REGIONAL BICYCLE AND PEDESTRIAN STUDY

A Strategic Vision for Walking and Bicycling in the Greater Nashville Region

Pedestrian and Bicycle Design Guidelines

Technical Memorandum 8

November 2009

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1.0 INTRODUCTION

In 2008, the Nashville Area Metropolitan Planning Organization (MPO), the regional transportation planning organization in the Middle Tennessee area, initiated the development of the region's first comprehensive Bicycle and Pedestrian Study for the greater Nashville region. The Regional Bicycle and Pedestrian Study is intended to establish a strategic vision for walking and bicycling in the region. This strategic vision will feed into the MPO's overall Long Range Transportation Plan and provide the basis by which future funding priorities of the MPO are established for bicycle and pedestrian accommodations within Davidson, Rutherford, Sumner, Wilson and Williamson counties, plus the cities of Spring Hill and Springfield.

Working with local governments, businesses, non-profit organizations, and the general public the Nashville Area MPO developed the Regional Bicycle and Pedestrian Study as a mechanism to foster a better understanding of bicycle and pedestrian needs within the region. The Study is also intended to serve as a means of guiding policies, programs, and investments intended to maximize opportunities for greater walking and biking activity now and in the future within the greater Nashville region.

In general, the Regional Bicycle and Pedestrian Study:

- Provides a comprehensive inventory of existing and currently proposed on and off-road bicycle and pedestrian facilities in the greater Nashville region
- Increases the region's understanding of how non-motorized modes add to system-wide capacity by improving connectivity between residential areas, employment centers, schools, retail centers, recreational centers, and other attractions
- Serves as a framework for identifying and selecting bicycle/pedestrian projects for the region's Long Range Transportation Plan and Transportation Improvement Program; and
- Provides guidance for engineering, education, enforcement, encouragement, and evaluation activities to help improve the safety of non-motorized travel modes.

Issues that concern pedestrians and bicyclists most are often overlooked during the planning, design, construction, and maintenance of roadways. In recent years, Complete Streets policies have been adopted throughout the U.S. at all levels of government, to ensure the consideration of all modes of travel in the transportation system. In general, Complete Streets policies cover multiple modes of transportation including walking, bicycling, automobiles, transit, and freight. The policies address the needs of all users including those with disabilities, the young, and older adults.

Complete streets policies ensure that all modes of transportation are considered from the beginning of all transportation projects. By implementing this process in all planning, design, and construction projects a continuous and consistent transportation system for bicyclists, pedestrians, and transit users is created. Many of the transportation projects in the Nashville MPO region are expected to include bicycle and pedestrian facilities.

Consideration of pedestrian facilities at the beginning of a transportation project helps to ensure a safe, friendly, cost effective facility is planned and constructed. Neighborhoods that have high-quality pedestrian facilities typically have more pedestrian activity. Creating a high-quality, pedestrian-friendly facility involves more than installing a sidewalk. Pedestrian facilities need to be accessible to everyone, comfortable, inviting, and, above all, safe. If people are not walking, it is probably because the pedestrian system lacks one or more of these qualities. The following guidelines ensure the planning, design, and construction of safe, inviting pedestrian facilities.

In order to increase the number of trips made by bicycle, it is important that accommodations for bicycling be considered early in the planning phase, and fully integrated into transportation projects. Although bicycling is a popular form of exercise, with increasing gas prices and congestion, a growing number of people are commuting by bicycle and otherwise bicycling for transportation. With the increase in bicycling trips there is a need to make bicycle travel safer and a more accessible option. The following guidelines are meant to create well-designed bicycle facilities that are safe, convenient and comfortable to encourage bicycle travel.

Both the pedestrian and the bicycle guidelines are based on nationally-recognized standards and practices, and embrace and promote the creation of complete streets for communities within the Nashville region.

2.0 PEDESTRIAN FACILITIES GUIDELINES

2.1 PURPOSE OF THE DESIGN GUIDELINES

The pedestrian facilities design guidelines section is intended to function as a stand-alone reference guide for local governments, engineers, planners, and others who make decisions that affect pedestrian travel in the Nashville MPO region. The purposes of the guidelines are to provide useful information in order to create a safe and successful pedestrian infrastructure and to ensure that pedestrian facility designs are consistent throughout the Nashville MPO region. Consistent designs allow pedestrians to be prepared for the types of facilities that they will encounter, and they allow pedestrians and motorists to operate predictably with each other. Consistency and predictability are essential to providing a safe and efficient multi-modal transportation system.

The pedestrian facilities design guidelines section is based on nationally-recognized guidelines that have been established by the U.S. Department of Transportation Federal Highway Administration, the American Association of State Highway and Transportation Officials (AASHTO), and the Institute of Transportation Engineers (ITE). In addition to these sources, the pedestrian facilities design guidelines are also based on innovative ideas and designs that have been successfully implemented in other cities and states. The guidelines presented in this document have been developed to meet the specific needs of the Nashville MPO region. However, due to the size of the region and the unique characteristics of the communities within the region, this document cannot provide guidance for every pedestrian design issue that may be encountered. In situations that are not covered by this document, appropriate planning and engineering principles should be applied.

The Americans with Disabilities Act

The *Americans with Disabilities Act* (ADA) is a federal law that was signed on July 26, 1990. The ADA prohibits discrimination on the basis of disability and mandates that all disabled persons be provided full access to all public facilities in the country. Designing and constructing public facilities that are not usable by people with disabilities is a violation of the ADA.

Current ADA standards, which are contained in the 2002 edition of the *Americans with Disabilities Act Accessibility Guidelines* (ADAAG), thoroughly outline requirements for building design. However, ADAAG provides little guidance regarding the design of facilities in public right-of-way. The U.S. Access Board is the federal agency that is responsible for the development of minimum accessibility guidelines to assist the Department of Transportation (DOT) and the Department of Justice (DOJ) in establishing design standards for the ADA. This board released a draft update of the ADA guidelines on June 17, 2002. The draft update was revised on November 23, 2005 and is entitled *Accessible Public Rights-of-Way Planning and Designing for Alterations.* This document provides more specific guidance for public right-of-way and includes provisions for sidewalks, sidewalk ramps, street crossings, and related pedestrian facilities. Although these guidelines have not yet been adopted, the Federal Highway Administration (FHWA) and the U.S. Access Board encourage their use since they offer the most authoritative guidance available regarding accessible design in public right-of-way.

The current and proposed ADA guidelines provide minimum design standards for ensuring accessibility. Alternate standards may be applied provided that the alternate standards meet or exceed the minimum ADA guidelines. The recommendations presented in the pedestrian facilities design guidelines section are consistent with, and in some cases exceed, the standards presented in *Accessible Public Rights-of-Way Planning and Designing for Alterations* (refer to the US Access Board's website – http://www.access-board.gov/prowac/ for the most up to date ADA accessibility guidelines).

Design Considerations

Everyone is a pedestrian at one time or another. Pedestrian facilities must be designed to meet a wide range of needs. Pedestrians vary in age, height, physical ability, mental ability, and reaction time. Therefore, there is not a typical "design pedestrian".

One's decision to walk is not only based on convenience, but also on the perceived quality of the experience. The choice to walk is influenced by both "hard" factors, such as the continuity of the sidewalk system, and "soft" factors, such as the shade or the beauty offered by street trees. Therefore, pedestrian facilities should be designed with the following considerations:

- Pedestrian facilities should be easily accessible for all users.
- Pedestrian facilities should offer real and perceived safety. They should be free of hazards and obstructions and should be designed so as to minimize conflicts with vehicular traffic.
- Sidewalks and crosswalks should be wide enough to comfortably accommodate the anticipated volume of pedestrians. The widths should be based on the pedestrian volumes, adjacent land uses, and roadway classifications.
- Crosswalks should be frequent and as short as possible.
- Pedestrian facilities should provide direct connections between origins and destinations.
- Pedestrian facilities should be continuous.

- Landscaping and street furnishings should be provided to create an attractive and comfortable sidewalk corridor.
- Sidewalk corridors should be compatible with the community and the context for which they are provided. Their design should complement the adjacent land uses, as well as enhance the design and transportation objectives of the neighborhoods through which they travel or downtown centers for which they serve.

2.2 SIDEWALKS

Sidewalks are “pedestrian lanes” within the public right-of-way. They are typically separated from the vehicular travel lanes by a curb and/or a planting strip, which serve to buffer pedestrians from vehicular traffic. Sidewalks improve pedestrian safety by providing dedicated facilities that accommodate all types of pedestrian travel. They also enhance a community’s quality of life by increasing mobility and encouraging public interaction as well as tourism and commerce.

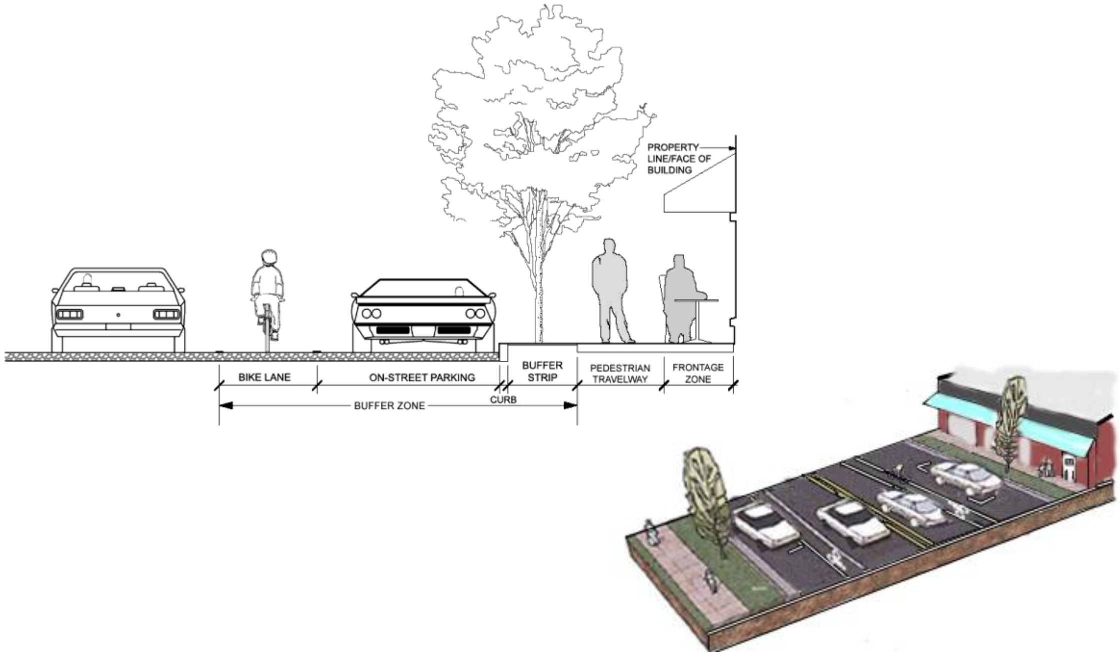
The Sidewalk Corridor

The primary function of a sidewalk corridor is to provide a safe, convenient, and accessible route for pedestrian travel. In addition to accommodating pedestrians, the sidewalk corridor may also accommodate other roadway and pedestrian appurtenances, such as utilities, street trees, street furniture, landscaping, and sidewalk cafes.

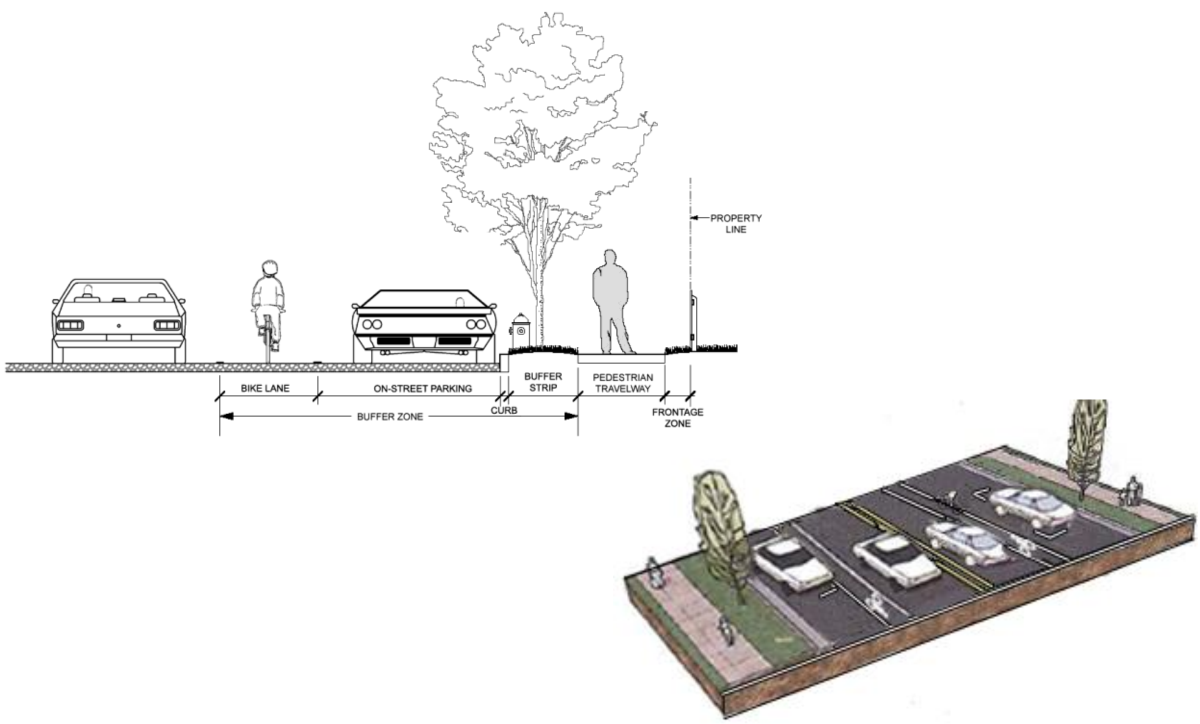
The sidewalk corridor consists of three zones, which are illustrated in Figure 1. These zones are:

- Buffer Zone
- Pedestrian Travelway
- Frontage Zone

Downtown Sidewalk Corridor



TYPICAL CROSS SECTION OF SIDEWALK CORRIDOR IN COMMERCIAL ZONE



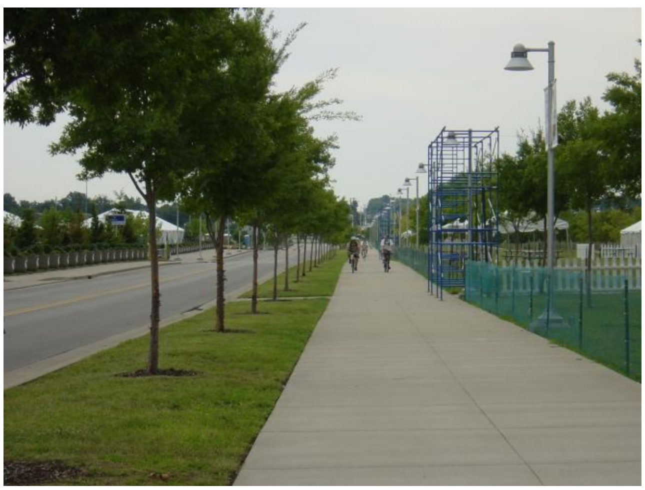
TYPICAL CROSS SECTION OF SIDEWALK CORRIDOR IN RESIDENTIAL ZONE

Figure 1: The sidewalk corridor consists of the buffer zone, the pedestrian travelway, and the frontage zone.

The Buffer Zone

The buffer zone is the area between the outside edge of the vehicular travel lanes and the front edge of the sidewalk. This zone typically consists of a landscaped buffer strip that is located between the back of the curb and the sidewalk. In commercial areas that have high pedestrian volumes, the buffer strip may be paved for an additional walkable width. The buffer strip can accommodate roadway and pedestrian features, such as street trees and other landscaping materials, utilities, and street furniture. In addition to a buffer strip, the buffer zone can also include a bike lane, a parking lane, and a curb.

