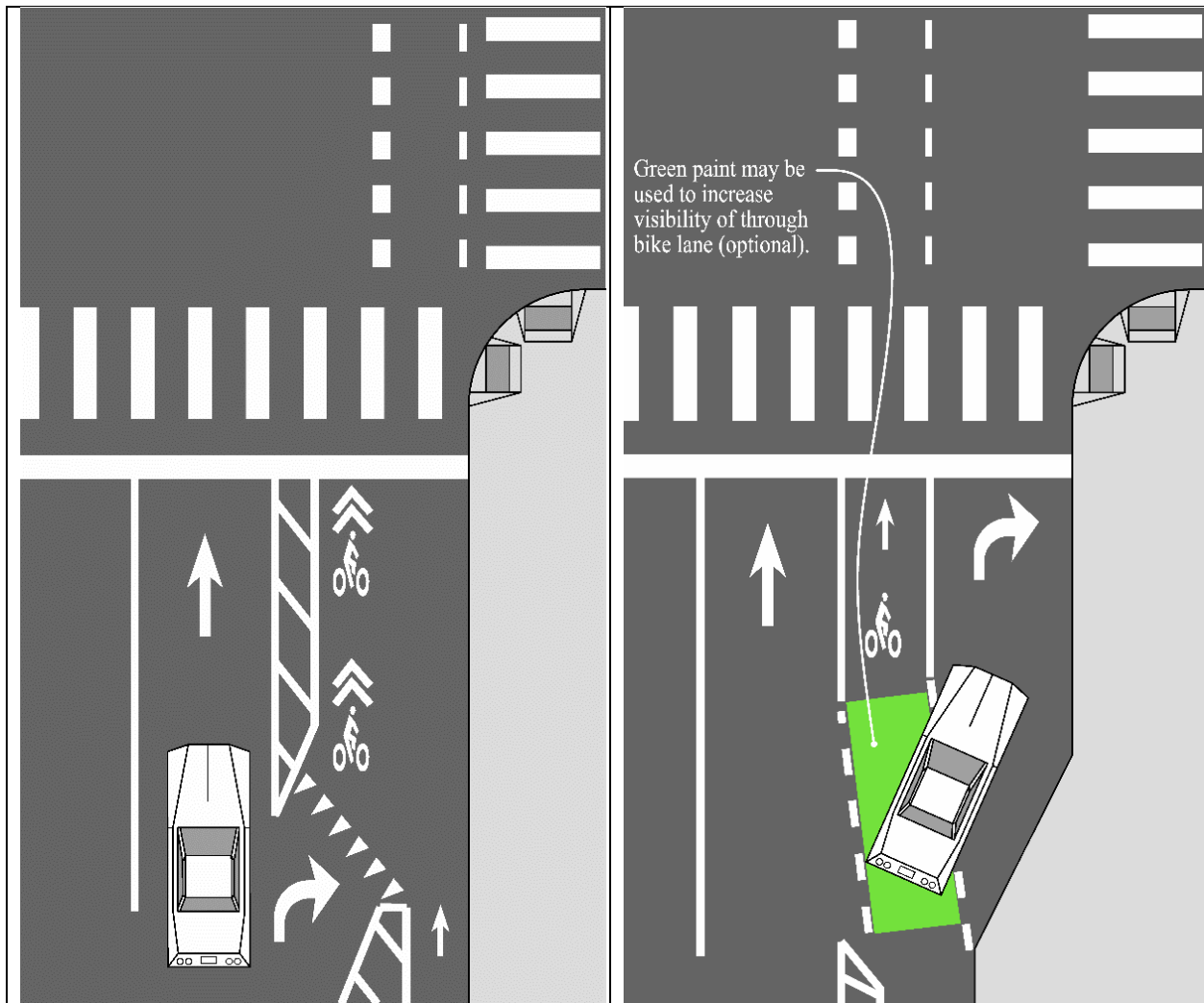
- Designers should communicate where motorists are expected to yield to bicyclists (e.g., markings and signage).
- Bicycles should not operate between turning lanes and moving lanes with traffic operating over 30 mph on either side of them for distances longer than 200 feet.
- Bicycle crossings of weaving or merging movements by motor vehicles operating over 20 mph should be avoided or minimized to a length of 200 feet or less.
- It is preferable for motorists merging and crossing movements across bicycle lanes be confined to a location where motor vehicles are likely to be traveling at speeds less than 20 mph.
- It is preferable for bicycle crossings of intersections to be marked.

A conventional or buffered bicycle lane can be transitioned to a protected bicycle lane and follow the design of a protected intersection to increase the comfort of the bikeway at the intersection. Designers should consider this design as operating speeds reach 35 mph or higher. When a protected intersection is not feasible for operating speeds of 35 mph or greater or motor vehicle turning volumes exceed 150 turning vehicles per hour, a bicycle ramp should be considered to give bicyclists a choice to exit the roadway to a shared use path or sidewalk prior to the intersection, see Section 12B-3, Q for bicycle ramp design parameters.

Where conflicts occur, intersection treatments like bicycle boxes, protected intersections, and bicycle signals can improve the safety, visibility, and/or comfort of bicyclists. Where conflict areas are present, pavement markings and signage should be used as speeds and volumes increase to improve legibility and safety. Bicycle crossing or lane extension lines, two stage turn boxes, and bicycle boxes may include an optional green pavement paint. If used, the green pavement paint must meet the MUTCD “Interim Approval for Optional Use of Green Colored Pavement for Bicycle Lanes (IA-14).” Because drivers and bicyclists in Iowa may not be familiar with the use of bicycle boxes and bicycle signals, it is critical to provide extensive educational information prior to implementing either of these strategies at urban intersections.

- 1. Shared Through/Right Motor Vehicle Lane:** When bicycle lanes are present on two-lane roadways, bicycle lane lines may be solid or dotted on the approach to and within intersections where motor vehicles are allowed to enter a bicycle lane to prepare for a turning, crossing, or merging maneuver. A solid line may be appropriate where turning volumes are low. At intersection approaches with limited space where a right-turn lane is not required but there are relatively high right-turn volumes (more than 150 vehicles during the peak hour) or an existing crash history, designers should consider converting the conventional bicycle lane to a separated bicycle lane by adding a 2 foot minimum buffer with flexible delineator posts beginning at least 50 feet in advance of the intersection to provide added comfort for bicyclists, slow the speed of turning motorist, and reduce the conflict area. Signal phase separation of bicyclists and motorists should be considered, but if concurrent movements are allowed, a bicycle box or forward bicyclist queuing area should be considered.
- 2. Right Turn Only Lanes:** Where right turn lanes are introduced and conventional or buffered bicycle lanes are present, the through bicycle lane should be shifted to the left of the right turn lane and markings and signage should clearly indicate conflict areas. Merging areas should be minimized and should not exceed 200 feet to limit the conflict area. Depending on how a turn lane is introduced (e.g., in the parking lane, intersection widening, etc.), designers should refer to Section 12B-3, A, for the design of the lateral shift of the bicycle lane to a position to the left of the right turn lane; see Figure 12B-3.13. See Section 12B-3, F, 4 for conflict marking recommendations. Dual right turn only lanes should be avoided on streets with bicycles. If dual right turn lanes are necessary to accommodate heavy right-turn volumes, a designer should transition the bicycle lane to a separated bicycle lane or shared use path in advance of the intersection. The high right turn volumes will require the provision of a separate bicycle crossing phase; see Section 12B-3, L.
- 3. Bicycle Ramps and Mixing Zones:** On roadways with operating speeds over 35 mph, or at locations where right turn lanes exceed 200 feet in length, designers should consider providing a bicycle ramp to allow bicyclists to exit the roadway to an off-street bikeway or sidewalk prior to the merge area; see Section 12B-3, Q for the design of bicycle ramps. On lower speed roadways where there is insufficient width to maintain a bicycle lane through the intersection, a mixing zone may be appropriate. A mixing zone is an area at an intersection where the bicycle lane becomes a shared lane with the turning vehicles; see Figure 12B-3.13. For separated bicycle lanes, the vertical element should be discontinued prior to the location motorists are expected to merge into the shared bicycle and right turn only lane. Merging area and turn lane length should both be minimized (each to a maximum of 200 feet) to limit the conflict area. Sharrow markings are used to guide the bicyclists from the bicycle lane through the intersection.