A buffer zone is desirable because it protects pedestrians from vehicles traveling on the roadway. In addition to providing a physical buffer between pedestrians and vehicles, a buffer zone increases a pedestrian's perception of safety, thereby creating a more comfortable walking environment.



Buffer Zone with Trees

At a minimum, the buffer zone should consist of a buffer strip that is at least four feet wide. This width will provide adequate separation between pedestrians and vehicles traveling on a low-speed, low-volume roadway, such as a local road. Four feet is also the minimum width for sustaining street trees, providing them with just enough green space to absorb water and maintain a healthy root system. Street trees are not recommended for buffer strips that are less than four feet wide.

Wider buffer strips should be considered on roadways of higher classification. Collector and arterial roadways carry more traffic, and traffic on these roadways travel at higher speeds. To provide safety and comfort, it is desirable to increase the separation between pedestrians and motorists on collector and arterial roadways. For example, the width of the buffer strip could be increased to five feet along collector roads and six feet along arterial roads. Appropriate engineering judgment should be used when planning buffer strips along collector and arterial roadways.

The Pedestrian Travelway

The pedestrian travelway is the portion of the sidewalk corridor that provides an unobstructed path of travel for pedestrians. This zone is more commonly referred to as the sidewalk.

Sidewalks should be firm, stable, and slip resistant. They should not be constructed of materials that will cause unpleasant vibrations when traveled on by persons using wheelchairs or other mobility aids. The width of sidewalks should be based on pedestrian volumes, land use, and roadway classifications. At a minimum, sidewalks should be five feet wide to accommodate wheelchair turning and passing movements. At no time should the width of the unobstructed sidewalk path be reduced to less than four feet. Sidewalks wider than five feet may be desirable along arterial and collector roads and in commercial and downtown areas. Typically, these areas have higher pedestrian volumes, and they need additional sidewalk width to accommodate the pedestrian traffic. For example, it may be desirable to have a six-foot wide sidewalk along a collector street or an eight-foot wide sidewalk along an arterial street. In a commercial area, it may be desirable to provide a sidewalk that is ten feet wide or wider, depending on the pedestrian volumes in the area. Appropriate engineering judgment should be applied when planning sidewalks along collector and arterial roadways and in commercial and downtown areas.

When railings, fences, walls, or other structures are located adjacent to the pedestrian travelway, pedestrians tend to use only the portion of the sidewalk that is farthest away from the structure. This tendency reduces the functional width of the sidewalk. In order to maintain the full, usable width of the sidewalk, structures should be constructed no closer than one foot to the back edge of the sidewalk.

The Frontage Zone

The frontage zone is the portion of the sidewalk corridor that is located between the pedestrian travelway and the edge of the right-of-way. In commercial and downtown areas, the frontage zone is typically an extension of the sidewalk and is used for sidewalk cafes, landscaping, seating, and building awnings. In residential areas, the frontage zone may be grass-covered. Often suburban and older arterial thoroughfares lack frontage zones with sidewalks usually placed adjacent to the right-of-way line.

The features that are typically found in frontage zones improve aesthetic quality of the sidewalk corridor and enhance the walking experience for pedestrians. To accommodate these features, frontage zones in commercial and downtown areas should be a minimum of five feet wide.

2.3 PEDESTRIAN FACILITIES ALONG RURAL ROADWAYS

Many of the region's roads have cross-sections that include shoulders and ditches instead of curb and gutter. These roadways typically travel through rural areas. When these roadways travel through dense residential, mixed-use, or commercial areas, curb and gutter and sidewalk should be constructed along these roadways. However, in low-density, rural areas, the low volumes of pedestrians may not warrant such extensive construction. In these areas, pedestrians may be adequately accommodated on the existing roadway by providing the following support efforts:

- Keep the posted speed limits reasonably low and enforce the speed limits.
- Maintain the paved and unpaved shoulders. The shoulders should be free of debris, tall grass, snow, and other objects that may prevent someone from stepping off of the roadway when traffic approaches.
- Increase the shoulder width by reducing the travel lane widths.

In some rural areas, major community destinations, such as schools or regional parks, may create a localized need for dedicated pedestrian facilities. In these cases, it may be appropriate to deviate from the standard guidelines in order to provide pedestrian facilities that are compatible with the area's rural context. Side paths and shoulders are two types of rural pedestrian facilities that can accommodate pedestrians outside of the vehicular travelway, thereby increasing pedestrian safety.

2.4 SIDE PATHS

As shown in Figure 2, a side path is a facility that is dedicated to non-motorized travel and is separated from the roadway by a buffer strip. The buffer strip should be at least five feet wide to provide adequate separation between the roadway and the side path. A ditch or a swale is often located in the buffer strip in order to accommodate storm water from the roadway. When a ditch or a swale is present, it is recommended that culverts be provided at intersections and at regular intervals

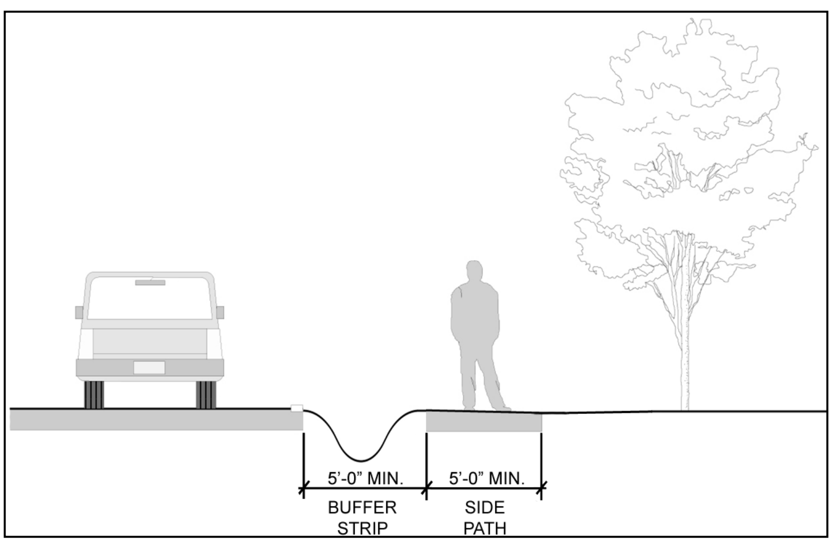


Figure 2: A side path along a rural roadway should be at least five feet wide and separated from the roadway by a buffer.

along the roadway in order to provide adequate access to and from the side path.

Side paths that are intended primarily for pedestrian use should be at least five feet wide. In areas where side paths will function as multi-use facilities, the width of the side paths should be increased to at least ten feet wide, although 12 feet is preferable. Multi-use side paths should be designed according to the greenway guidelines presented in the AASHTO *Bicycle Facilities Design Guidelines.*

2.5 SHOULDERS

In some rural areas, traditional sidewalks and side paths may not be feasible due to cost or right-of-way constraints. In these areas, paved shoulders can be used for pedestrian travel. Although shoulders are the least preferred pedestrian facility type, they can be acceptable, particularly when the alternative is no pedestrian facilities at all.

A pedestrian shoulder facility is illustrated in Figure 3. As shown, the shoulder should be at least five feet wide. Because paved shoulders can also be used by bicyclists, paved shoulders should meet the shoulder bike lane guidelines presented in the AASHTO *Bicycle Facilities Design Guidelines*.

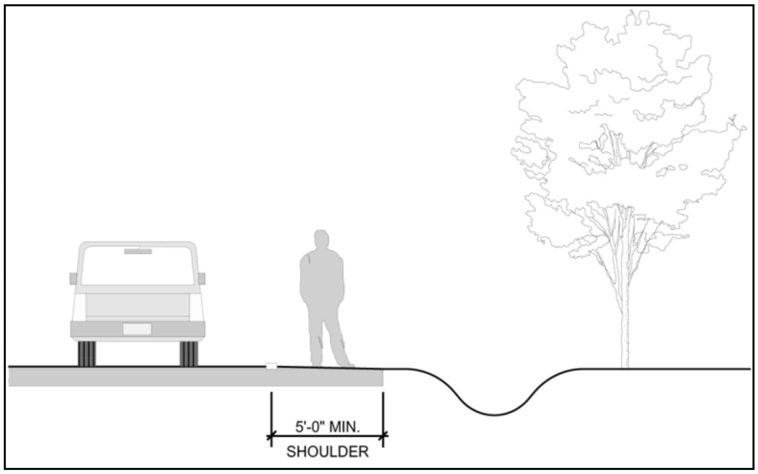


Figure 3: Paved shoulders can adequately serve pedestrian traffic in rural areas where sidewalks and side paths cannot be constructed.

Off-Street Pedestrian Connector Facilities

Off-street pedestrian connector facilities provide connections between destinations or sidewalks that would otherwise require pedestrians to travel along out-of-direction, street-based routes. Typically, these facilities only extend a short distance and are independent of the roadway network, as shown in Figure 4.

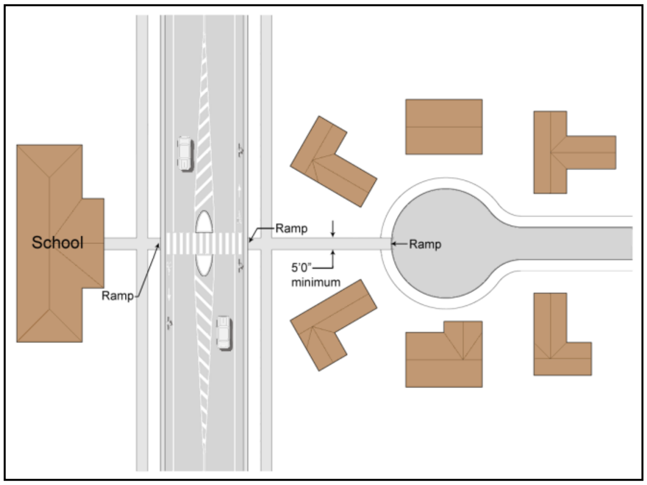


Figure 4: Off-street pedestrian connector facilities provide direct access to destinations and sidewalk systems that could only be reached by street-based routes.

Off-street pedestrian connector facilities should be at least five feet wide. Areas with high pedestrian volumes may require wider facilities. Off-street connector facilities that are intended to accommodate other non-motorized forms of transportation, such as bicycling, should be at least ten feet wide, although 12 feet is preferable. Also, multi-use connector facilities should be designed according to the greenway standards presented in the AASHTO *Bicycle Facilities Design Guidelines*.

Off-street pedestrian connection

2.6 DRIVEWAYS

Driveway designs can sometimes cause safety and access problems for pedestrians. Driveways that are not well defined, that are excessively wide or have excessive slopes, or have large turning radii can be difficult for pedestrians to cross. Also, multiple adjacent driveways create more conflict points between motorists and pedestrians, thereby reducing pedestrian safety. Appropriate driveway design can reduce the number of motorist/pedestrian conflicts, improve access for people with disabilities, and enhance the visibility of motorists and pedestrians at driveways. The same principles that apply to driveway design can also be used for the design of alleys.

General Design Issues

With the exception of signalized, commercial driveways, pedestrians always have the right-of-way when crossing driveways. Driveway design should communicate this message to motorists. As shown in Figure 5, a sidewalk crossing a driveway should extend through the driveway, rather than the driveway extending through the sidewalk. Also, the crossing should maintain the same slope, cross-slope, material, and scoring pattern as the adjacent sidewalk. The driveway ramp should be located in the buffer strip so that it does not interfere with pedestrian travel. If a buffer strip is not provided, then appropriate engineering judgment should be applied to develop an alternate design that will meet ADA guidelines.

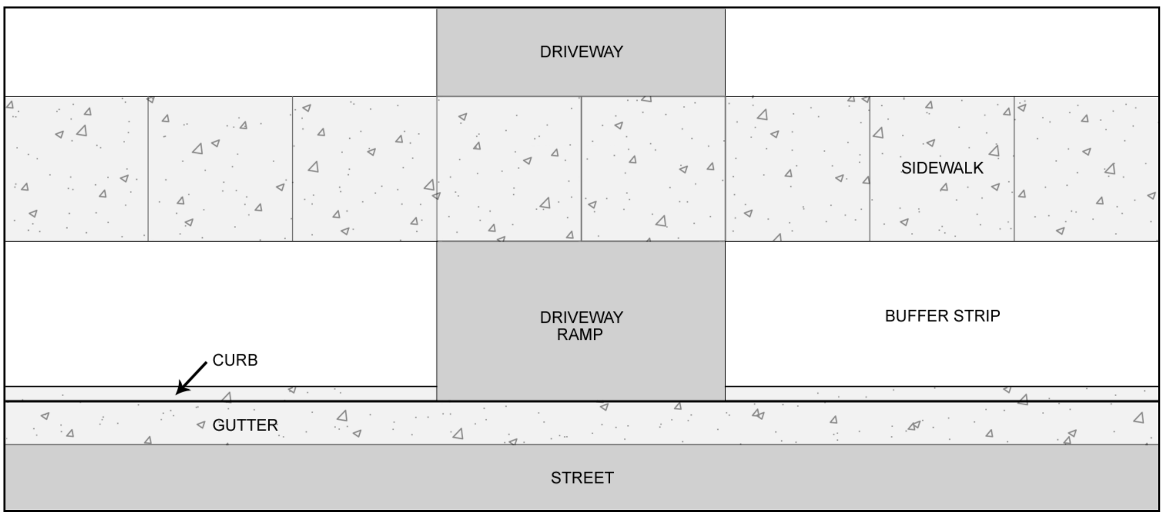


Figure 5: The sidewalk should extend through the driveway and should maintain the same slope, cross-slope, material, and scoring pattern as the adjacent sidewalk.

It is recommended that buffer strips be incorporated in sidewalk corridors wherever possible. However, in areas where physical or right-of-way constraints prevent the use of buffer strips, the following methods can be applied at driveways to accommodate pedestrians:

- In areas with wide sidewalks, the driveway ramp may extend into the sidewalk, provided that the unobstructed portion of the sidewalk is at least four feet wide. The driveway ramp should be constructed of the same material as the sidewalk. This method is illustrated in Figure 6, Detail A.
- The sidewalk may be wrapped around the driveway entrance to create enough room for a driveway ramp between the sidewalk and the curb. This method, which is illustrated in Figure 6, Detail B, may have disadvantages for sight-impaired pedestrians who rely on the curb line for guidance.
- The sidewalk may be lowered to the driveway elevation, as illustrated in Figure 6, Detail C. However, the dip in the sidewalk that is created by this method may be unexpected and uncomfortable for pedestrians.

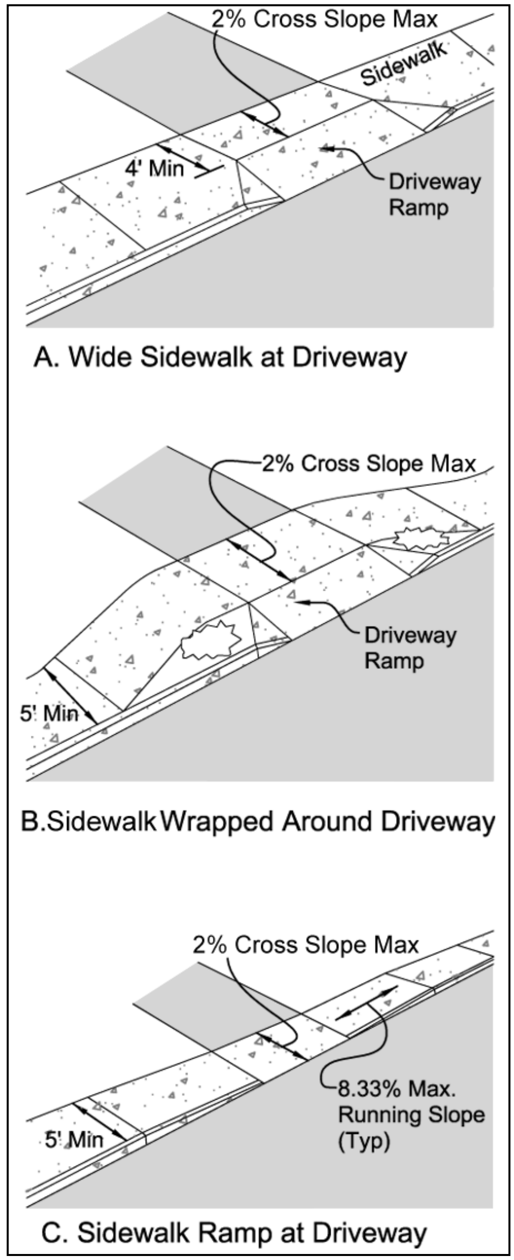


Figure 6: In locations without buffer strips, ADA-compliant pedestrian crossings at driveways can be accomplished by providing a wide sidewalk, wrapping the sidewalk around the driveway, or by ramping the sidewalk at the driveway.

Gravel Driveways

Gravel driveways can create problems for pedestrians traveling on the sidewalk or roadway. Vehicle movements on gravel driveways tend to track gravel onto the sidewalk and roadway, which can make the pedestrian travelway impassible for people who use wheelchairs or have limited mobility. In order to reduce the likelihood of gravel migrating to the sidewalk or roadway, gravel driveways should be paved for a minimum distance of five feet behind the sidewalk, as shown in Figure 7. If an alternate pedestrian facility is provided, such as a side path or a paved shoulder, then the paved portion of the driveway should extend to at least five feet behind the alternate pedestrian facility.

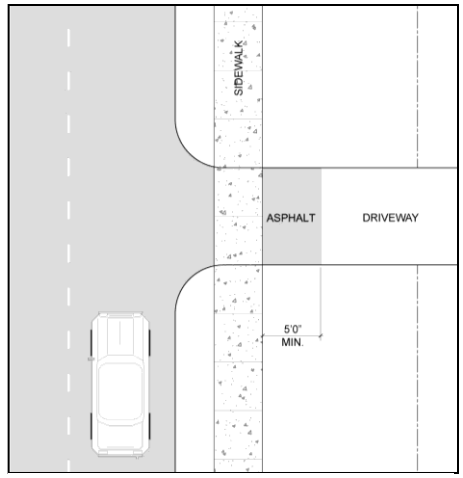


Figure 7: Gravel driveways should be paved from the road to at least five feet behind the sidewalk.

Commercial Driveways

Due to traffic control conditions, traffic volumes, and widths, the design of pedestrian crossings at commercial driveways requires some additional considerations. Signalized commercial driveways, including the pedestrian crossing facilities at these driveways, should be designed to meet the standards for conventional roadway intersections. Also, pedestrian refuge medians should be considered on driveways that include three or more lanes.

Reducing/Eliminating Driveways

Multiple adjacent driveways and driveways that are excessively wide increase the likelihood of conflicts between motorists and pedestrians. For new developments, the number and width of driveways should be limited. For existing developments, driveways should be consolidated wherever possible. The width of continuous driveways should be reduced, which will eliminate potential vehicle/pedestrian conflicts while providing adequate vehicular access. Also, driveway curb cuts that are no longer being used should be eliminated to improve pedestrian facilities.

2.7 INTERSECTIONS

Well-designed sidewalks improve mobility for pedestrians by allowing them to safely and conveniently travel along the roadway without unnecessary exposure to vehicular traffic. However, at times, pedestrians need to cross the road to get to their destinations. Navigating through intersections can be confusing and difficult for pedestrians since intersections require motorists, pedestrians, bicyclists, and other right-of-way users to cross paths. Proper design and guidance is essential at intersections so that users can operate predictably with each other. Predictability improves safety for all right-of-way users.

The design of an intersection should clearly indicate how all users should navigate through the intersection. At signalized intersections, both motorists and pedestrians are required to obey the traffic signals. At unsignalized intersections that have marked crosswalks, and at other locations that have marked crosswalks, motorists must yield to pedestrians. Pedestrians are required to yield to motorists at unsignalized intersections that do not have marked crosswalks. The design of an intersection should reinforce these regulations. However, it should be noted that there is no legal difference between a marked and unmarked intersection crossing. Therefore, all intersections should be designed to maximize pedestrian safety.

Design Considerations

Almost all intersections have the potential for pedestrian traffic. Therefore, intersection design should not only accommodate vehicular traffic, but should also accommodate pedestrian traffic. Intersections with the following characteristics tend to function well for pedestrians:

- Accessible pedestrian features, such as ramps and pushbuttons, are provided to accommodate users of all abilities.
- Safe pedestrian movements are provided for on each leg of the intersection.
- Pedestrian crossings are short and direct and do not require out-of-direction travel.
- Motorists and pedestrians are highly visible to each other.
- The intersection design slows vehicular traffic and prohibits free-flowing turning movements.
- The signage, pavement markings, and other traffic control devices clearly indicate how right-of-way users should operate.
- Pedestrian refuge medians are provided.
- Corners and medians are designed to prevent vehicles from encroaching into pedestrian areas.
- Corners provide enough storage area to accommodate pedestrians who are waiting to cross, as well as pedestrians crossing traffic.

2.8 SIDEWALK RAMPS

Sidewalk ramps, also known as curb ramps, are required to connect pedestrian access routes to street crossings. Sidewalk ramps provide a smooth transition from the sidewalk elevation to the street elevation. Wherever possible, sidewalk ramps should be located within the width of the crosswalk. Typically, this will require two sidewalk ramps on each street corner, as shown in Figure 8. This design positions pedestrians in the proper alignment for crossing the street. The use of diagonal sidewalk ramps, as shown in Figure 9, is discouraged. Many sight-impaired pedestrians rely on the slope of the curb ramp to orient them in the proper direction for crossing the street. Diagonal ramps can misdirect sight-impaired pedestrians, causing them to walk into the middle of the intersection. Diagonal ramps can also increase crossing times for pedestrians who use wheelchairs or other mobility aids. Diagonal ramps require these users to re-align themselves while in the street before proceeding through the crosswalk.

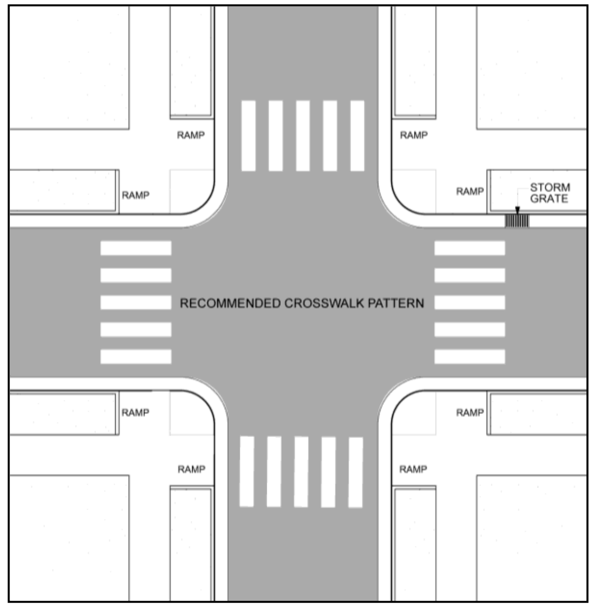


Figure 8: Sidewalk ramps should be placed in line with the crosswalk which will typically require two ramps per corner.

Diagonal ramps also reduce motorists' and pedestrians' visibility of each other. Pedestrians crossing at diagonal ramps may not be as visable to motorists as pedestrians who are crossing in line with the sidewalk. Similarly, diagonal ramps can make it more difficult for pedestrians to see right-turning vehicles. As illustrated in Figure 10, right-turning vehicles will approach pedestrians from behind at diagonal ramps. The two-ramp configuration allows right-turning vehicles to approach pedestrians from the side, increasing the pedestrians' visibility of right-turning vehicles.

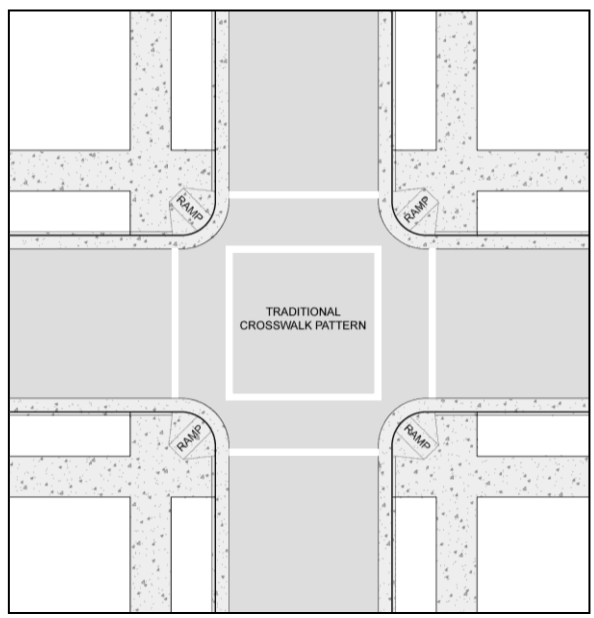


Figure 9: The use of diagonal ramps is discouraged because they can misdirect sight-impaired pedestrians and increase crossing times for wheelchair and other mobility aid users.

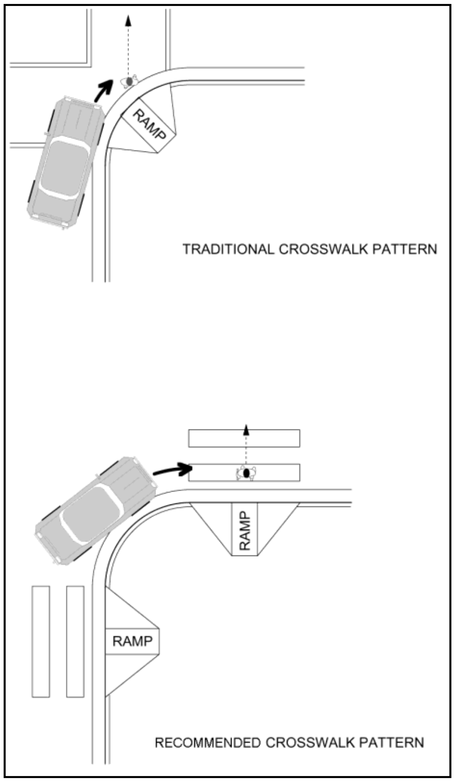


Figure 10: The two-ramp configuration allows right-turning vehicles to approach pedestrians from the side, rather than from behind, as with the diagonal ramp configuration.

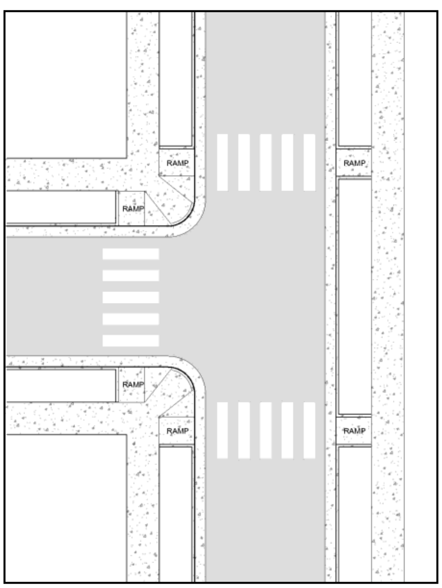


Figure 11: Sidewalk ramps should be provided on each leg of a three-way intersection, regardless of the presence of a crosswalk.

There may be some instances, particularly at existing intersections, where inlets, utility poles, and other constraints may interfere with the two-ramp configuration. In these situations, every effort should be made to remove or relocate obstacles and construct two sidewalk ramps per corner. However, recognizing that this may not always be feasible or practical, diagonal ramps can be used in locations where physical or cost constraints prevent the construction of two sidewalk ramps.

Sidewalk ramps at three-way intersections should follow the same guidelines as sidewalk ramps at four-way intersections. As shown in Figure 11, sidewalk ramps should be provided to cross each leg of the intersection.

Example sidewalk ramps at a three-way intersection

<u>Types of Ramps</u>

There are three types of sidewalk ramps. These ramps, which are illustrated in Figure 12, include:

- Perpendicular Ramps
- Parallel Ramps
- Blended Transitions

The required dimensions and cross-slopes for each type of sidewalk ramp are shown in Figure 12. The ADA guidelines for sidewalk ramps should be carefully reviewed prior to constructing sidewalk ramps.

Perpendicular ramps are sidewalk ramps that slope perpendicularly to the roadway. The perpendicular ramp design is best suited for wide sidewalks and for sidewalks that have buffer strips. Perpendicular ramps provide pedestrians with a continuous travelway and do not require pedestrians to cross the ramps when walking along the sidewalk.

Parallel ramps are sidewalk ramps that are positioned parallel with the roadway. This type of ramp is best suited for narrow sidewalks that do not have a buffer strip. Perpendicular ramps are preferred over parallel ramps because parallel ramps require all pedestrians to cross the ramps when traveling on the sidewalk.

Blended transitions are used to construct diagonal ramps at street corners that have narrow sidewalks without buffer strips. Blended transitions are created by sloping the intersecting sidewalks to a level landing at the corner. Whenever possible, two perpendicular ramps should be provided at a street corner instead of a blended transition.

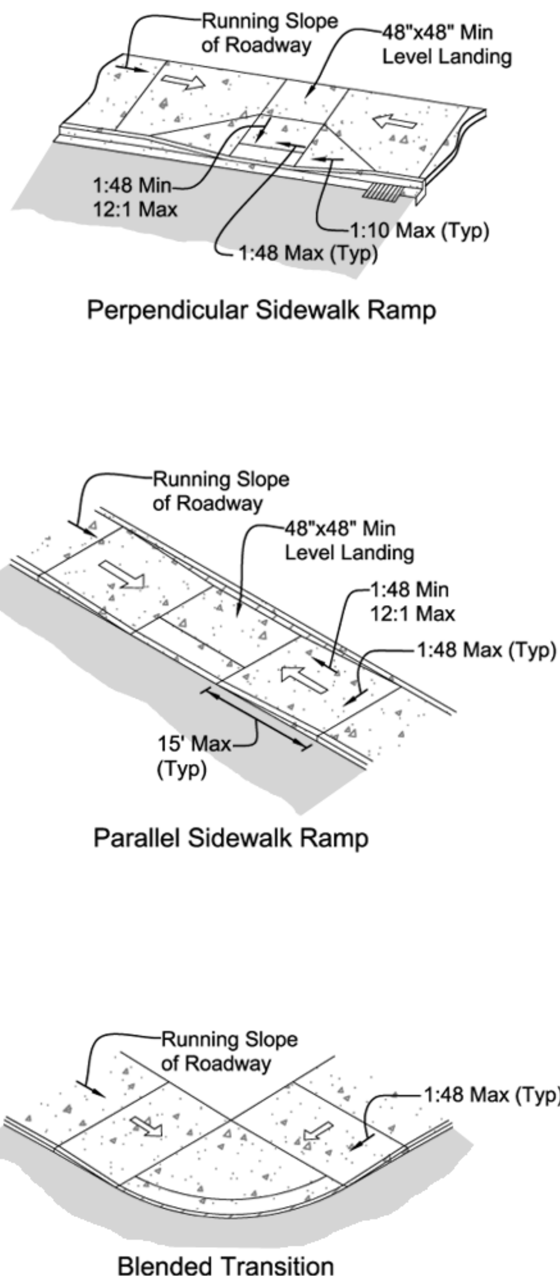


Figure 12: The preferred ramp type is perpendicular; however, there are applications for parallel ramps and blended transitions.