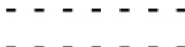
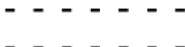









Figure 12B-3.13: Mixing Zones and Through Bicycle Lane



Source: Adapted from *Urban Bikeway Design Guide*, NACTO

- 4. Intersection Pavement Markings:** Intersection pavement markings are used to highlight conflict areas and aid bicyclist navigation. Figure 12B-3.14 summarizes the preferred pavement markings based on the intersection and bikeway type.

Figure 12B-3.14: Bicycle Crossings and Intersection Marking Selection Guidelines

Intersection Type	Condition	Separated Bicycle Lane	Conventional/ Buffered Bike Lane	Bicycle Boulevard
Signalized	Turn Conflict			No Markings
	No Turn Conflict			No Markings
	Bikeway Corridor Turns Left			
Unsignalized	High Turning Volume			No Markings*
	All other conditions			No Markings
	Bikeway Corridor Turns Left			No Markings

*Additional treatment may be needed

Source: Adapted from Ohio DOT *Multimodal Design Guide*

- a. **Bicycle crossing Markings / Lane Extension Lines:** Where a bikeway crosses an intersection separate from a crosswalk, bikeway lane markings may be extended through the intersection to delineate the bicycle crossing and raise awareness of the presence of bicyclists. Bicycle lane crossings are desirable to:
- Delineate a preferred path for people bicycling through the intersection, especially crossings of wide or complex intersections;
 - Improve the legibility of the bicycle crossing to roadway users; and
 - Encourage motorist yielding behavior, where motorists must merge or turn across the path of a bicyclist.

Bicycle crossings may also be supplemented with green colored pavement. If used, the green colored pavement should align with the dotted extension line pattern of the dotted edge lines.

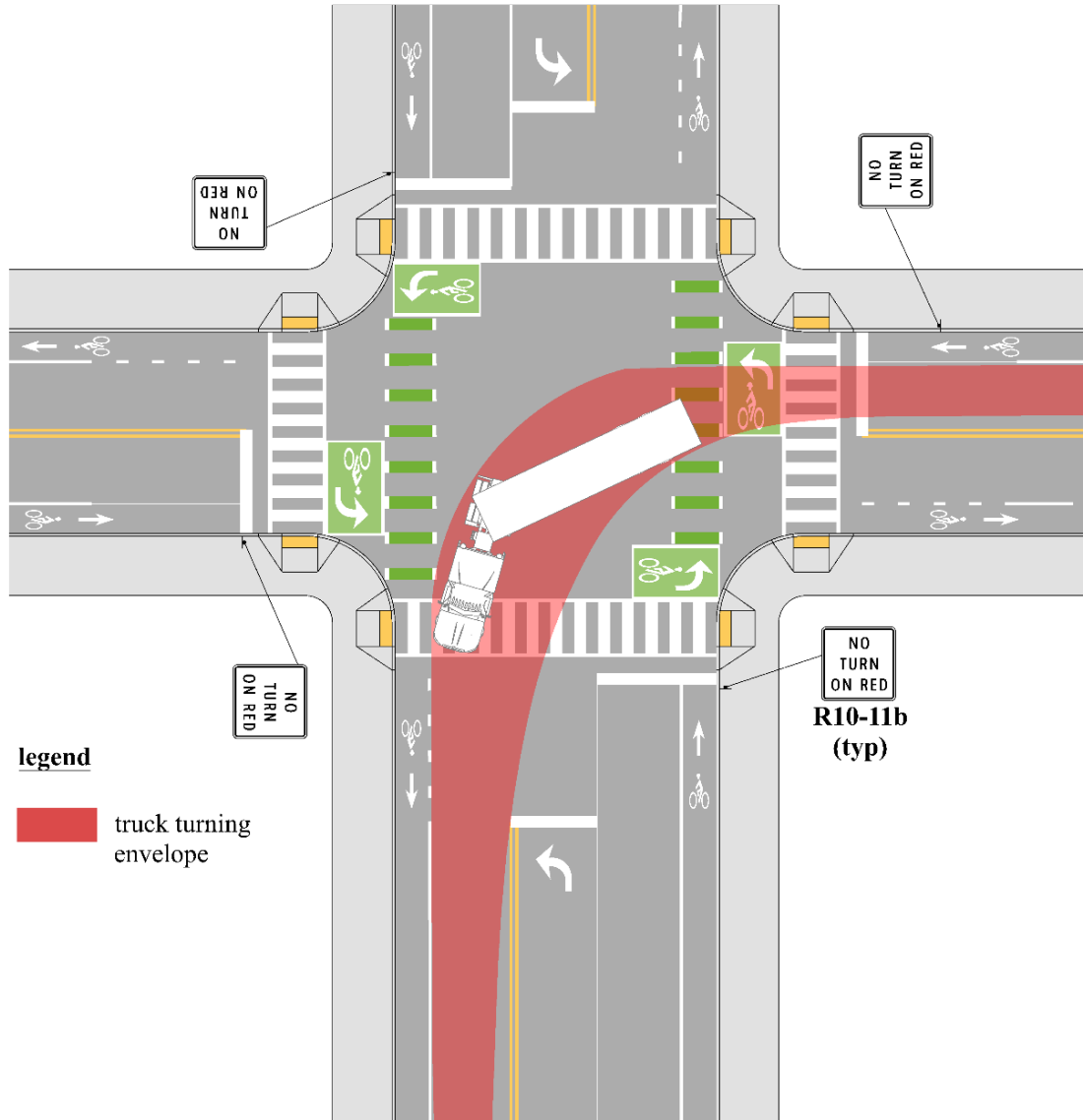
- b. **Two-Stage Turn Boxes:** Weaving across travel lanes and merging with motor vehicle traffic to reach the left side (or right side when the bicycle lane is located on the left-hand side of a one-way street) of the street is challenging for most bicyclists. Where there are high volumes of left-turning bicyclists, or where a designated or preferred bicycle route requires a left turn, a provision for left-turning bicyclists should be provided. This can generally be accomplished by providing a two-stage turn box, which has interim approval in the MUTCD (IA-20).

With the two-stage bicycle turn box, bicyclists traverse the intersection within the bicycle lane, stop within the turn box, reorient themselves to the cross street, and wait for the green signal for the cross street to proceed, eliminating the need to merge across travel lanes, see Figure 12B-3.15. It may be used for left or right turns (e.g., where a bicycle lane is placed on

the left side of a one-way street). It may be used at any signalized intersection but is preferable on high volume and multilane roads.

A two-stage bicycle turn box must be located outside of the path of through and turning traffic; should be located adjacent to, preferable to the right of, the direct path of bicyclist travel; and should be located downstream of the crosswalk and downstream of the stop line. It must include a bicycle symbol and a turn arrow to clearly indicate proper direction and positioning.

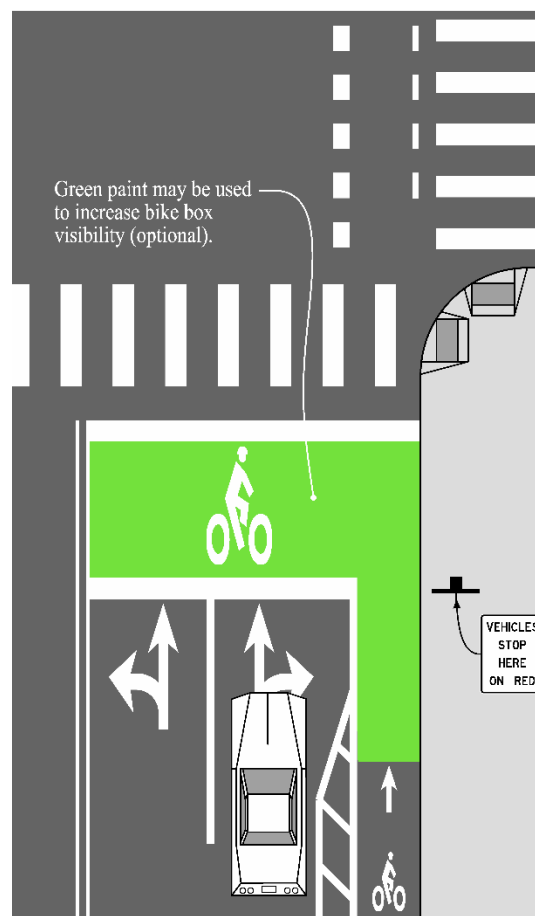
Figure 12B-3.15: Two-Stage Bicycle Turn Box Placement



- c. **Bicycle Box:** Bicycle boxes, which have interim approval in the MUTCD (IA-18), are placed between the vehicle stop line and the pedestrian crosswalk; see Figure 12B-3.16. Bicycle boxes increase the visibility of bicyclists to motorists, provide an advance queuing area to store larger numbers of bicyclists, and reduce bicyclist encroachment into crosswalks during the red signal phase. Bicycle boxes are limited to signalized intersections. Bicycle boxes are typically formed by two transverse lines, typically 10 to 16 feet deep and the combined width of the bicycle lane, the buffer space, and all of the adjacent same direction traffic lanes at the intersection.