Detectable Warning Surfaces

Detectable warning surfaces have a distinctive pattern of raised domes that provide tactile cues, which are detectable by cane or by foot, to sight-impaired pedestrians. Detectable warning surfaces should be applied at the boundary between pedestrian and vehicular routes. In particular, these surfaces should be installed at pedestrian street crossings, pedestrian median and refuge islands, and at rail line crossings. The current and draft ADA guidelines should be carefully reviewed prior to installing detectable warning surfaces.

Street Corner Radii

The design of turning radii at street corners impacts both motorists and pedestrians. Small turning radii reduce crossing distances for pedestrians, as illustrated in Figure 13. They also reduce vehicular travel speeds, which increases pedestrian safety. However, small turning radii can be difficult for large trucks or buses to navigate, causing them to encroach into other vehicular travel lanes or into the pedestrian travelway. Large turning radii can be more easily navigated by motorists. However, the increased crossing distance that is associated with large radii increases pedestrians exposure to vehicular traffic. Large turning radii also facilitate increased traffic speeds, which can be dangerous for pedestrians at intersections.

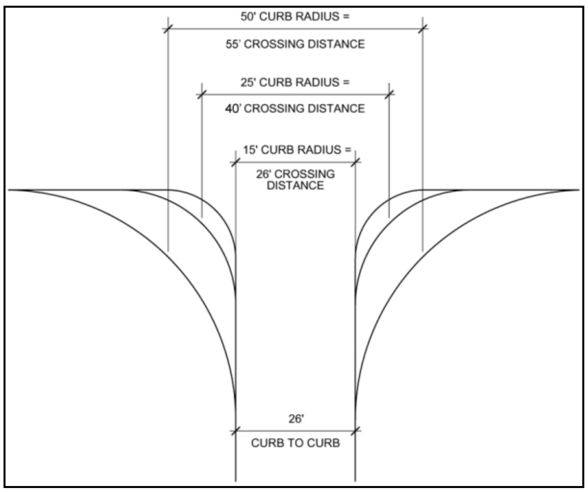


Figure 13: Smaller corner radii result in shorter crossing distances for pedestrians and therefore reduce crossing times.

The curb radii at an intersection should be no larger than what is necessary to accommodate the turning paths of the vehicles that are expected to use the intersection. Passenger vehicles on arterial streets can typically be accommodated with a radius of 15 feet to 25 feet in diameter. However, trucks and buses on arterial streets may require a radius of 30 feet to 50 feet in diameter. AASHTO's *A Policy on Geometric Design of Highways and Streets* states "For arterial street design, adequate radii for vehicle operation should be balanced against the needs of pedestrians and the difficulty of acquiring additional right-of-way or corner setbacks. Because the corner radius is often a compromise, its effect on both pedestrians and vehicular movements should be examined."

The presence of on-street parking or bicycle lanes can minimize curb radii while increasing the effective turning radius for vehicles. This concept is illustrated in

Figure 14. As shown, the parking lane provides increased pavement width at the intersection, which allows vehicles to encroach into the pavement beyond the terminus of the parking lane when turning right. The actual corner radius is very small, which reduces the crossing distance for pedestrians. Also, the parked vehicles act as a buffer between the vehicular and pedestrian travelways

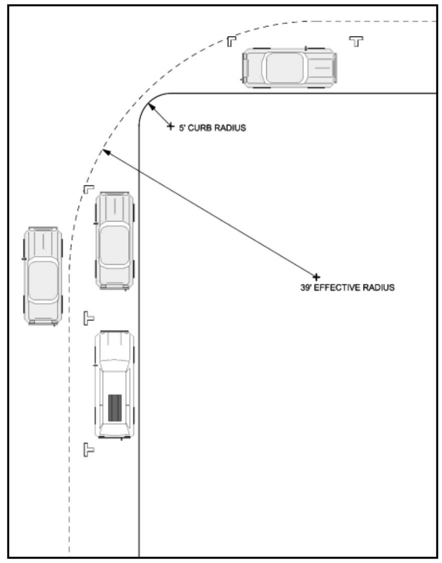


Figure 14: Parking lanes and bicycle lanes increase the effective turning radius for vehicles, which allows the actual corner radius to be as small as 15 feet or less in most cases.

Raised Intersections

A raised intersection encourages slow movements through an intersection with high pedestrian volumes on all crosswalk legs. The design is essentially a speed table for the entire intersection. Approaches are ramped up to the crosswalks at curb height, which eliminates the need for curb ramps. Bollards may be necessary at corners to preclude encroachment by vehicles onto sidewalks.

2.9 CROSSWALKS

The design of crosswalks can significantly affect a pedestrian's ability to cross an intersection. Most crashes involving pedestrians occur while the pedestrians are attempting to cross the street. One reason for this is that both motorists and pedestrians fail to follow standard operational rules at intersections. Properly designed crosswalks clearly indicate to motorists that they are approaching a pedestrian area. The safety and convenience offered by properly designed crosswalks also attracts pedestrians, encouraging them to use the crosswalk instead of crossing at another location.

Design Considerations

The design of crosswalks should maximize pedestrian safety. Well-designed crosswalks have the following characteristics:

- The pavement markings and signage clearly indicate to both motorists and pedestrians where pedestrians should cross the road.
- They are provided at frequent intervals to encourage their use.
- They are aligned with the sidewalk, creating a continuous pedestrian travelway.
- They do not require pedestrians to wait an unreasonable amount of time before crossing the road.
- They provide adequate time for pedestrians, including those with limited abilities, to cross the road.
- They limit pedestrians' exposure to vehicular traffic by providing short crossing distances. The crossing distances may be shortened by pedestrian refuge medians.
- They are located in areas that have adequate stopping sight distance for approaching vehicles.

Crosswalks should be provided on each leg of all signalized intersections and intersections within a downtown central business district unless safety related circumstances dictate otherwise. They should also be provided on arterial and collector streets. Mid-block crosswalks may be appropriate in specific locations if an engineering study determines that they are warranted and safe. Other intersection locations that have a

Raised Mid-Block Crosswalk

high volume of pedestrian activity, or have a high number of children, elderly, or disabled pedestrians, should also have marked crosswalks. Facilities that might necessitate a crosswalk include schools, assisted living facilities, libraries, parks, transit stops, and other pedestrian generators.

Although some intersections may not require marked crosswalks, pedestrians should be permitted to cross the street at most intersection locations. Crossing prohibitions should be limited to locations where special circumstances, such as inadequate sight distance, create a safety hazard for pedestrians.

Crosswalks should be relatively smooth to avoid causing unpleasant vibrations for pedestrians using wheelchairs and other mobility aid devices. Bricks and cobblestones may be used in crosswalks provided that they create a relatively smooth walking surface. Because these materials are less visible to motorists, they should only be used in conjunction with other marking devices, such as white reflective thermoplastic tape.

Pavement markings and signage are the tools that are most commonly used to define a crosswalk. However, there are many techniques that can be applied to enhance a crosswalk design. Pedestrian refuge medians, curb extensions, signal improvements, and other devices should be considered when designing a crosswalk.

The frequency of designated crossing opportunities can contribute to a pedestrian's decision to use a crosswalk or to cross the street at an unmarked, unexpected, location. Pedestrians have a tendency to cross a street at what they perceive to be the most convenient location. They will usually not travel out of their way to cross at a marked crosswalk, especially if the marked crosswalk does not appear to offer any additional safety benefits. The frequency of marked crosswalks should take into account the density of developments in the area. High-density areas should have designated crossing facilities that are spaced no more than 300 feet apart. Marked crossing facilities can be spaced farther apart in low-density areas.

Additional Design Considerations for Three-Way Intersections

Typically, crosswalks should be provided on each leg of a three-way intersection. They should also be constructed according to the general design standards for crosswalks at four-way intersections.

On-street parking can sometimes interfere with crosswalks at three-way intersections. Some motorists parking on the through street have a tendency to block the crosswalk on that street. Appropriate pavement markings and signage should be used to clearly indicate the limits of the on-street parking and to discourage motorists from encroaching into the crosswalk. Parking enforcement efforts can also discourage this practice.

As previously stated, marked crosswalks should typically be provided on each leg of a three-way intersection. However, when two three-way intersections are located within proximity to each other, the multiple crossing opportunities can be confusing and distracting for motorists and pedestrians. At these offset intersections, it may be desirable to eliminate some of the crosswalks and enhance the remaining crosswalks, as shown in Figure 15. This technique can make the movements of motorists and pedestrians more predictable, which improves their safety.

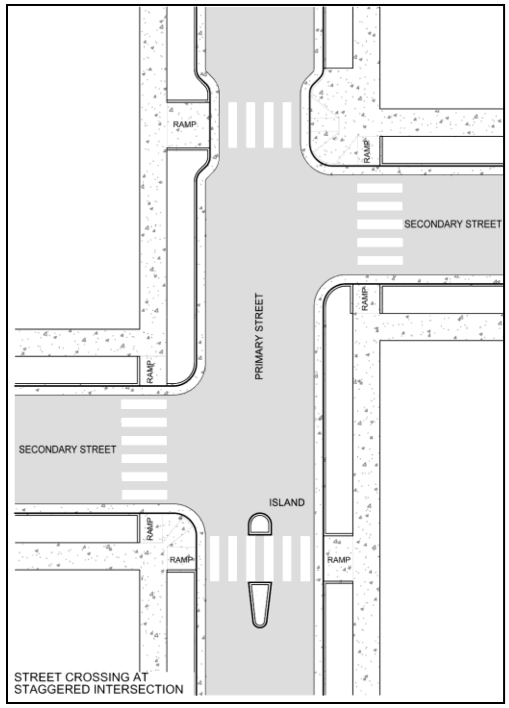


Figure 15: At offset, three-way intersections, it may be appropriate to eliminate some crosswalks and enhance the remaining crosswalks.

Additional Design Considerations for Skewed Intersections

Generally, good design practice calls for intersections to be designed with cross streets intersecting at right angles. Among the disadvantages of an intersection at which roads intersect at sharp angles: crosswalk distances increase significantly, motorists may make turns at a higher speed, and turning vehicles may approach pedestrians from behind rather than from the side.

In general, crosswalks are located on alignment with sidewalks. However, at some tangent intersections, particularly on wide streets, the crosswalk should be marked at right angles to cross-traffic, as illustrated in Figure 16. This reduces the amount of time that pedestrians are exposed to vehicles, reduces crossing distance, and is the instinctive path of travel for most pedestrians.

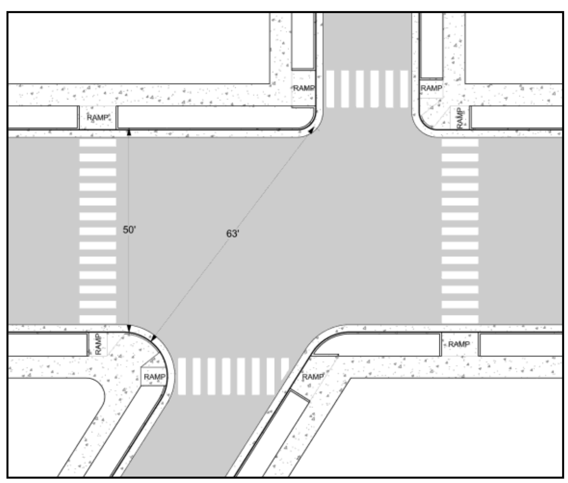


Figure 16: At a skewed intersection, shorter, safer crossing is usually more desirable to pedestrians than a direct crossing.

Additional Design Considerations for Mid-Block Crossings

In certain locations and when properly designed, mid-block crossings can improve pedestrian safety. However, when inappropriately used, they can create additional problems for pedestrians and motorists. Mid-block crossings should only be used in locations where traditional crosswalks are not adequately spaced or where there is a well-defined need for a pedestrian crossing. Also, a mid-block crosswalk should not be constructed unless an engineering study determines that the crossing is necessary and safe. The following locations may be suitable for mid-block crossings:

- Locations that have a high number of pedestrians crossing the road, where a mid-block crossing may serve to concentrate multiple crossings to a single location.
- School crossings.
- Locations where the optimal crossing location, which is not at an intersection, should be clearly identified.

Mid-block crossings should not be considered at the following locations:

- On roadways where traffic travels at 40 mph or greater, unless other treatments such as traffic calming, traffic signals with pedestrian signals, or other substantial crossing improvements are provided.
- Locations within 300 feet of another crossing, with the exception of locations that have a well-defined need for a mid-block crossing.
- Locations within 300 feet downstream of a traffic signal or transit stop.

Additional measures can be used to enhance mid-block crosswalks and improve pedestrian safety. These measures include the following:

- Reduce the roadway width at the crossing to promote lower vehicular speeds.
- Provide a pedestrian refuge median/island at the crossing to reduce the crossing width.
- Install warning signs or other traffic control devices.
- Provide adequate lighting.

Minimizing Crossing Distance

To reduce pedestrians' exposure to vehicular traffic, the length of crosswalks should be as short as possible. There are several methods that can be used to decrease the crossing distance at a crosswalk, yet still accommodate vehicular traffic. These methods include:

- Reducing the size of corner radii at intersections

- Reducing the width of vehicular travel lanes
- Reducing the number of vehicular travel lanes
- Constructing curb extensions
- Installing pedestrian refuge medians/islands

Reduced Curb Radii

As previously discussed, constructing smaller corner radii at intersections can significantly reduce the crossing distance for pedestrians, as shown in Figure 13. The corner radii at an intersection should only be as large as what is required to accommodate the types of vehicles that are expected to travel through the intersection. This practice will increase pedestrian safety while maintaining vehicular traffic flow.

Reduction in Travel Lane Width

The lengths of pedestrian crossings can also be shortened by reducing the width of the vehicular travel lanes. As stated in *AASHTO's A Policy on Geometric Design of Highways and Streets*, "…there are circumstances where lanes less than 12 feet wide should be used. In urban areas where pedestrian crossings, right-of-way, or existing development become stringent controls, the use of 11-foot lanes is acceptable. Lanes 10 feet wide are acceptable on low-speed facilities, and lanes 9 feet wide are appropriate on low-volume roads in rural and residential areas."

Reduction in Number of Travel Lanes

Reducing the number of vehicular travel lanes, or conducting a "road diet", can reduce pedestrian crossing distances and create space for additional pedestrian facilities, bicycle facilities, medians/islands, on-street parking, or landscaping. This concept is illustrated in Figure 17.

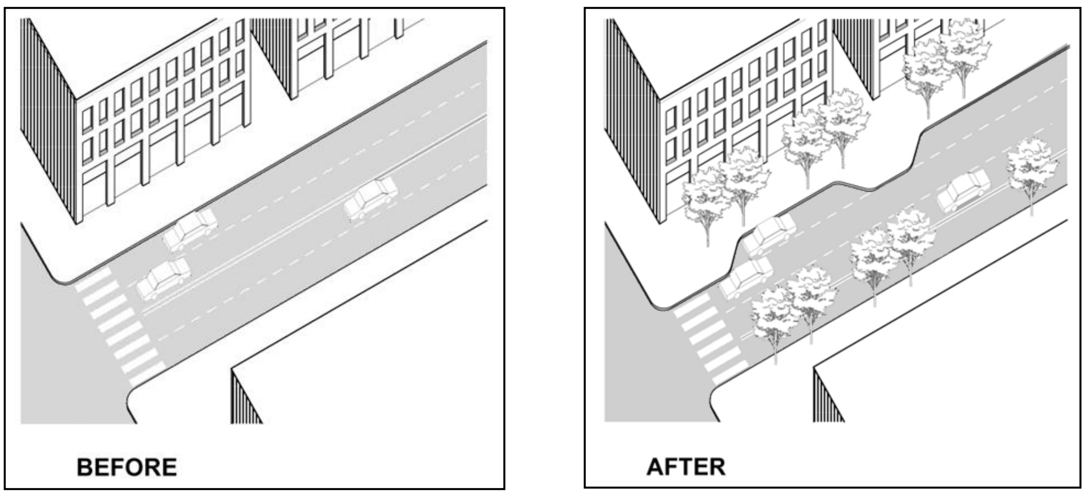


Figure 17: On some roadways, the number of travel lanes may be reduced, which will result in shorter pedestrian crossings.

Road diets often result in improved traffic operations. The ideal roadway for a road diet is typically a four-lane road that has an average daily traffic (ADT) volume of approximately 12,000 to 18,000 vehicles per day, although roads with higher ADT's can benefit from road diets. In some situations, the level of service at an intersection may decrease as a result of a road diet. However, the reduction in the level of service at an intersection may be worth providing improved pedestrian crossings and pedestrian corridors. Before reducing the number of lanes on a particular roadway, an engineering study should be conducted to determine if a road diet is an appropriate solution.

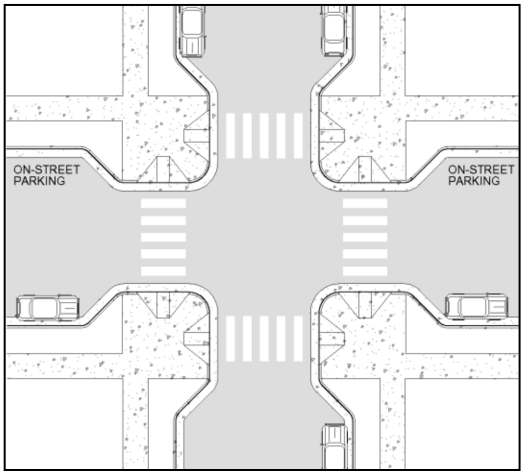


Figure 18: Curb extensions can be used to reduce pedestrian crossing distance at intersections and at mid-block crosswalks.

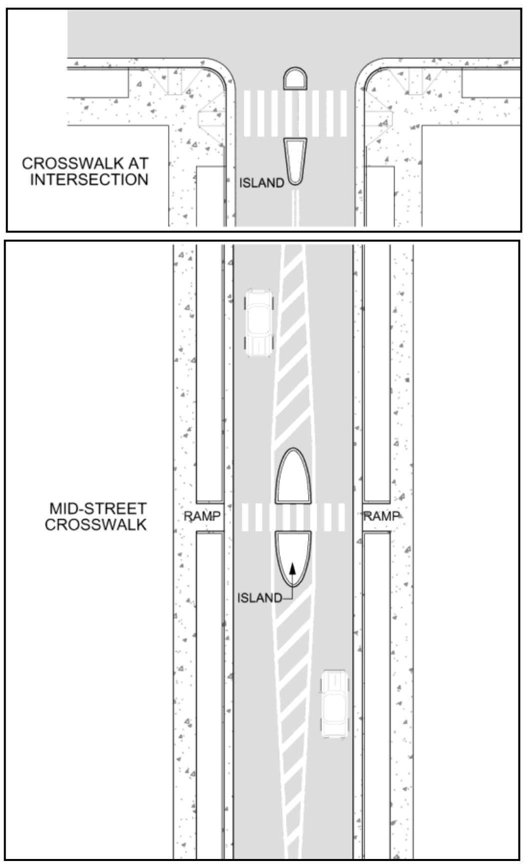


Figure 19: Pedestrian refuge medians/islands provide a safe waiting area for pedestrians who are crossing the roadway.

<u>Curb Extensions</u>

Curb extensions reduce the width of a roadway for a short distance. As shown in Figure 18, curb extensions are often used at intersections in downtown areas, and the additional lanes that are created between consecutive curb extensions are typically used for on-street parking. Curb extensions can also be beneficial at mid-block crosswalks and at three-way intersections. There are many benefits that can be gained from using curb extensions. These include:

- Increasing visibility between pedestrians and motorists.
- Preventing vehicles from parking in locations that block crosswalks, sidewalk ramps, and sight lines.
- Providing additional curb/ sidewalk space, which can be used for other functions, such as transit stops, benches, or bike racks.

<u>Pedestrian Refuge Medians/Islands</u>

Pedestrian refuge medians/islands, as shown in Figure 19, provide waiting areas for pedestrians and prevent the need for pedestrians to cross both directions of vehicular travel at the same time. They may be installed at intersections or at mid-block crosswalks, and are particularly beneficial on wide, higher-speed roadways. Pedestrian refuge medians/islands should be considered in locations where the pedestrian crossing distance is greater than or equal to 60 feet, which is equivalent to a five-lane roadway. Pedestrian refuge medians/islands can also be beneficial on some roadways that have shorter crossing distances.

Pedestrian refuge in median

Pedestrian refuge medians/islands offer the following benefits:

- They help define the pedestrian crosswalk.
- They can provide protection from motor vehicles.
- They reduce crossing times for pedestrians.
- They can accommodate a pedestrian crossing sign, which helps to alert motorists of the pedestrian crossing.

Additional Crosswalk Enhancements

<u>Raised Crosswalks</u>
A raised crosswalk is a modified speed table. By adding crosswalk markings to a speed table, a raised crosswalk can be a good application where a high-visibility mid-block crossing is warranted, such as at a school, trail crossing, or other high-volume mid-block location.

2.10 PEDESTRIAN SIGNALS

Guidelines for installing pedestrian signals are presented in the *Manual on Uniform Traffic Control Devices* (MUTCD), which is a publication by the U.S. Department of Transportation Federal Highway Administration. As stated in the MUTCD, pedestrian signals "shall" be used in conjunction with vehicular traffic control signals under any of the following conditions:

- If an engineering study determines that traffic signal control is warranted based on Warrant 4, Pedestrian Volume, or Warrant 5, School Crossing.
- If an exclusive pedestrian signal phase is provided at a signalized intersection.
- If there is an established school crossing at a signalized location.
- If there are multi-phase signal timings that might confuse pedestrians, such as split-phase timing.

The MUTCD also states that pedestrian signals "should" be used under the following conditions:

- If an engineering study determines that a pedestrian signal would reduce vehicle/pedestrian conflicts.
- If pedestrians are only permitted to cross a portion of the street during a single phase interval, such as at a pedestrian refuge median/island that

has a waiting area.

- If the vehicular traffic signals are not visible to pedestrians crossing the street, or if they do not give sufficient guidance to pedestrians.

Pedestrian Signal Indications

The MUTCD provides guidance regarding the symbols and illumination that shall be used in pedestrian signals to identify the "Walk" and the "Don't Walk" phases. The "Upraised Hand" is used to symbolize the "Don't Walk" phase, and the "Walking Person" is used to symbolize the "Walk" phase. The MUTCD states the pedestrian signal indications have the following meanings:

- The steady "Walking Person" symbol means that pedestrians who are facing the signal may start to cross the road in the direction of the indication. However, this movement may be in conflict with turning vehicles.
- The flashing "Upraised Hand" symbol means that pedestrians should not start to cross the road in the direction of the signal, but that any pedestrians who are already crossing the road may proceed.
- The steady "Upraised Hand" symbol means that pedestrians are not permitted to enter the roadway in the direction of the symbol.

Countdown Pedestrian Signal

In addition, the proposed MUTCD recommends all new and existing pedestrian signal heads include a pedestrian change interval countdown display unless the duration of the pedestrian change interval is 3 seconds or less. The countdown pedestrian signal is to be located adjacent to the associated "Upraised Hand". The display of the remaining number of seconds should begin at the beginning of the pedestrian change interval and is to display the number of seconds remaining until the termination of the pedestrian change interval.

Countdown pedestrian signals can reduce pedestrian delays and can discourage pedestrians from entering the crosswalk near the end of the pedestrian clearance interval. However, they are not accessible to sight-impaired pedestrians. Also, the lack of consistency as to when the countdown begins can be confusing to pedestrians who are not familiar with the intersection.

Accessibility

Sight-impaired pedestrians often rely on the noise of traffic to determine when to cross the road. Quiet vehicles, vehicles turning right on red, pedestrian-activated signals, wide streets, and low traffic volumes can reduce the effectiveness of this technique. To assist sight-impaired pedestrians, *Accessible Public Rights-of-Way Planning and Designing for Alterations* requires pedestrian signal systems, where provided, to include both audible and vibrating indications of the "Walk" phase. Typically, this can be accomplished with a small device that emits an audible tone or a voice message and vibrates when the "Walk" phase begins. This device also includes a small directional arrow that indicates the direction of the crossing. The current and proposed ADA guidelines should be carefully reviewed before installing a pedestrian signal to ensure the signal conforms to the latest ADA guidelines.

Pushbuttons

Pedestrian signal pushbuttons are typically used at intersections that do not provide a regular "Walk" interval with each signal cycle or at intersections where the vehicular signal does not provide enough crossing time for pedestrians. At such intersections, pedestrian signal pushbuttons allow pedestrians to activate a sufficiently-timed "Walk" phase by depressing the pushbutton. Signalized intersections should be designed to include a "Walk" phase with each signal cycle. However, if this is not practical, then a pedestrian signal pushbutton should be installed for both directions of travel at each crosswalk with a supplemental plaque and tactile arrow indicating the crosswalk signal activated by the pushbutton.

Pedestrian Pushbutton

Design Considerations

Pedestrian signal pushbuttons should be easy to use and should clearly indicate to pedestrians when and where they may cross the street. The following design considerations should be applied when installing a pedestrian signal pushbutton:

- The pushbutton should be located within five feet of the extension of the crosswalk lines and within ten feet of the curb, shoulder, or pavement.
- Pushbuttons that are located on the same street corner should be separated by at least ten feet.
- The pushbutton should be accessible from the level landing at the top of the curb ramp.
- The pushbutton should be oriented toward the pedestrian and should be visible from the pedestrian's crossing position.

- The pushbutton should include an arrow that clearly indicates which crosswalk is affected by the pushbutton.
- The pushbutton should include a sign that displays instructions for operating the pushbutton and the pedestrian signal.
- Pushbuttons should be provided for every leg of a signalized intersection that does not have a regular “Walk” interval incorporated into the signal cycle.

Accessibility

The current and proposed ADA guidelines contain accessibility standards for pedestrian signal pushbuttons. These standards include regulations such as requirements for locator tones, the dimensions of pushbuttons, and the force required to activate pushbuttons. As recommended in *Accessible Public Rights-of-Way Planning and Designing for Alterations,* pedestrian signal pushbuttons should provide a locator tone for sight-impaired pedestrians. However, both the current and proposed ADA guidelines should be carefully reviewed when installing pedestrian signal pushbuttons to ensure the design conforms to the guidelines.

Pedestrian Signal Timings

The MUTCD and the current and proposed ADA guidelines include recommendations for pedestrian signal timings. When in conflict, it is recommended that the guidelines presented in the *Accessible Public Rights-of-Way Planning and Designing for Alterations* be followed since these guidelines are more stringent.

“Walk” Phase

The “Walk” interval should last for at least seven seconds, although, there are situations where a shorter “Walk” interval may be appropriate. In order to maximize the safety of pedestrians, “Walk” intervals of at least seven seconds are recommended.

At many intersections, the vehicular traffic signal timings result in pedestrian crossing times in excess of seven seconds. Often, this additional time is applied to the flashing “Don’t Walk” phase. This practice results in pedestrian delay and can confuse pedestrians who do not realize that they have plenty of time to cross the street. It is recommended that any additional pedestrian crossing time be applied to the “Walk” phase.

Flashing “Don’t Walk” Phase

The length of the “Don’t Walk” interval should be based on the crossing distance and the pedestrian travel speed. As recommended in *Accessible Public Rights-of-Way Planning and Designing for Alterations*, the crossing distance should be calculated as the sum of the crosswalk length plus the length of one curb ramp. The pedestrian travel speed should be assumed to be 3.5 feet per second.

Steady "Don't Walk" Phase
The timing of the steady "Don't Walk" phase is typically determined by the vehicular traffic signal timings. This phase is typically equal to the time in which the parallel traffic has a red light.

Animated Eye Pedestrian Signals

Animated eye pedestrian signals can be used in conjunction with conventional pedestrian signals. Animated eye pedestrian signals display eyes that scan from left to right to encourage pedestrians to look for turning vehicles when crossing the roadway. Animated eye pedestrian signals should be considered at signalized crossings that have a high level of conflicts between pedestrians and turning vehicles. However, overuse of these signals may reduce their effectiveness because pedestrians may become accustomed to them and ignore them.

HAWK (High Intensity Activated CrossWalK)

The HAWK (High-intensity Activated CrossWalK) signal is similar to the pedestrian crossing signal but has a different signal operation. The HAWK signal is activated by a pedestrian pushbutton. The overhead signal begins flashing yellow and then solid yellow, advising drivers to prepare to stop. The signal then displays a solid red and shows the pedestrian/cyclist a "Walk" indication.

This treatment is profiled in ITE's *Traffic Control Devices Handbook* and is proposed to be included in the revised 2009 MUTCD.

2.11 TRANSIT STOPS

Public transportation systems are an important component of the transportation network. They help to reduce traffic congestion by combining many would-be single occupant vehicles (SOV) into one vehicle. They also provide dependable transportation for those who cannot drive because they are too young, too old, or do not have access to a vehicle.

A healthy public transportation system can greatly improve the quality of life for a community. The reverse is also true. A poorly-designed and poorly-maintained public transit system can make a community appear less desirable and can make travel within the community more difficult, especially for those who rely solely on the transit system for transportation. In order to ensure the health of a transit system in a community, the public transportation system must be a viable transportation option. Transit facilities must be safe, convenient, comfortable, and accessible.

Because every transit trip begins and ends with walking, public transportation systems rely heavily on pedestrian facilities. Well-designed pedestrian facilities can greatly enhance the usability of a transit system. Pedestrian corridors should provide accessible and direct connections between transit stops and daily destinations, such as schools, office buildings, shopping centers, and recreational facilities. Transit stop facilities are equally important. Bus stops should be accessible to everyone, including those with mobility and/or sight impairments. Bus stops should also be safe and should provide adequate lighting. Comfort features, such as sheltered seating and shade, should be incorporated into bus stops to make public transportation pleasurable and to promote transit usage. Accessory facilities, such as trash receptacles, bike racks and lockers, and transit/community information centers, should also be incorporated.

Transit stops should be highly visible and should be provided at convenient intervals along a transit route. To increase user safety, bus stops should be located on the far side of an intersection, as shown in Figure 20. This practice encourages pedestrians to cross the street behind the bus, which provides them with a clear view of oncoming vehicles. Bus stops that are placed on the near side of an intersection require pedestrians to cross the street in front of the bus. This practice causes the pedestrians view of oncoming traffic to be blocked by the bus.

Bus stops that are placed on the far side of an intersection can also provide better merging opportunities for buses. This is because the traffic control at the intersection provides gaps in the traffic flow, which allows the buses to more easily merge back into traffic after completing a stop. Far side stops are also preferred over near side stops when right turn lanes are present. If placed on the near side, the bus stop would require the bus to block the right turn lane during the stop. The far side stop eliminates this issue.

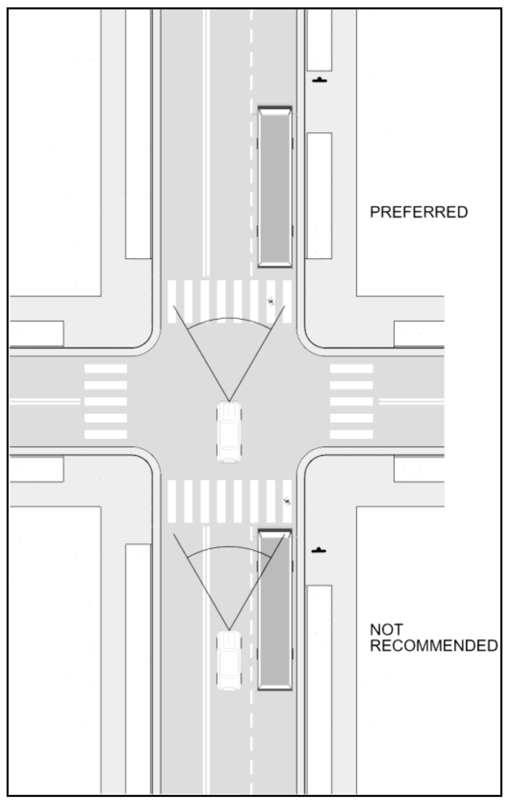


Figure 20: Transit stops located on the far side of an intersection are safer than those on the near side since they increase motorists' and pedestrians' visibility of each other.