In limited situations, bicycle boxes may be used to facilitate left turns for bicyclists when there is unusually heavy left turn volume of bicyclist, such as near the entrance to a popular shared use path. Research shows the use of bicycle boxes to make left turns is limited in practice; the preferred treatment is the two-stage bicycle turn box.

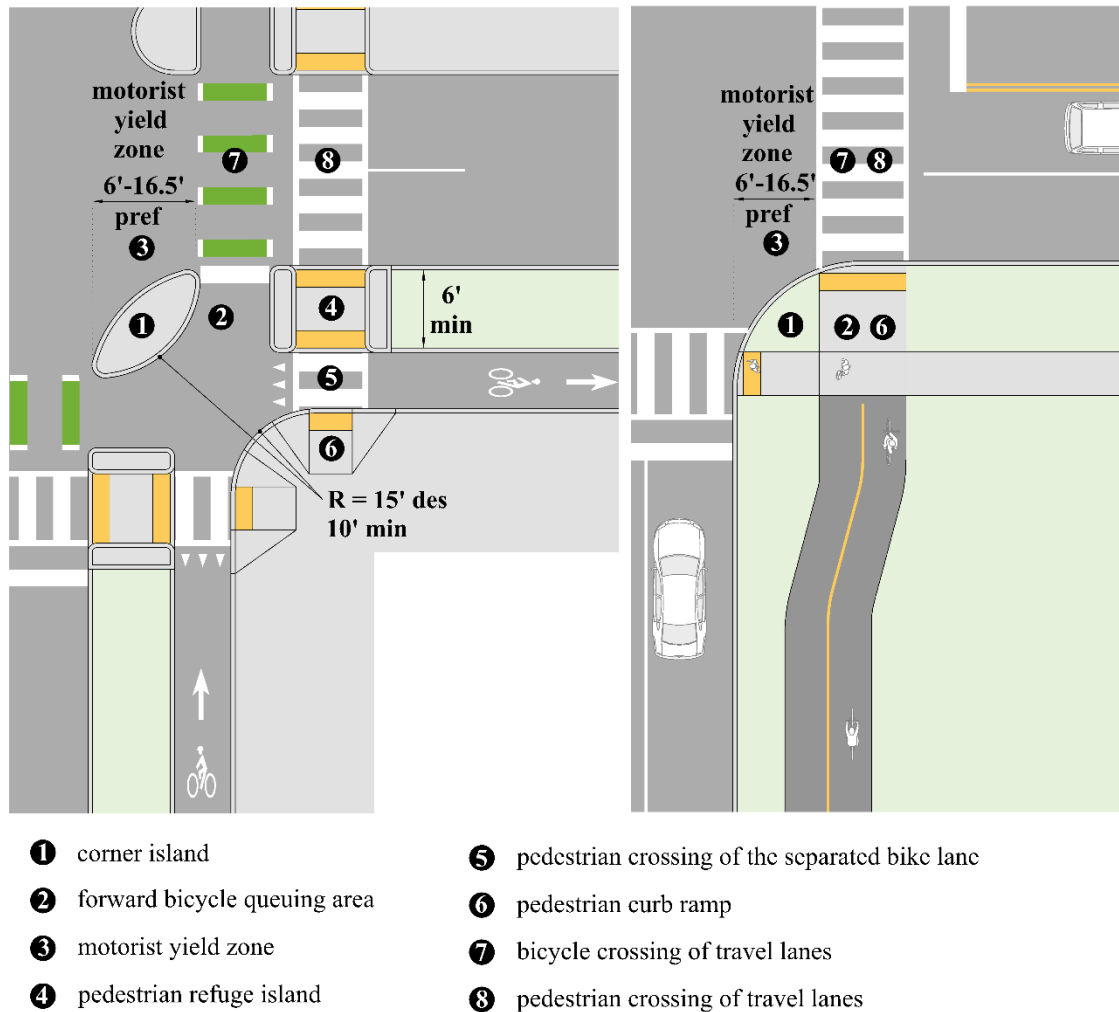
Figure 12B-3.16: Bicycle Box



Source: Adapted from *Urban Bikeway Design Guide*, NACTO

5. **Protected Intersections:** A major goal in providing separated bicycle lanes is to minimize conflicts between bicyclists, pedestrians, and motorists at intersections. For this reason, it is preferable to maintain separation between the separated bicycle lane and the adjacent motor vehicle travel lanes at intersections. Protected intersections provide a design that maintains separation between modes and can work for intersections of separated bicycle lanes and Type 1 shared use paths. The following discussion focuses on design guidance for the geometric elements of a protected intersection for separated bicycle lanes and shared use paths (See Figure 12B-3.17).

Figure 12B-3.17: Protected Intersection Design for Separated Bicycle Lanes and Shared Use Paths



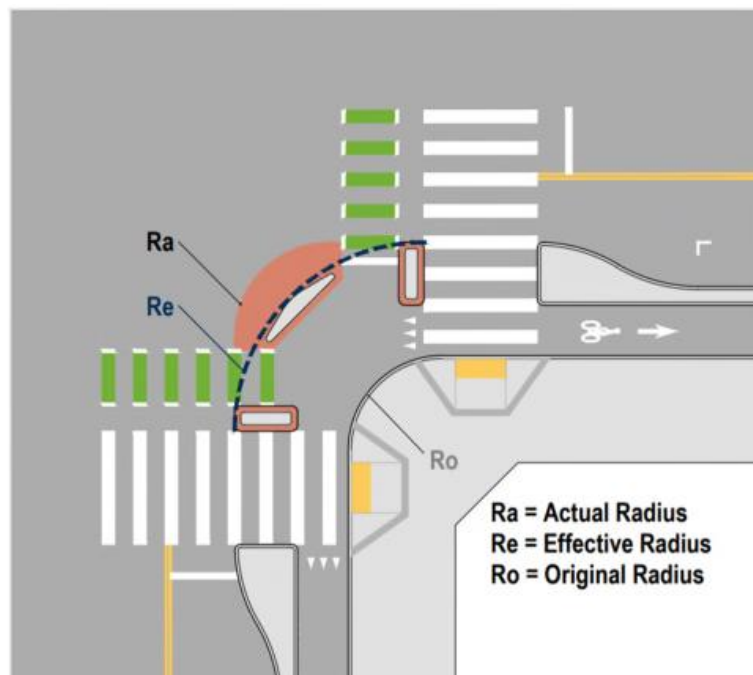
Source: Adapted from MassDOT *Separated Bike Lane Planning & Design Guide*

- a. **Corner Island:** The corner island (labeled as 1 in Figure 12B-3.17) allows the bicycle lane or shared use path to be physically separated up to the intersection crossing point where potential conflicts with turning motorists can be controlled more easily. It also creates space for a forward bicycle queuing area, creates additional space for vehicles to wait while yielding to bicyclists and pedestrians who are crossing the road, reduces motorist turning speeds; and can reduce through bicyclist speeds by adding deflection to the bicycle lane or shared use path.

Corner islands may be constructed of concrete and curbing, or may be constructed with low cost materials, such as paint and flexible delineator posts or engineered rubber curbs and/or rubber speed cushion. If a corner island is constructed of mountable materials, such as rubber speed cushions, designers should understand the forward queuing area for bicyclists and pedestrian crossing islands may no longer be protected from turning motorists and should therefore be removed. Where flex posts or other vertical elements are used, they should be placed at least 1 foot offset from the turning radius of design vehicles at all intersections and driveways.

- b. Truck Apron:** A truck apron is a design strategy used to accommodate the turning needs of large vehicles while slowing the turning speeds of smaller vehicles by reducing the actual radius. A truck apron is designed to be mountable by larger vehicles to accommodate their larger effective turning radius needs. The mountable surface encourages the design vehicle, typically a passenger (P) or delivery vehicle (SU-30), to turn without using the apron and reduces their effective turning radius and speed.

Figure 12B-3.18: Actual vs Effective Radius



Source: City of Des Moines' Bike Guide

Truck aprons can be installed with corner reconstruction or in a retrofit condition. They can be constructed with a gap between the mountable curb and the curb face to facilitate surface drainage, if necessary.

For constructability and visibility, truck aprons have a minimum size requirement to be effective. Where the distance between the effective radius and the actual radius is less than 5 feet, truck aprons are not feasible. A smaller distance will become difficult to visually differentiate from the surrounding surfaces and may be more difficult to construct.

Truck aprons that are too large may similarly not be effective at communicating the use of the space, which may be confusing to motorists and people trying to navigate the intersection. Where the distance between the effective radius and the actual radius is greater than 15 feet,

truck aprons are not recommended. This situation can be found in intersections where full reconstruction of the intersection should be considered.

Designers should consider the following guidance when implementing a truck apron:

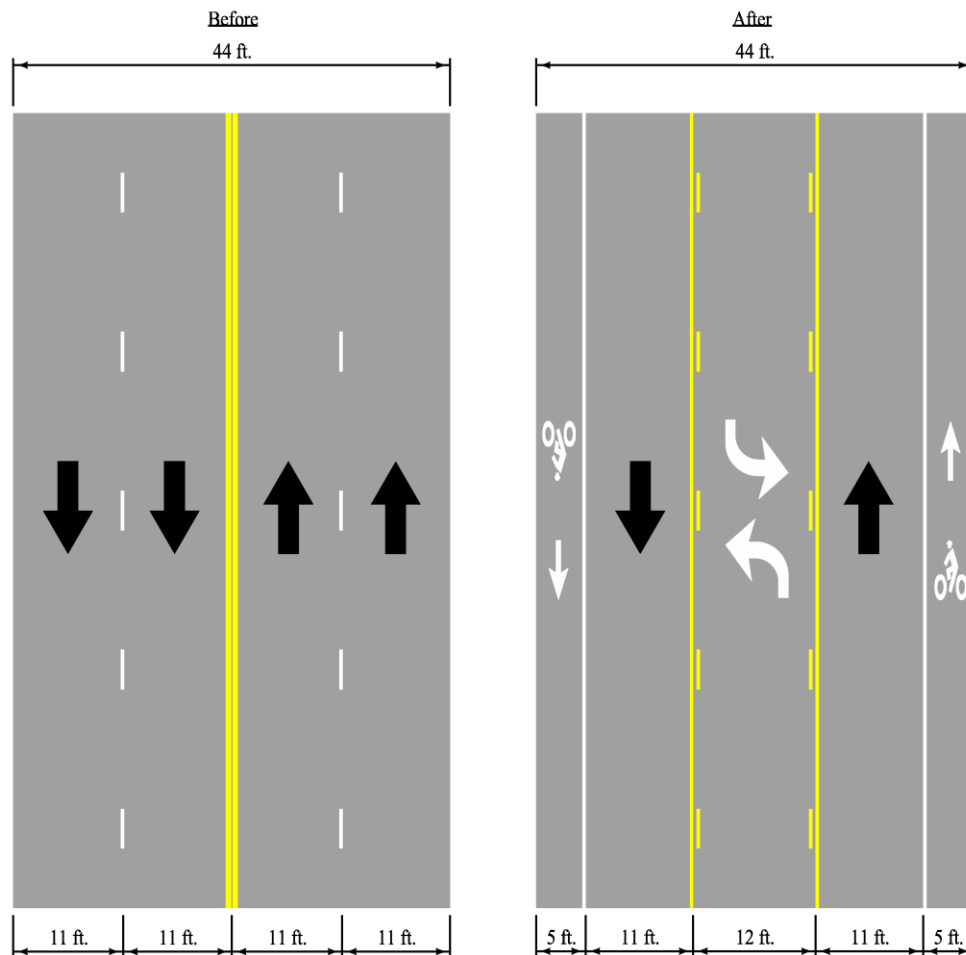
- The pavement color and texture within the truck apron should be distinct from the adjacent roadway and sidewalk.
 - Reflective raised pavement markers should be used at the actual radius to ensure the path of travel is visible at night. Retroreflective lane edge line striping should also be provided.
 - Channelizing pavement markings may be installed on the mountable truck apron to discourage use of the space by smaller vehicles.
 - A truck apron should have a mountable section between 2 and 3 inches high when the control vehicle represents less than 5% of the total turns at an intersection.
 - When the control vehicle represents more than 5% of the total turns at an intersection, or where both cross streets are served by frequent transit, a truck apron with a 1 to 2 inch height mountable section may be used.
- c. Forward Bicycle Queuing Area:** The forward bicycle queuing area is a waiting area for stopped bicyclists (labeled as 2 in Figure 12B-3.17). The area is fully within view of motorists who are waiting at the stop bar (if present), which improves bicyclist visibility. Ideally, the bicycle queuing area should be at least 6 feet long to accommodate a typical bicycle length.
- d. Motorist Yield Zone:** The motorist yield zone is a bicycle and pedestrian crossings set back from the intersection to create space for turning motorists to yield to bicycles and pedestrians (labeled as 3 in Figure 12B-3.17). The offset improves motorist view of approaching bicycles by reducing the need for motorists to scan behind them and potentially creates space for a motorist to yield to bicyclists and pedestrians without blocking traffic.
- e. Pedestrian Refuge Median:** The pedestrian refuge median is a space where pedestrians may wait between the street and the separated bicycle lane (labeled as 4 in Figure 12B-3.17). It should be a minimum width of 6 feet and should include detectable warning surfaces. A pedestrian refuge median allows pedestrians to negotiate potential bicycle and motor vehicle conflicts separately, improves visibility of pedestrians to motorists approaching the intersection, shortens the pedestrian crossing distance, and reduces the likelihood of pedestrians blocking the bicycle lane.
- f. Pedestrian Crossing of the Separated Bicycle Lane:** Where pedestrians are expected to cross separated bicycle lanes, crosswalks (labeled as 5 in Figure 12B-3.17) indicate a preferred crossing location and communicate a clear message to bicyclists that pedestrians have the right-of-way. Yield lines and YIELD HERE FOR PEDESTRIANS signs in the bicycle lane in advance of the crosswalk may be used to emphasize pedestrian priority.
- g. Pedestrian Curb Ramp:** Curb ramps and detectable warning surfaces (labeled as 6 in Figure 12B-3.17) should meet pedestrian accessibility guidelines. It is preferable to use the curb ramp style that will shorten crossing distances and provide directional cues to pedestrians.
- h. Bicycle Crossing of Travel Lanes:** For separated bicycle lanes, bicyclists cross the motorist travel lane between the motorist yield zone and pedestrian crossing. For shared use paths, bicyclists cross with pedestrians in the pedestrian crossing (labeled as 7 in Figure 12B-3.17). Bicycle crossings for separated bicycle lanes are often striped using bicycle crossing markings and should be striped using crosswalks for shared use paths.

- i. **Pedestrian Crossing of Travel Lanes:** Pedestrians cross the motorist travel lane behind the motorists yield zone and behind bicycle crossings when present (labeled as 8 in Figure 12B-3.17).
6. **Traffic Signals and Bicycle Signals:** Special signal timings and bicycle signal heads may be used at intersections to separate bicycle through movements from vehicle movements for increased safety. More detailed guidance on traffic signals for bicycle facilities is found in Section 12B-3, L.