As with other pedestrian and roadway features, bus stops should not block the pedestrian travelway. Bus stop benches, shelters, and signs should be placed in the buffer strip or the frontage zone of the sidewalk corridor. If the transit facilities are placed in the buffer strip, then the sidewalk should extend to the curb allowing easy access to transit facilities. The waiting area for the bus stop should be concrete. If located in the buffer strip, then the waiting area should be at least eight feet wide and 25 feet long. If located in the frontage zone, the waiting area should be at least six feet wide and 12 feet long.

As previously stated, transit stops should be located at regular intervals along the transit route. However, excessive stops should be avoided. Bus stops that are not regularly used should be evaluated to determine if they are needed. Similarly, bus stops that are placed within close proximity to each other should also be evaluated to determine if some of these stops can be eliminated. Eliminating unnecessary stops will improve the efficiency of the transit system and will provide space for other pedestrian features, such as landscaping, newspaper stands, or sidewalk cafes.

2.12 ENCROACHMENTS

Sidewalks are often rendered impassible due to encroachments that occur along the sidewalk corridor. These encroachments are in violation of the ADA and tend to discourage pedestrian activity. Efforts should be made to improve pedestrian travelways by eliminating existing encroachments and preventing future encroachments.

Vegetation

Overgrown vegetation can reduce the usable width of the pedestrian travelway. The horizontal and vertical clearances identified in the ADA guidelines should be maintained along all sidewalk corridors. This is especially important for sight-impaired pedestrians. Local ordinances require property owners to prevent vegetation on their property from encroaching into the sidewalk. However, many property owners are not aware that this is their responsibility. Efforts should be made to notify property owners who are in violation of this regulation.

Parked Vehicles

Parking lots that are placed adjacent to the sidewalk can sometimes result in the parked vehicles extending over the sidewalk. Ideally, parking lots should be separated from the sidewalk by a landscaped buffer. However, other measures can be used to prevent parked vehicles from encroaching into the pedestrian travelway. Curbs or wheel stops can be installed to limit how close to the sidewalk vehicles can park.

Gravel

Gravel on unpaved driveways tend to migrate onto the sidewalk as vehicles exit the driveway. The loose gravel that collects on the sidewalk can be dangerous for pedestrians and can render the sidewalk impassible for pedestrians who have limited mobility, especially for those who use wheelchairs. As with vegetation, property owners are required to prevent gravel from their property encroaching onto the sidewalk. Property owners in violation of this regulation should be notified of their responsibilities. To prevent future gravel encroachments, gravel driveways should be paved for a distance of five feet behind the sidewalk. The *Driveways* section of the Pedestrian Facilities Design Guidelines provides additional information regarding gravel driveways.

Construction Zones

Signage and traffic control devices are used to guide motorists through construction zones. However, in many cases little or no consideration is given to pedestrians in construction zones. When sidewalks are closed without proper guidance to alternate pedestrian routes, pedestrians are left to navigate the construction zone by traveling in the street. This is dangerous since construction zones can be unfamiliar and confusing for motorists as well as pedestrians.

Like motorists, pedestrians need proper guidance through construction zones. Alternate pedestrian routes should be provided and should have the following characteristics:

- The routes should be direct and convenient and should follow, as much as possible, the route of the sidewalk prior to construction.
- The routes should be clearly signed so that they are obvious to pedestrians and motorists.
- The routes should present the safest options for navigating through the construction zone. If the routes do not appear to be safe, then pedestrians will not be inclined to use the designated routes. Adequate lighting should also be provided along the alternate route to enhance pedestrian safety.
- Adequate notice of the alternate pedestrian route should be provided in advance of the construction zone. This is particularly important if a street crossing is necessary to access the designated alternate route.
- Like sidewalks, the alternate pedestrian route should separate pedestrians from motorists. In some situations, this may require that a physical barrier be placed to create a travelway for pedestrians along the roadway.
- Any roadway crossings that are associated with the alternate pedestrian route should provide adequate crossing facilities. These facilities should include crosswalks and, at signalized intersections, pedestrian signals.

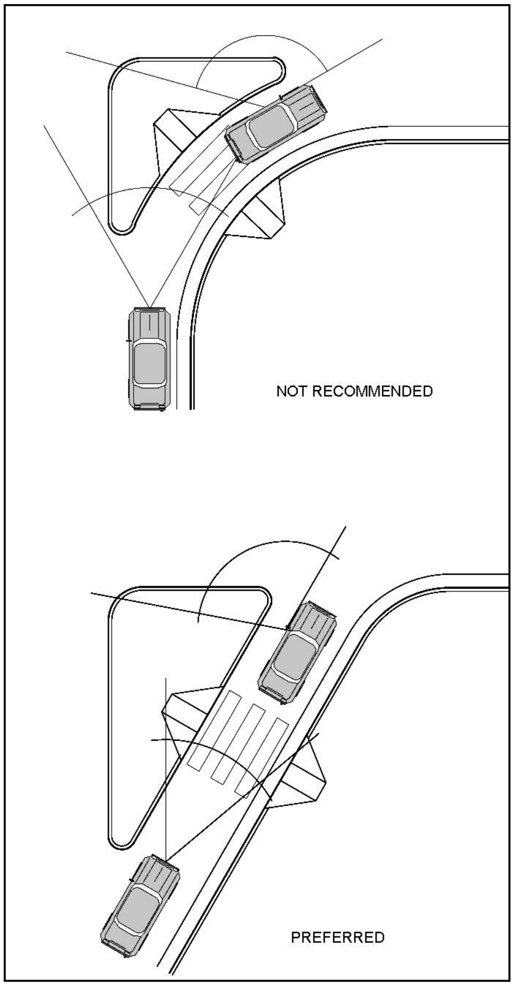


Figure 21: Straight, angled right turn slip lanes, as shown in the bottom figure, increase motorists' and pedestrians' visibility of each other. Circular slip lanes, as shown in the top figure, reduce the visibility between motorists and pedestrians.

Right Turns

Motorists who are turning right at an intersection can create problems for pedestrians who are crossing the intersection. Right-turning motorists are typically looking to their left, in the direction of oncoming traffic, when making the right turn. They tend to not notice pedestrians who are crossing the intersecting roadway on their right side. Similarly, pedestrians are typically looking for through traffic on the street that they are crossing and tend to not notice the right-turning vehicles on the intersecting street. As a result, conflicts often arise between right-turning motorists and pedestrians. The two types of right-turning situations that create the most conflicts are right-turns on red and right turns from slip lanes. Methods for improving these situations are described below.

Right Turns on Red

Unless specifically prohibited, motorists may legally turn right on red at a signalized intersection. This practice can be dangerous to pedestrians since the vehicles turning right on red may travel though the crosswalk on the intersecting street during the pedestrian "Walk" signal phase.

According to the MUTCD, right turns on red should be prohibited at signalized intersections that provide an exclusive pedestrian phase or have frequent conflicts between motorists and pedestrians. At locations where right turns are prohibited, a "No Turn on Red" sign should be installed.

The MUTCD recognizes that it may be desirable to allow right turns on red at some intersections. If right turns on red are permitted at a signalized intersection and the crosswalks are marked, then a "Turning Traffic Must Yield To Pedestrians" sign should be installed.

Right-Turn Slip Lanes

A right-turn slip lane allows motorists to turn right at a signalized intersection without being controlled by the traffic signals. Slip lanes often do not have stop controls, which encourages higher turning speeds. The higher speeds and lack of signal control make slip lanes dangerous for pedestrians who are crossing the roadway.

Slip lanes should not be provided at intersections that have a high volume of pedestrian traffic. However, where vehicular traffic volumes justify the use of a slip lane, there are some design principles that can be applied to increase pedestrian safety. These principles are:

- Install a curb along the island that separates the slip lane from the intersection.
- Provide a pedestrian travelway through the island, which will serve as a pedestrian refuge. The pedestrian travelway should be ADA compliant and should include sidewalk ramps at the curb.
- Provide a marked crosswalk across the slip lane. The crosswalk can be enhanced by providing pedestrian crossing signage and by requiring motorists to yield to pedestrians in the crosswalk.
- Require right-turning traffic to merge into the through lane on the cross-street. Slip lanes that provided dedicated lanes on the cross-street encourage higher travel speeds since motorists do not have to yield to cross-street traffic.
- As illustrated in Figure 21, construct the slip lane so that it forms the hypotenuse of the right triangle created by the intersecting roadways. This design increases motorists' and pedestrians' visibility of each other. The circular slip lane that is commonly used decreases visibility between motorists and pedestrians.

2.13 RELATED PLANNING ISSUES

Land Use

The practicality of walking is often determined by the pattern in which land is developed. Given the proper facilities, most people are willing to walk for about fifteen minutes, or one-half mile, for transportation trips. This distance has become a benchmark planning principle for those designing walkable communities. Almost all driving, transit and bicycling trips also include walking at both ends, making walkability a critical issue at almost every destination.

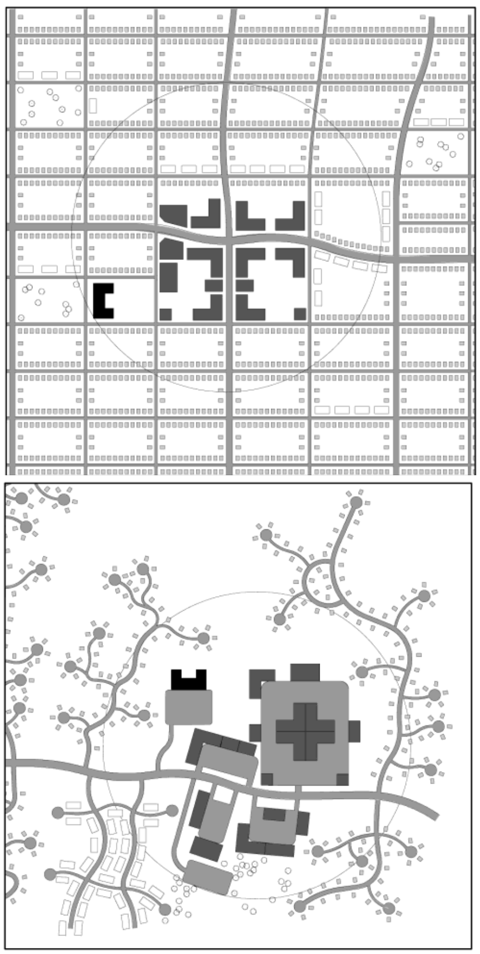


Figure 22: The top illustration shows a half-mile radius around the commercial center of a densely developed, mixed-use area with a grid network of streets. This development pattern encourages walking and bicycling. The illustration at bottom shows a low-density, segregated development pattern, which limits practical pedestrian and bicycle travel.

Some land use patterns that encourage walking include:

- Development densities that allow people to live close to destinations such as schools and stores.
- Mixed-use zoning that allows commercial and residential land uses in the same area, along with standards that ensure compatible building design.
- Locating buildings close to the street, which can slow traffic and offers easier pedestrian access.

Some common land development practices that discourage pedestrian travel include:

- Segregated land uses that create long distances between destinations.
- Commercial properties set far back from the street with large parking lots in between. Such sites also typically include access for automobiles only.
- Large lots in residential areas that create greater distance between home and other destinations.

The top example in Figure 22 illustrates a land use pattern that encourages various types of travel. As shown, the mixed-use development within the grid pattern, and the proximity to residential areas promotes walking or biking to various destinations. The illustration at the bottom shows how segregated developments discourage walking and bicycling to these destinations because of the distances from homes and between the destinations themselves.

Roadway Network

In the decades following World War II, planning practices shifted from traditional urban patterns to non-grid road systems with cul-de-sacs and other features that reduce connectivity. This approach tends to concentrate traffic on collector and arterial streets, which can result in single points of access to many destinations, and often requires significant out-of-direction travel. While indirect travel routes aren't always a major deterrent to drivers, they can result in added travel time and inconvenience for pedestrians. An interconnected grid of streets offers many routes and points of access to destinations for pedestrians, cyclists and motorists. As illustrated in Figure 23, when retrofitting a non-grid network, off-street connector trails can sometimes provide the directness of route – to schools, shopping, or other destinations – that the street system doesn't offer. For example, providing a connector trail from the end of a neighborhood cul-de-sac to a library can decrease parking demands at the library and reduce the vehicular load on nearby roadways.

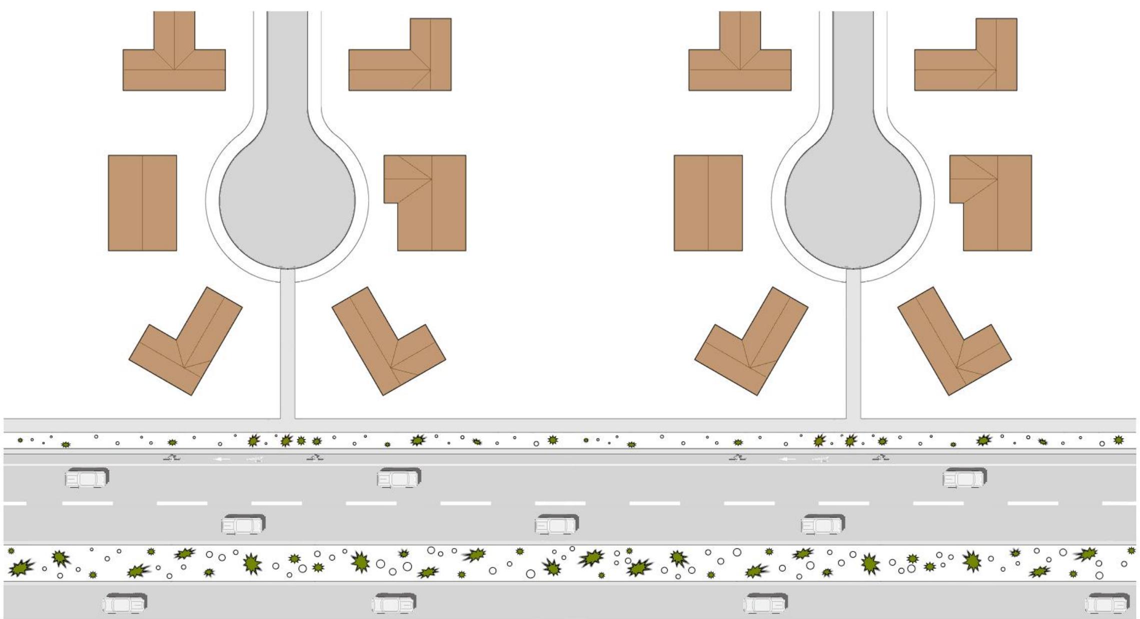


Figure 23: In subdivisions with cul-de-sacs, pedestrian connectors can be provided for more direct access to destinations.