G. Retrofitting Bicycle Facilities on Existing Roadways

Existing streets and highways may be retrofitted to improve bicycle accommodations by either reconfiguring the travel lanes to accommodate bicycle lanes or by widening the roadway to accommodate bicycle lanes or paved shoulders. These retrofits are best accomplished as either a reconstruction project or a repaving project as these projects will eliminate traces of old pavement markings. (AASHTO *Bicycle Guide* 4.9).

Figure 12B-3.19: Example of Road Diet



* Dimensions are illustrative

Source: Adapted from AASHTO *Bicycle Guide* Exhibit 4.23

H. Bicycle Boulevards

A bicycle boulevard is described as a local street or a series of contiguous street segments that have been modified to function as a through street for bicyclists while discouraging through vehicle traffic. To be effective, bicycle boulevards should be long enough to provide continuity over a distance of between 2 and 5 miles. [Section 12B-1](#) provides additional guidance on when bicycle boulevards are an appropriate bicycle facility.

Due to the low traffic volumes and speeds, local streets naturally create a bicycle-friendly environment for bicyclists to share the roadway with vehicles. However, many local streets are not continuous enough for long bicycle routes. Therefore, in order to create a bicycle boulevard, some short sections of paths or segments may need to be constructed between local streets in order to create the continuous route. The following three principles should guide bicycle boulevard planning and design:

- 1. Manage Motorized Traffic Volumes and Speeds:** To minimize conflicts and the frequency of motorists passing bicyclists, bicycle boulevards should meet the guidelines of Table 12B-3.09 for daily and hourly motor vehicle volumes and operating speeds:

Table 12B-3.09: Bicycle Boulevard Motorized Traffic Volume and Speed Performance Criteria

	Peak Hourly Traffic Volume (vehicles/hour) ¹	Average Daily Traffic Volume (ADT)	Operating Speed
Preferred	150	1,000	15
Acceptable	300	2,000	20
Maximum	450	3,000	25

¹ Assumed to be 15% of ADT

Source: Based on NACTO Urban Bikeway Design Guide

The design of the street should result in the preferred motorist volumes and operating speeds being achieved at all times of the day. Where daily or peak hourly traffic volumes or traffic speeds exceed the maximum guidelines, traffic calming or traffic diversion strategies should be considered. Traffic diverters are treatments that allow bicycle through traffic but reduce or deny vehicle traffic.

- 2. Prioritize Right-of-way at Local Street Crossings:** Along bicycle boulevards, most of the intersections a bicyclist will cross will be local streets crossing other local streets. For bicycle boulevards to serve as efficient routes for longer distance travel, they should minimize the need for bicyclists to stop at crossings of local streets. Consider the following elements:
 - Two-way stop-controlled intersection that give the bicycle boulevard priority
 - Neighborhood traffic circles or mini roundabouts
- 3. Provide Safe and Convenient Crossings at Major Streets:** Major street crossings along bicycle boulevards can be significant barriers. Treatments such as median refuge islands, beacons, and signals should be installed to accommodate bicyclists crossing.

I. Bicycle Guide Signs

Guide signs are an important element to all bicycle facilities because they help bicyclists navigate to their destination. There are many guidelines and standards that go along with the type and placement of guide signs. See both the MUTCD and *AASHTO Bicycle Guide* 4.11.

J. Railroad Crossings for Bicycles

Where roadways or shared use paths cross railroad tracks on a diagonal, the designer should take care in the design of the crossing as to prevent steering difficulties for the bicyclists. This includes:

- Increasing the skew angle between the tracks and the bicycle path to 60 degrees or greater so bicyclists can avoid catching their wheels in the flange of the tracks. This can be accomplished with reverse curves or with a widened shoulder.
- Creating a smooth crossing surface that will last over time and not be slippery when wet.
- Minimizing flange openings as much as possible. Under special rail conditions, rubber fillers products may be used. Contact the railroad company for approval prior to the design and installation of the fillers.

See both the MUTCD and *AASHTO Bicycle Guide* 4.12.1.

K. Obstruction Markings for Bicycle Lanes

The design of bicycle facilities should avoid obstruction and barriers as much as possible. However, in rare circumstance when an obstruction or barrier cannot be avoided, signs, reflectors, and markings should be used to alert they bicyclists. (*AASHTO Bicycle Guide* 4.12.2).

L. Traffic Signals for Bicycles

Traffic signals have traditionally been designed based off the operating characteristics of motor vehicles. At intersections where shared lanes, bicycle boulevards, or bicycle lanes are present, traffic signal designers should include the characteristics of bicyclists to their traffic signals. The signal parameters that should be evaluated are minimum green interval, total phase length, and extension time. This information can be found below in 12B-3, L, 2, in *AASHTO Bicycle Guide* 4.12.3 and 4.12.4, as well as the latest edition of the “Highway Capacity Manual.”

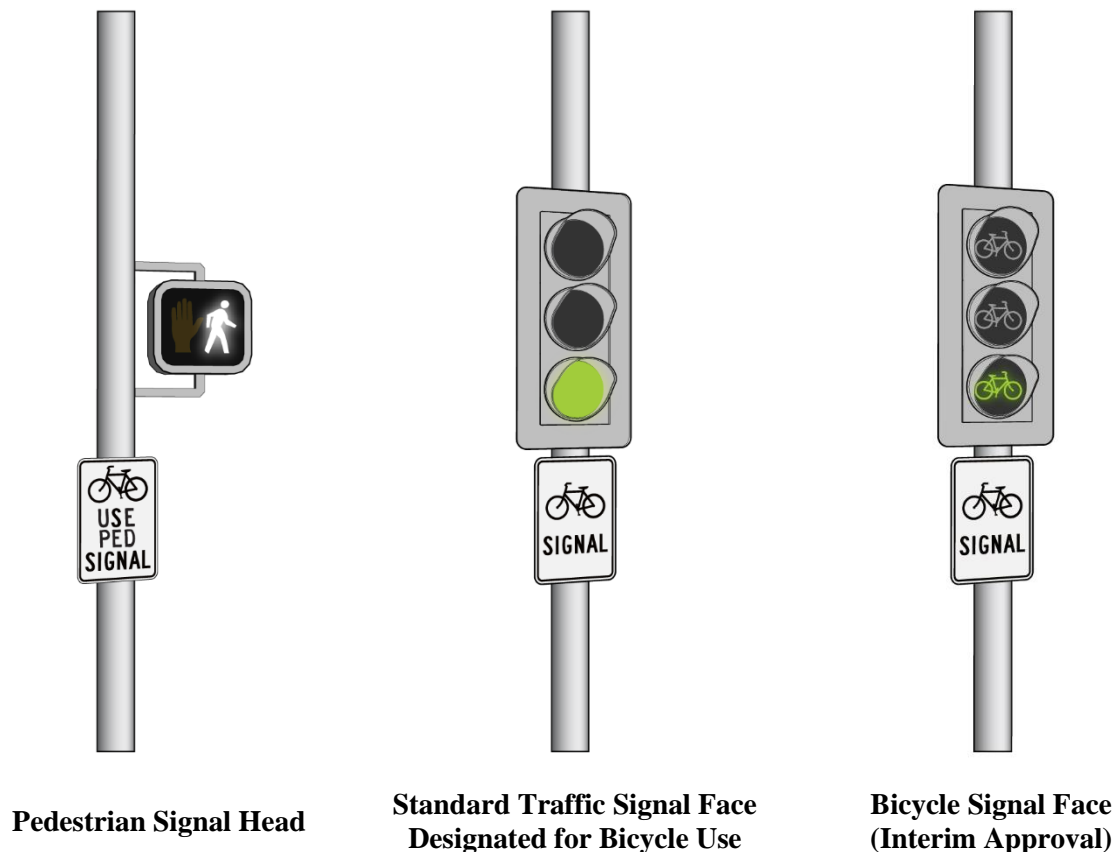
In addition, designers should ensure signals are actuated, the existing signal detection can reliably detect the presence of bicyclists in a shared lane, and detection is provided for bicycle lanes. Additional markings and signage should be considered as needed for bicyclists to position themselves within the detection zone in shared lanes; see MUTCD 9C.05.

1. Traffic Signal Indication Options for Bicycles. A bicyclist traveling in a shared lane is controlled by the vehicular signal head. Where it is necessary or desirable to control a bicycle operating in a separated bicycle lane independently from a motor vehicle, a bicyclist may be controlled by a pedestrian signal head, a traffic signal head designated for bicycle use, or a bicycle signal face. Each of these three options are shown in Figure 12B-3.20 and briefly discussed below. Along a corridor, it is recommended that traffic signal indications for bicyclists are consistent and as uniform as possible.

- **Pedestrian Signal Heads:** Some agencies direct bicyclists to follow pedestrian signal indications when bicyclists are operating in a separated bicycle lane in the roadway and bicyclists cannot see vehicle signal faces, or when bicyclists have a separate signal phase from motor vehicle movements. To do this, the BIKES USE PED SIGNAL sign (MUTCD R9-5) should be mounted adjacent to the pedestrian signal heads.

- **Standard Traffic Signal, Designated for Bicycle Use:** A standard traffic signal face may be designated exclusively for bicyclists by mounting a BICYCLE SIGNAL sign (MUTCD R10-10b) adjacent to the traffic signal. This may be beneficial where bicyclists cannot see existing vehicle signal faces, where they have a separate signal phase, or where it is desired to maximize the time a bicyclist may legally enter an intersection.
- **Bicycle Signal Heads (Interim Approval):** Bicycle signal heads use the traditional green, yellow, and red indications but have bicycle stenciled lenses. A supplemental “Bicycle Signal” plaque should be added below the bicycle signal head. Bicycle signal faces currently have interim approval for situations where there are no conflicting motor vehicle movements with the signalized bicycle movement.

Figure 12B-3.20: Examples of Signal Indication Options for Bicyclists



Source: Adapted from MassDOT *Separated Bike Lane Planning & Design Guide*

2. Traffic Signal Phasing and Timing for Bicyclists:

- a. **Signal Phasing:** Several signal phasing schemes can be used to reduce conflicts or reinforce bicyclists' and motorists' responsibility to yield:
 - A flashing yellow right turning arrow and flashing bicycle signal to reinforce yielding where the bicycle phase is concurrent with permissive motor vehicle turns.
 - A leading bicycle signal phase, which provides 3 to 5 seconds of green time before the corresponding vehicle green indication.
 - A concurrent protected bicycle phase, which runs concurrently with parallel through-vehicle phases, but conflicting vehicle turns across the bikeway are restricted.
 - An exclusive bicycle phase, in which all vehicle movements are restricted.

The decision to provide a protected phase or a leading bicycle interval for a separated lane or shared use path (see [Section 12B-2](#)) should be based on a need to eliminate or manage conflicts and improve safety at an intersection. The potential for conflict at a given intersection is evaluated using the volume of turning motor vehicles crossing the bikeway. Table 12B-3.10 provides peak hourly volume thresholds for turning motor vehicle traffic crossing a bikeway to determine when a protected phase or leading bicycle interval should be considered.

Table 12B-3.10: Hourly Turning Traffic Thresholds for Time-Separated Bicycle Movements

Facility Operation	Left Turn Crossing One Oncoming Lane	Left Turn Crossing Two Oncoming Lanes
One-Way Separated Bike Lane	<p>≥ 100</p> <p>≥ 150* </p>	<p>≥ 50</p> <p>≥ 150* </p>
Two-Way Separated Bike Lane or Shared Use Path	<p>≥ 50</p> <p>≥ 100* </p>	<p>ANY</p> <p>≥ 100* </p>

* Threshold also applies to left turns on one-way streets

Source: Adapted from MassDOT *Separated Bike Lane Planning and Design Guide*

- b. **Signal Timing:** Practitioners should consider the operating characteristics for bicyclists when calculating minimum green, yellow change, and red clearance interval design, which in most cases are determined by signal timing requirements for higher speed motor vehicles. A design speed of 8 mph and acceleration of 2.5 ft/s², which is the speed and acceleration of a slow moving adult bicyclist, is recommended.
 - **Bicycle Minimum Green:** In many cases, the existing vehicle minimum green will not be adequate for a bicyclist. Vehicle minimum green types, ranging between 4 and 15 seconds, are based primarily on driver expectancy and queue clearances. With a 4 second minimum green (not uncommon for a minor street approach), a typical adult bicyclist only has time to react and begin accelerating, traveling less than 10 feet. A minimum green time based on a bicyclist traveling halfway across the intersection will typically result in a phase length long enough for a bicyclist to fully clear the intersection before the conflicting approach receives the green indication. However, at some wider crossings, the minimum green time may need to be longer.

Table 12B-3.11: Bicycle Minimum Green Time

D (ft)	Minimum Green (s)	D (ft)	Minimum Green (s)
25	6.5	110	13.7
30	6.9	115	14.1
35	7.3	120	14.6
40	7.8	125	15
45	8.2	130	15.4
50	8.6	135	15.8
55	9.0	140	16.3
60	9.5	145	16.7
65	9.9	150	17.1
70	10.3	155	17.5
75	10.7	160	18.0
80	11.2	165	18.4
85	11.6	170	18.8
90	12.0	175	19.2
95	12.4	180	19.7
100	12.9	185	20.1
105	13.3	190	20.5

Source: Adapted from MnDOT *Bicycle Facility Design Manual*

$$G_{min} = t + \frac{1.47v}{2a} + \frac{d + L}{1.47v}$$

Equation 12B-3.02

where:

G_{min} = bicycle minimum green time, s

v = attained bicycle crossing speed, assumed 8 mph

t = perception reaction time, assumed 1.5 s

a = the bicycle acceleration, assumed 2.5 ft/s²

d = distance from stop bar to middle of the intersection, ft

L = typical length of a bicycle, assumed 6 ft

- Total Phase Length:** Depending upon intersection width, change, and clearance intervals, the total phase time may not be sufficient for a bicyclist to clear the far side of the intersection before the conflicting approach receives the green indication. After the minimum green time is calculated based on the following equation, it should be evaluated to verify that the total phase time is greater than the total time for a bicyclist starting from a stop to cross the intersection. The minimum green time should be increased until the total phase time is equal to or greater than the total time for a bicyclist to cross the intersection.

$$G_{min} + Y + R_{clear} \geq t + \frac{1.47v}{2a} + \frac{W + L}{1.47v} \quad \text{Equation 12B-3.03}$$

where:

G_{min} = bicycle minimum green time, s

Y = yellow change interval, s

R_{clear} = all red interval, s

W = intersection width, ft

L = typical length of a bicycle, assumed 6 ft

v = attained bicycle crossing speed, assumed 8 mph

t = perception reaction time, assumed 1.5 s

a = bicycle acceleration, assumed 2.5 ft/s²

M. Bridges and Viaducts for Bicycles

Two considerations should be considered before the design of bicycle accommodations with bridges - the length of the bridge and the design of the approach roadway. If the bridge approach does not include bicycle accommodations, the bridge can still facilitate use by bicyclists by including a wide shoulder or bicycle lanes and including paved shoulders, shared lanes, or a shared use path as part of the bridge project. Additionally, if the bridge is continuous and spans over a 1/2 mile in length with speed of excess of 45 mph, a concrete barrier separated shared use path on both sides of the bridge should be considered. By allowing paths on both sides of the bridge, wrong-way travel of the bicyclists will be deterred. (AASHTO *Bicycle Guide* 4.12.5).

N. Traffic Calming and Management of Bicycles

There are many things a designer can do to reduce the traffic speed of bicyclists and to manage bicycles effectively. These things include: narrowing streets to create a sense of enclosure; adding vertical deflections such as speed humps, speed tables, speed cushions, and raised sidewalks; adding curb extension or chokers; adding chicanes; installing traffic circles; and incorporating multi-way stops. (AASHTO *Bicycle Guide* 4.12.6 and 4.12.7).