Access Management

Urban collectors and arterials with commercial frontage are attractive to both pedestrians and drivers because they usually provide the best access to

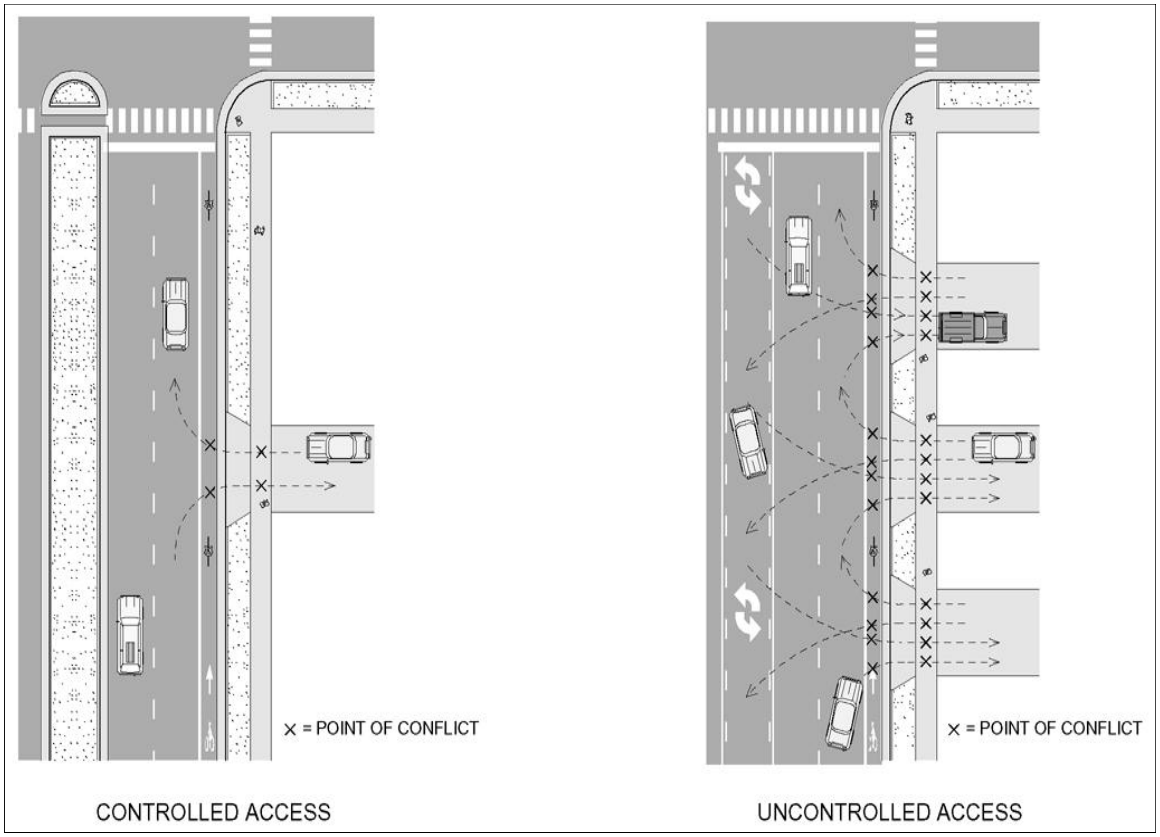


Figure 24: Access management reduces the number of conflict points between motorists, bicyclists, and pedestrians.

destinations, and the most direct routes through a community. Although traffic speeds and volumes on such roadways can discourage walking, it is the intersections, driveways, and curb cuts where accidents are most likely to occur. Unlimited access creates many conflicts between cars entering or leaving the roadway, and pedestrians walking along the roadway, as illustrated in Figure 24.

Limiting or consolidating driveways, and using other access management design tools such as curbed medians benefits both pedestrians and drivers. Advantages include:

- Reducing the number of conflict points.
- Redirecting vehicles to intersections with appropriate traffic control devices.
- Improving traffic flow in an attempt to reduce the need for road widening, perhaps allowing part of the right-of-way to be reclaimed for pedestrian facilities.

Studies have also shown that access management techniques can effectively improve safety and traffic flow without negatively impacting adjacent businesses. It is recommended that access management designs also consider the potential for negative impacts on pedestrians. For example, pedestrian crossing opportunities should not be reduced and redirecting motor vehicle traffic should not significantly increase out-of-direction travel for pedestrians.

Roadway Design Standards & Land Development Regulations

Local jurisdictions within the Nashville MPO should adopt roadway design standards that include cross-sections to accommodate the pedestrian facilities. Additionally, local jurisdictions should update their local subdivision and zoning regulations to encourage provisions and standards that promote pedestrian accommodations as part of the land development process.

3.0 BICYCLE FACILITIES GUIDELINES

In recent years, the benefits of bicycling have been recognized more and more by transportation officials and the public. Although cycling is already a popular form of recreation, a growing number of people are commuting by bicycle and otherwise cycling for transportation. As a result, cities throughout the country have been working to make cycling a safer and more accessible option for their communities.

In order for such efforts to be successful, it is important that accommodations for bicycling be considered early in the planning phase, and fully integrated into transportation projects. Well-designed bicycle facilities should be safe, convenient, and comfortable to encourage bicycle travel.

3.1 PURPOSE OF THE DESIGN GUIDELINES

The purpose of the bicycle facility design guidelines section is to provide guidance to engineers, planners, designers, and others in safely integrating a bicycle infrastructure into the existing and future transportation system in the Nashville MPO region. These guidelines are intended to provide useful technical information about bicycle facilities in order to create a bicycle-friendly community with consistent design standards. Consistent designs allow bicyclists to be prepared for the types of facilities that they will encounter, and they allow cyclists and motorists to operate predictably with each other. Consistency and predictability are essential to providing a safe and efficient multi-modal transportation system.

These guidelines are based primarily on the national guidelines established by the American Association of State Highway and Transportation Officials' (AASHTO) 1999 *Guide for the Development of Bicycle Facilities* and the U.S. Department of Transportation Federal Highway Administration's 2003 edition of the *Manual on Uniform Traffic Control Devices* (MUTCD). Additional documents, such as the Institute of Transportation Engineers' 2002 *Innovative Bicycle Treatments* and various state design manuals, were also used in the development of the design guidelines. Also included are design standards and techniques that have been successful in communities throughout the country.

The guidelines have been developed in response to the characteristics and conditions of the Nashville MPO region. However, the guidelines cannot address every design issue that may arise. In locations where issues are not covered by the design guidelines, appropriate engineering judgment should be applied.

3.2 BICYCLE LANES

A bicycle lane is a portion of the roadway cross-section that has been designated for the preferential or exclusive use of bicyclists by striping, pavement markings, and signage. Bike lanes should be one-way facilities located on both sides of the roadway, in order to carry bicycle traffic in the same direction as adjacent motor vehicle traffic. On one-way streets, bike lanes should be on the right side of the road. Bike lanes are highly regarded by many cyclists because of the safety benefits they provide to cyclists.

Bike lanes are typically considered to be the most desirable facility for higher-volume, urban roadways, including collector roadways. On such roadways, bike lanes benefit both bicyclists and motorists by segregating users, thereby increasing overall capacity. In addition, bike lanes provide a defined area for bicycle travel, decrease sudden lane changing by roadway users, and help to make cyclists feel more confident.

Width

It is recommended that bike lanes be at least four to six feet in width. However, exact bike lane width should be determined by the type of roadway. Bike lanes on roadways without curb and gutter should have a minimum width of four feet. For roadways with curb and gutter, the bike lane should be at least four feet wide, and should be measured from the gutter pan seam. Bike lanes located next to on-street parking, guardrails or the face of a curb are recommended to have a minimum of five feet in width. Bike lane width is recommended to be increased to six feet when the following roadway conditions are present:

- Streets with high traffic volumes
- Heavy vehicle volumes are high
- Steep grades
- Bike lane is adjacent to parking and parking turnover is moderate to heavy

Bike lanes in excess of six feet are generally not recommended, since they can be used for parking or conventional travel lanes.

Pavement Markings

Bicycle lanes should be delineated from conventional travel lanes by a six-inch, single, solid white line. An additional solid white line can be placed between the bike lane and parking lane to encourage motorists to park closer to the curb and to discourage motorists from using the parking lane as a travel lane. This line should be four inches wide.

Standard pavement markings, as shown in Figure 25, should be placed within bike lanes to indicate the designated space for cyclists. Bicycle lane markings, including symbols and a directional arrow, should be placed after every major intersection, at least 65 feet from the intersection. Symbols and arrows should be located at least every 1,000 feet between intersections.

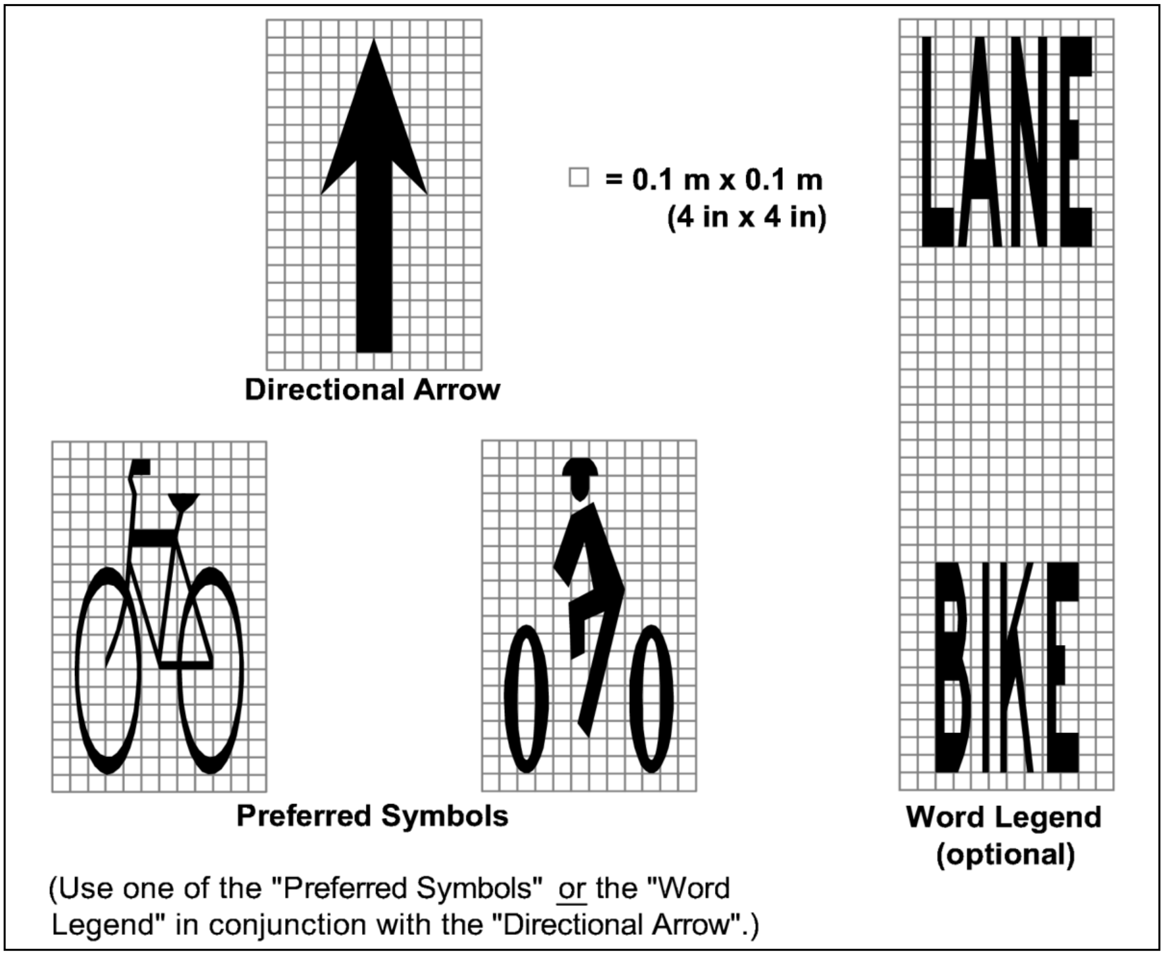


Figure 25: Typical bike lane symbols, as shown above, are used in bike lanes to indicate designated bicycle use and direction of travel.

Standard pavement markings for bicycle lanes should be white, retro-reflectorized, and created using durable, skid-resistant material. If possible, it is recommended that pavement markings be located out of the path of motor vehicle crossings to maintain the life of the markings. At bus stops, bike lanes should be striped with dashed lines to indicate where buses are expected to merge into the bike lane in order to reach the curb.

It should be noted that the diamond symbol, which was recommended in the past, is no longer used for bike lanes. This symbol is now associated with High Occupancy Vehicles (HOV) lanes and other motor vehicle facilities. It is recommended that the diamond symbol in existing locations be eliminated as part of regular maintenance.

Bike Lanes Adjacent to Parking Lanes

Bike lanes are often installed adjacent to on-street parking. Figure 26 shows bike lanes on a street with and without on-street parking. As mentioned previously, bike lanes on streets with parking should be at least five feet wide to provide additional space to avoid opening car doors and car mirrors, and to maneuver around vehicles moving into and out of the parking lane. A width of six feet is desirable when parking turnover is significant. AASHTO states that the minimum combined width for the bike lane and the parking lane should be 12 feet. Where on-street parking is present, the bike lane should always be placed between the parking lane and the conventional travel lane, never between the parking lane and the curb. Diagonal parking can cause visibility problems for cyclists and is generally not recommended on streets with bike lanes.

Bike Lanes next to Adjacent On-Street Parking

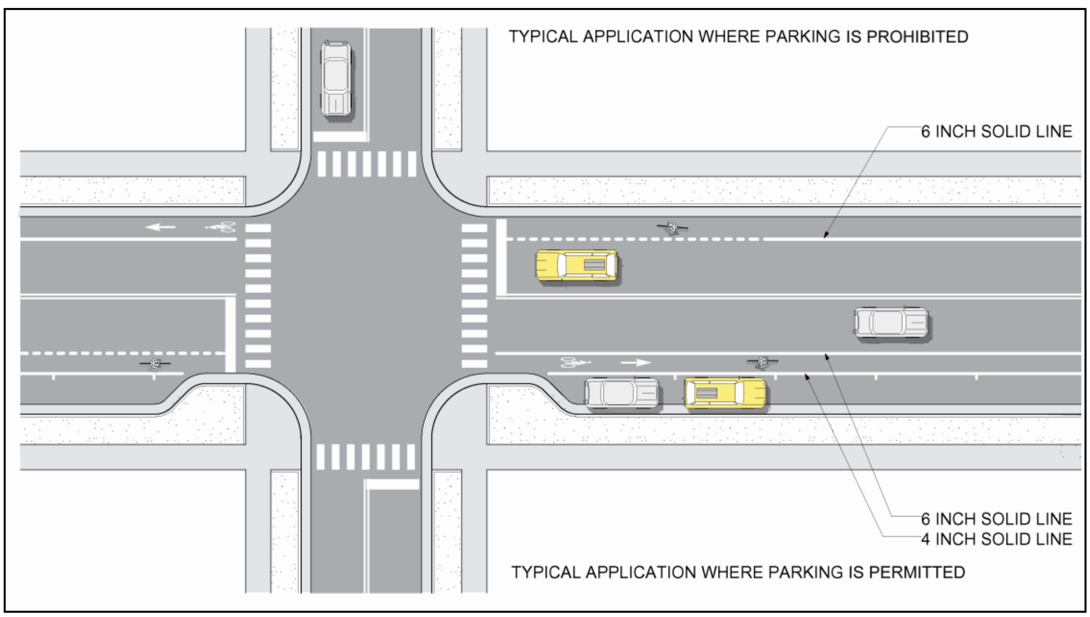


Figure 26: This figure shows bike lanes on a street with and without on-street parking. Note that the curb extensions do not extend into the bike lanes on the side with on-street parking.

Bus/Bike Lanes

Where pavement width allows, a five to six-foot wide bike lane should be provided between the bus lane and conventional travel lanes. A shared lane for buses and bicycles is an option in locations where a bus lane is present, but there is not adequate room for separate bus and bicycle lanes. Both scenarios are illustrated in Figure 27. Shared bus/bike lanes can reduce conflicts with bicyclists, buses, and cars and can increase cyclist safety when used appropriately.