O. Intake Grates and Manhole Castings for Bicycle Travel

Intake grate openings should run perpendicular to the direction of travel to prevent bicycle wheels from dropping into the gaps and causing crashes. [SUDAS Specifications Figure 6010.603](#), Type R and Type S, are intake grates appropriate for use on bicycle routes. Where it is not immediately feasible to replace existing grates, metal straps can be welded across slots perpendicular to the direction of travel at a maximum longitudinal spacing of 4 inches. Additionally, open-throat intakes can be used instead of grate intakes in order to completely eliminate the grate. The presence of the depressed throat of the intake should be considered.

Surface grates and manhole castings should be flush with the roadway surface. In the case of overlays, the grates and castings should be raised to within 1/4 inch of the new surface. If this is not possible or practical, the pavement must taper into drainage inlets so it does not have an abrupt edge at the inlet. Take care in the design of the taper of the pavement around inlets and castings to avoid “birdbaths” or low spots that are not drainable in the pavement. (AASHTO *Bicycle Guide* 4.12.8).

P. Bicycles at Interchanges

Any work on the design of interchanges, including facilitating bicycle travel, must be coordinated with Iowa DOT. This subsection is provided for informational purposes because freeways and limited access facilities pose major barriers to people bicycling. The challenges posed by bicyclists crossing interchanges include:

- **Multiple Crossings:** Interchanges often require bicyclists to cross several ramps and intersections in stages. This can result in complex movements and delays.
- **Free-flow Movements:** Where ramps are free-flowing, it can be difficult and unsafe for bicyclists to find safe gaps to cross in a motor vehicle traffic stream that is high volume, high speed, or both.
- **Long Crossings and Skewed Crossings:** On and off-ramps often require bicyclists to cross a channelized traffic lane of motor vehicles traveling at high speeds at skewed angles. In urban areas, off ramps may have several lanes of traffic to store motor vehicles exiting the freeway and turning at signalized intersections. The more lanes of traffic, the longer the crossing distance for bicycles.

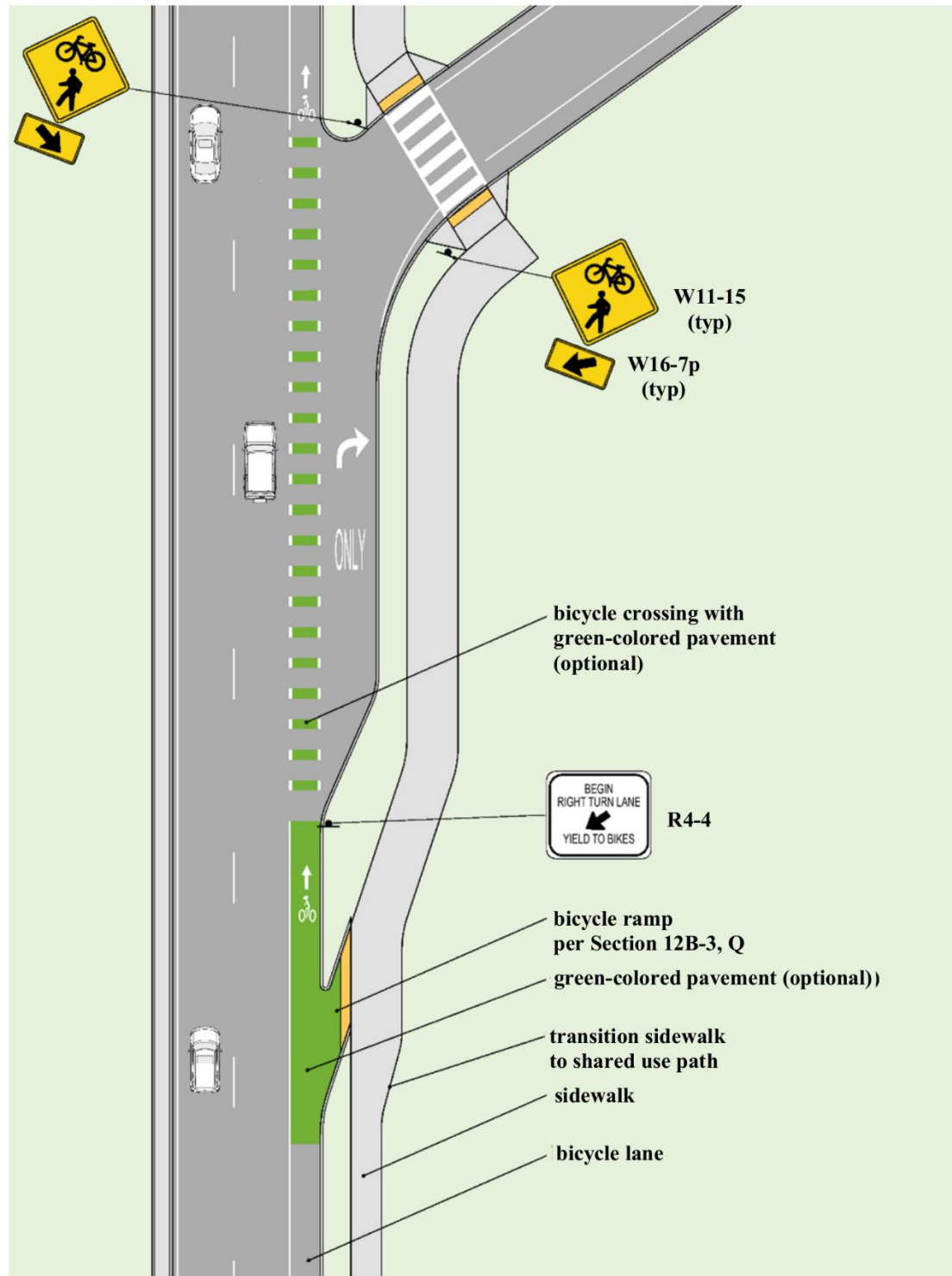
To be in compliance with Iowa DOT's Complete Streets policy, the paved shoulder widths and/or bicycle lane widths specified in Sections 12B-3, D and 12B-3, E must be continued through interchanges unless a design exception is granted.

When designing bicycle facilities at interchanges, it is important to consider safety, comfort, and convenience for the bicyclists. This is best achieved by designing ramps to intersect roadways at an angle of 60 to 90 degrees, and/or using single lane roundabouts for traffic control at the intersection between the local route and the ramps. Although freeways and limited-access facilities pose major barriers to bicyclists, continue paved shoulders at least 4 feet wide of bicycle lanes through interchanges unless a design exception is granted. These designs promote low speeds, minimize conflict areas, and increase visibility.

In many cases, it is not feasible to design interchanges with those preferred elements. In these cases, the higher speeds and volumes at these locations may justify the selection of a separated bicycle lane or shared use path following the bikeway selection guidance in [Section 12B-1](#). For a shared use path to provide the desired level of comfort and safety, crossings of traffic streams will require special consideration.

1. **Entrance Ramps:** Many of the safety challenges associated with entrance ramps are due to right and left-turn movements across a bikeway to access the ramp. For ramp crossing locations where vehicle speeds are likely to be 30 mph or less at the crossing, and ramp volumes result in regular gaps in traffic, it may be acceptable to provide on-street bicycle lanes. The potential conflict zone with turning motorists should be marked with dotted lines and green colored pavement at the crossing, see Figure 12B-3.20. However, at locations with higher speeds and ramp volumes of right turning motor vehicles, the designer should consider a bicycle lane, separated bicycle lane, or a shared use path following the bikeway selection guidance in [Section 12B-1](#).

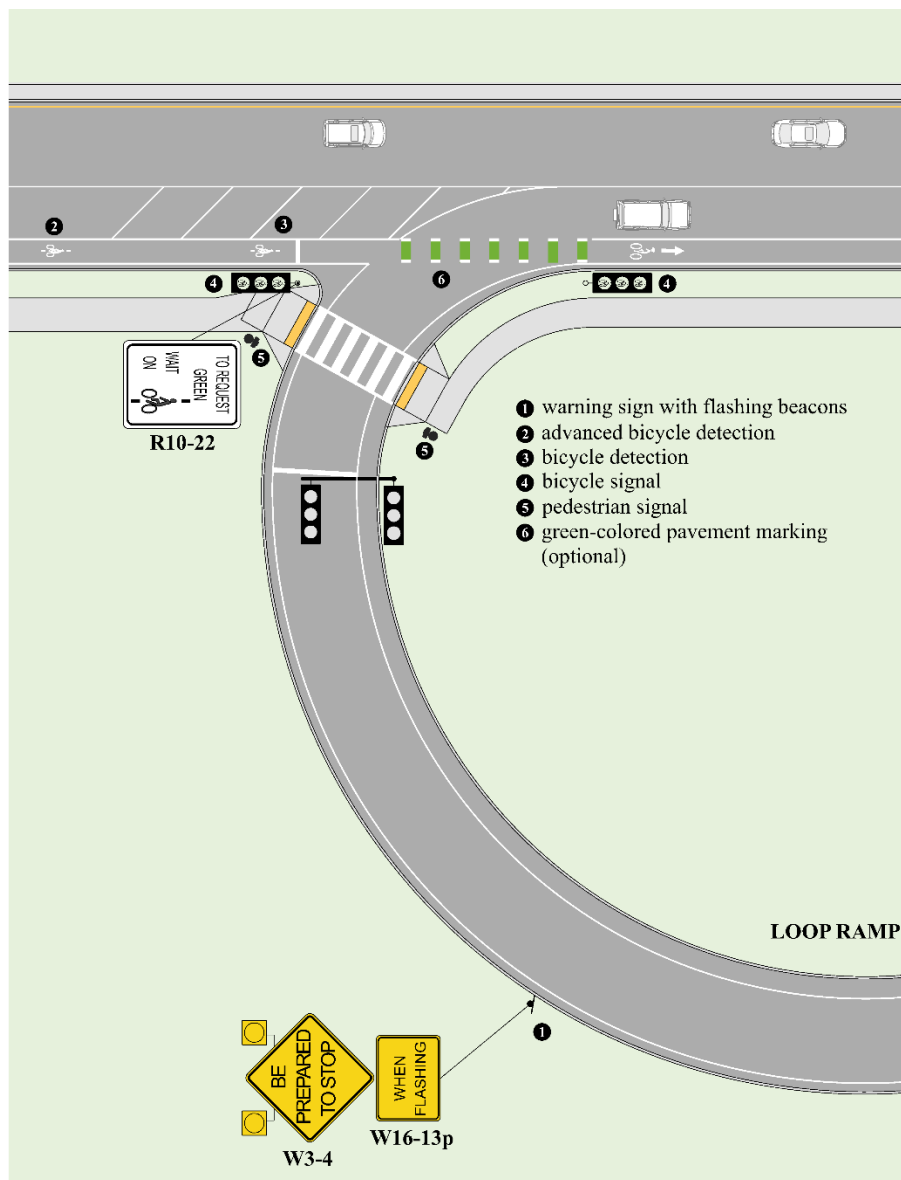
Figure 12B-3.21: Entrance Ramp with Right-Turn Lane, Bicycle Lane, and Shared Use Path



Source: Adapted from MnDOT *Bicycle Facility Design Manual*

2. **Exit Ramps:** Exit ramps can be difficult and unsafe for bicyclists to traverse due to the angle of the ramp and the often significant speed differential between bicyclists and motorists. Stop signs or signals are encouraged for motorists turning from the off ramp to the local route rather than allowing a free-flowing movement because this will increase the safety of the bicyclists. For ramp crossings where vehicle speeds are likely to be 30 mph or less at the crossing and ramp volumes result in regular gaps in traffic, it may be acceptable to provide on-street bicycle lanes. The potential conflict zone with turning motorists should be marked with dotted lines and green colored pavement at the crossing. Designs that permit high-speed free-flow movements from the exit ramp to an arterial roadway are not advised if regular bicycle and pedestrian activity is expected at the crossing locations. If prevailing vehicle speeds and volumes limit yielding behavior or adequate gaps in traffic, or where sight distance does not meet recommended criteria, it may be necessary to consider an active warning device or a traffic signal, as shown in Figure 12B-3.21.

Figure 12B-3.22: Exit Ramp with Bicycle Lane Crossing and Advance Warning or Traffic Signal



Source: Adapted from MnDOT *Bicycle Facility Design Manual*

At complex interchanges that have high volumes of bicyclists or pedestrians, high-speeds and free-flowing motor vehicle movements, a well signed and clearly directed grade-separated crossings may be necessary. These grade-separated facilities should still include good visibility, be convenient, and consist of adequate lighting. (AASHTO *Bicycle Guide* 4.12.9).

Two design guides provide detailed guidance on how to safely and accessibly provide safe facilities for people biking through interchanges:

1. ITE *Design Guidelines to Accommodate Pedestrians and Bicyclists at Interchanges*, 2016, identifies specific dimensions, safety features, signage, pavement markings, design geometries, and other treatments.
2. NCHRP Research Report 948: *Guide for Pedestrian and Bicyclist Safety at Alternative and Other Intersections and Interchanges*, 2021, provides specific guidance for other alternative interchange designs such as Diverging Diamond Interchange, Restricted Crossing U-Turn, Median U-Turn, and Displaced Left-Turn.

Q. Bicycles at Roundabouts

In designing roundabouts for bicycle usage, single lane roundabouts are safer and easier to navigate for bicyclists. Multi-lane roundabouts include too many conflict points due to bicyclists weaving/changing lanes and motorist cutting off bicyclists when exiting the roundabout.

In instances of bicycle lanes approaching a roundabout, the bicycle lane should be terminated at least 100 feet from the edge of the entry curve of the roundabout and prior to the crosswalk. Also, prior to the roundabout and after the termination of the bicycle lane, a tapering of the bicycle lane to the travel lane should be provided. This is done to achieve the appropriate entry width for the roundabout and the taper should be 7:1 for a 20 mph design speed or 40 feet for a 5 to 6 foot bicycle lane. Additionally, the bicycle lane line should be dotted 50 to 200 feet in advance of the taper to encourage bicyclists to merge into traffic. While some bicyclists may be comfortable traversing a roundabout in a shared lane environment, many bicyclists will not feel comfortable navigating roundabouts with vehicular traffic, especially multi-lane roundabouts, high-speed design roundabouts, and/or complex roundabouts. For comfort and safety reasons, roundabouts may be designed to facilitate bicycle travel on a shared use path.

Although the MUTCD directs on-street bicycle lanes to be terminated in advance of roundabouts, bicyclists should be given the option to merge with traffic and ride through the roundabout as a vehicle, or exit onto the adjacent sidewalk via a ramp. In many jurisdictions, bicyclists riding on sidewalks may be prohibited. However, the sidewalk can be widened and converted to a shared use path so it is lawful for bicyclists to traverse the roundabout separated from traffic. Bicycle ramps transition from the roadway to sidewalks prior to a roundabout and the following criteria should be followed:

- Place bicycle ramps at the end of the full width bicycle lane and just before the taper of the bicycle lane.
- Where no bicycle lane is present on the approach to the roundabout, a bicycle ramp should be placed at least 50 feet prior to the crosswalk at the roundabout to prevent pedestrians from mistaking the ramp as a crosswalk.
- Bicycle ramps should be placed at a 35 to 45 degree angle to the roadway.
- Bicycle ramps are intended for the exclusive use of bicyclists and therefore the slopes need not comply with pedestrian accessibility guidelines. Ramp grades can be steeper than pedestrian curb ramps; however, grades of 5 to 8% can help to address issues of comfort when transitioning from one elevation to another.

- Where a bicycle ramp connects directly into a sidewalk or shared use path, use a detectable warning surface at the top of the bicycle ramp and supplement with a directional indicator to guide pedestrians away from the bicycle ramp.
- The cross slope of a bicycle ramp should not be more than 2% to reduce the chance of bicyclists slipping on the bicycle ramp, especially during winter months.

If the ramp is placed within the sidewalk, it should be designed to meet accessibility requirements and include detectable warning surfaces at the bottom of the ramp instead of the top.

Bicycle ramps at the exits of roundabouts should be built with the similar geometry and placement as ramps at roundabout entries. Bicycle ramps at the exits of roundabouts should be placed at least 50 feet beyond the crosswalk of the roundabout. Refer to AASHTO *Bicycle Guide* 4.12.11 and the FHWA Roundabout Guide.

R. References

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