Shared Bus/Bike Lane

Shared bus/bike lanes are generally used on streets with relatively high automobile traffic, but light, or express, bus traffic. Shared bus/bike lanes with very high bus volumes can create significant conflicts with bikes. It should be noted that right turning vehicles are usually allowed in bus/bike lanes at intersections, and cars remaining in this lane between intersections can cause problems for cyclists. In locations where shared bus/bike lanes are used, the recommended lane width is at least 14 feet.

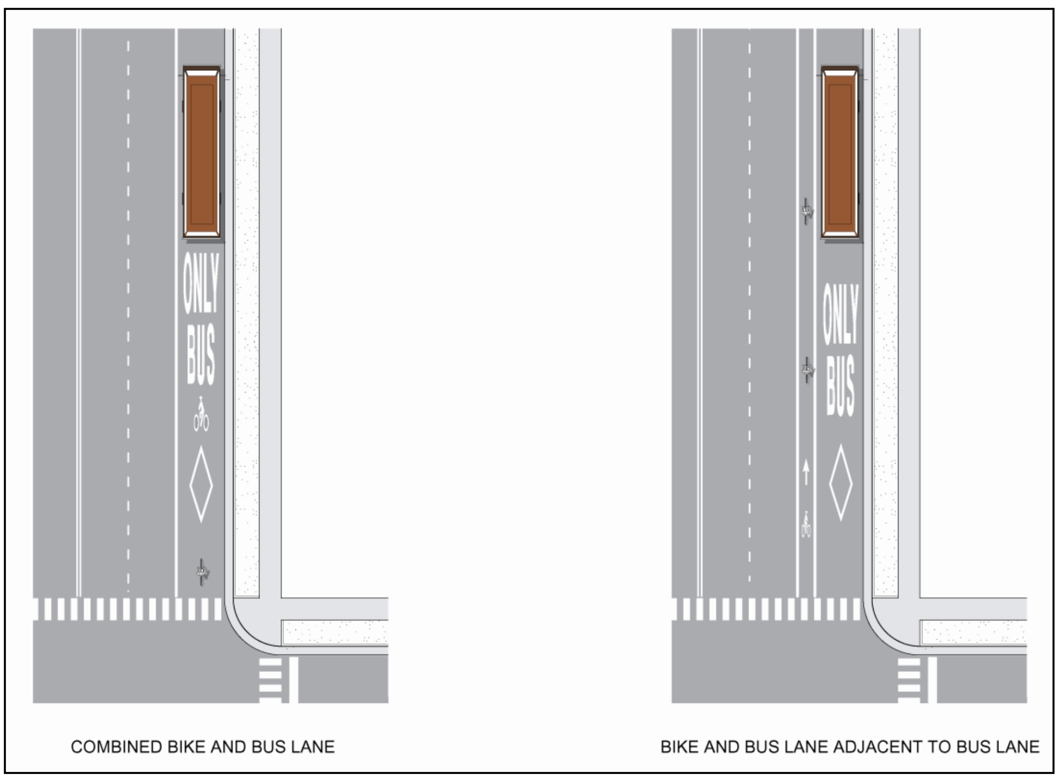


Figure 27: Bike lanes can share a lane with bus traffic, as shown to the left. If pavement width allows the preferred design is to provide a separate bike lane, as shown on the right.

Shoulder Bikeways

In many cases, the use of paved shoulders in rural areas or on roadways without curb and gutter is a good way to incorporate bicycle facilities. Shoulder bikeways are beneficial to all roadway users in that they provide added space for motorist emergencies and emergency vehicles, improve highway capacity and sight distance, and help to maintain the edge of the roadway. Although shoulder bikeways are typically not striped exclusively for bicycles because of their range of functions, they are still able to provide a cost-effective solution for accommodating bicycle travel on rural roadways.

To most safely accommodate bicycle travel on shoulder bikeways, it is generally recommended that a clear shoulder width of at least four feet be provided. A five or six-foot wide clear shoulder is suggested on roadways with high traffic volumes, average speeds over 50 mph, steep grades, a high volume of large vehicles, or the presence of shoulder rumble strips or obstructions on the side of the road.

Innovative Bike Lane Facilities

Left-Side Bike Lane on One-Way Streets

Although bike lanes are typically only recommended for the right side of the roadway, occasionally, bike lanes are installed on the left side of one-way streets for safety benefits. Installation of left side bike lanes can help minimize conflicts due to high bus volumes, a high percentage of right turning traffic, or a high volume of left turning bicycle traffic.

Bicycle traffic turning left from a left side bike lane may create conflicts with motorists who are not expecting bicycle travel on the left side of the street. Also, cyclists may encounter problems moving from the left side bike lane back to the right side of the roadway, if necessary.

Typically, lane width and striping requirements remain the same for left side bike lanes as for bike lanes installed on the right side of the street. Left side bicycle lanes have been used in Minneapolis, Minnesota; Berkeley, California; Eugene, Oregon; and Madison, Wisconsin.

Contra-Flow Bike Lanes

Contra-flow bike lanes allow bicycle traffic to travel in the opposite direction of motor vehicle traffic and are applied on one-way streets where directness and connectivity of bicycle facilities is a high priority. While contra-flow lanes are not generally recommended, they may be appropriate under the following circumstances:

- Fewer conflicts are present on the shorter route, improving safety
- Cyclists can safely re-enter traffic at each end of the lane
- Very few roads, driveways or alleys intersect the roadway on the contra-flow bike lane side
- Out-of-direction travel for cyclists is reduced considerably

Certain design features should be included for contra-flow bike lanes, such as:

- Contra-flow lanes should be placed to the left of motorists
- Proper signage alerting roadway users to two-way bicycle traffic should be provided on streets or driveways intersecting a road with a contra-flow bike lane
- Existing signals should be able to accommodate contra-flow bike traffic
- The contra-flow lane should be the priority on one-way streets where there is not enough width to accommodate both a contra-flow lane and a typical bike lane on the right side of the street

Contra-flow bike lanes should be striped with a double, solid, yellow line to indicate two-way travel. Cities that have used contra-flow bike lanes include Eugene, Oregon; Cambridge, Massachusetts; Minneapolis, Minnesota; Madison, Wisconsin; and San Francisco, California.

<u>Colorized Bike Lanes</u>

Colorized bike lanes can be used in high-conflict locations as a way to alert motorists to the presence of bicyclists and bike lanes, especially in areas where high volumes of motor vehicle traffic cross bike lanes. The use of colorized bike lanes has been shown to increase bicycle safety by improving visibility of bike lanes, encouraging motorists to yield, and warning motorists and cyclists of a potentially dangerous area.

Colorized Bike Lanes

Colorized bike lanes should be used for short segments at conflict points within the bike lane. Potential locations that may benefit from colored bike lanes include sections of bike lanes where ramps or roadways merge in such a way that typical bicycle lane markings may not be adequately visible.

Locations where colorized bike lanes have been used include Portland, Oregon; Cambridge, Massachusetts; Philadelphia, Pennsylvania; Montreal, Canada; and several cities throughout Europe. Although several colors have been used in Europe, green is the most commonly used color in the United States.

Bicycle Lanes at Intersections

Designing for bicycle travel at intersections is arguably the most crucial, and most challenging, aspect of bicycle facility design. Because a high proportion of incidents between bicycles and automobiles occur at intersections, it is important that bicycle facilities at intersections are designed in a manner that is direct, logical, predictable, and that minimizes unusual circumstances. Both cyclists and motorists must be provided with a well-defined path to follow and a clear indication of who has right of way. As usual, bicycles should be treated as vehicles at intersections and the path designated for bicycles should remain as close to conventional travel lanes as possible. Bike lanes may be striped all the way to the crosswalk. However, they should not extend through pedestrian crossings or through the intersection.

As cyclists approach an intersection, they will need to position themselves in the correct location for the movement they intend to make. For turning movements, this may require cyclists to merge into outside travel lanes in areas without bike lanes. Where bike lanes are present, they are often only intended for through movements. Turning cyclists will still need to position themselves appropriately in other lanes, as needed.

Free-flowing intersections, like those with slip lanes, allow motorists to make turns without being controlled by a traffic signal and enable higher-speed turns. This design decreases safety for cyclists, who must cross paths with motorists at some point. Therefore, slip lanes should be avoided where bicycle facilities are present.

<u>Intersections without Right-Turn Lanes</u>
Bicycle lanes that are provided at signalized or stop-controlled intersections without exclusive right turn lanes should be replaced with a dashed line for a minimum of 50 feet prior to the intersection. The dashed line will alert motorists and cyclists that they may be merging with one another at the intersection. Solid bike lane striping should start again immediately on the far side of the intersection.

Minor intersections that are not stop-controlled should be striped with a solid line all the way to the crosswalk. However, at intersections where a high volume of vehicles are turning right or where there is a near-side bus stop, the bike lane striping should be dashed for at least 50 feet or for the length of the bus stop.

Intersections with Right-Turn Lanes

At intersections where both bicycle lanes and exclusive right turn lanes exist, conflicts are created when right-turning motorists and cyclists traveling through the intersection must cross each other's path of travel. Bike lanes at these intersections should be placed to the left of the exclusive right-turn lane, as shown in Figure 28.

Merging and lane changes between motorists and cyclists should occur before reaching the intersection. To encourage motorists to move into the right turn lane, the bike lane should be striped with dashed lines at least 50 feet in advance of the intersection. The solid bike lane striping should resume when the full-width of the right-turn lane is achieved and should extend to the crosswalk or stop line.

Bike Lane at Intersection with Right Turn Lane

In locations without adequate space for both a separate bike lane and a right turn lane, the right-turn lane may be marked as a shared-use lane, with bicyclists directed to the left side of the lane. This approach has been

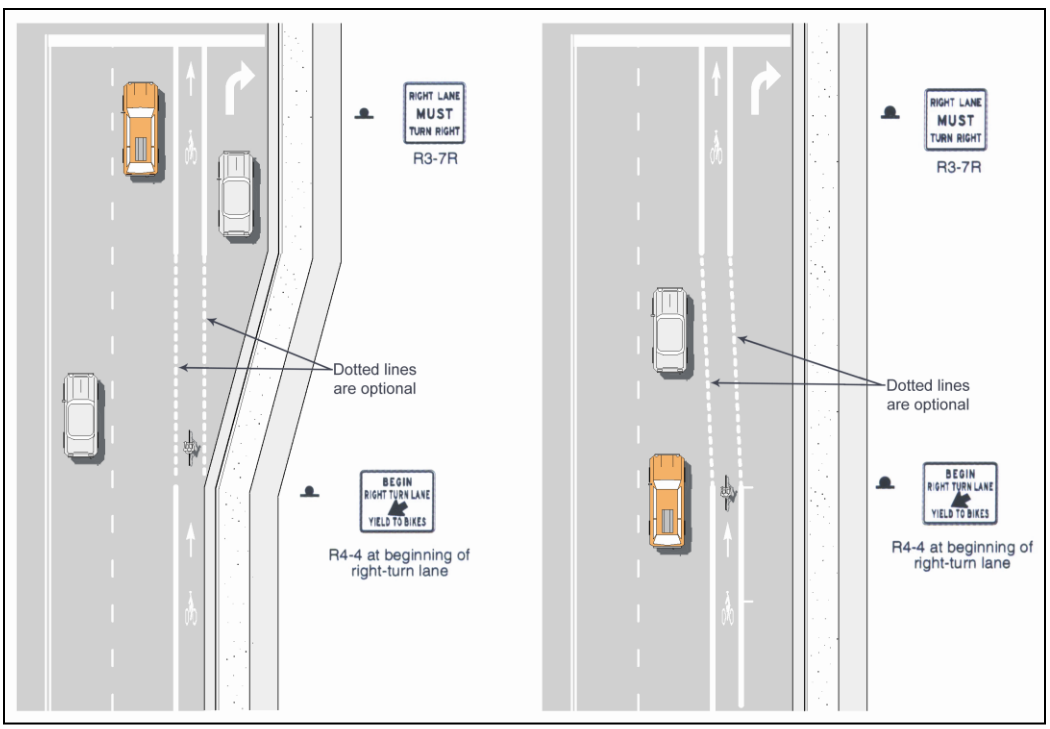


Figure 28: The illustration on the left shows an exclusive right turn lane without on-street parking, while the illustration on the right shows the right turn lane where on-street parking is present.

used in Chattanooga and Memphis, Tennessee as well as Eugene, Oregon. However it is not included in the AASHTO or MUTCD manuals. Another option, when space is limited, is to end the bike lane and widen the through lane to at least 14 feet for shared use.

In cases where a parking lane or a through travel lane is dropped at an intersection to create a turn lane, the bike lane should be located between the through lane and the right-turn lane, if possible. In locations where a through lane has been dropped to become a right-turn-only lane, the MUTCD states that bicycle markings should stop at least 100 feet before the beginning of the right-turn lane, and through bicycle markings should resume to the left of the right turn lane. At intersections with a high volume of right-turning bicycles, it may be appropriate to provide a right turn only bike lane in addition to a through bike lane.

Intersections with Dual Right-Turn Lanes

Approaches with dual right-turn lanes consist of either two exclusive right turn lanes or an exclusive right-turn lane and a shared through/right-turn lane. These configurations complicate the placement of a bike lane. Cyclists traveling straight through the intersection face the difficulty of merging across two right turn lanes to a through lane, or proceeding through the intersection in a lane where drivers may be turning right.

The MUTCD states that, in this situation, the bicycle lane should be discontinued. Possible alternatives at these locations include providing a dashed line from the edge of pavement to guide the cyclist to the shared through/right turn lane, or providing a sidewalk cut to allow the cyclist to approach the intersection as a pedestrian. Proper signage, as shown in Figure 29, should be provided to warn cyclists of the conditions ahead. Dual right turn lanes should be warranted by a engineering study and avoided, whenever possible, on streets where significant bicycle traffic is anticipated.

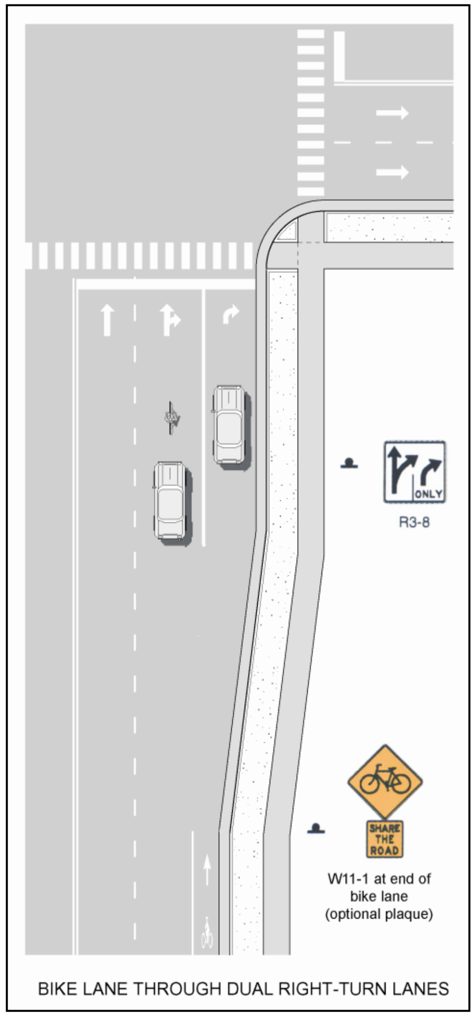


Figure 29: Proper signage should be installed at dual right turn lanes to warn motorists and cyclists of the lane configuration ahead.

T-Intersections

As Illustrated in Figure 30, at T-intersections, especially where traffic volumes are high and there is available space, bike lanes should be provided for both left and right-turning movements. If space is limited, the bike lane should be dropped in advance of the intersection so that cyclists may position themselves in the proper conventional lane. If the bike lane is dropped, the left turn lane is recommended to be at least 14 feet wide. The bike lane on the through street of the T-intersection should be striped through the intersection, except at crosswalks.

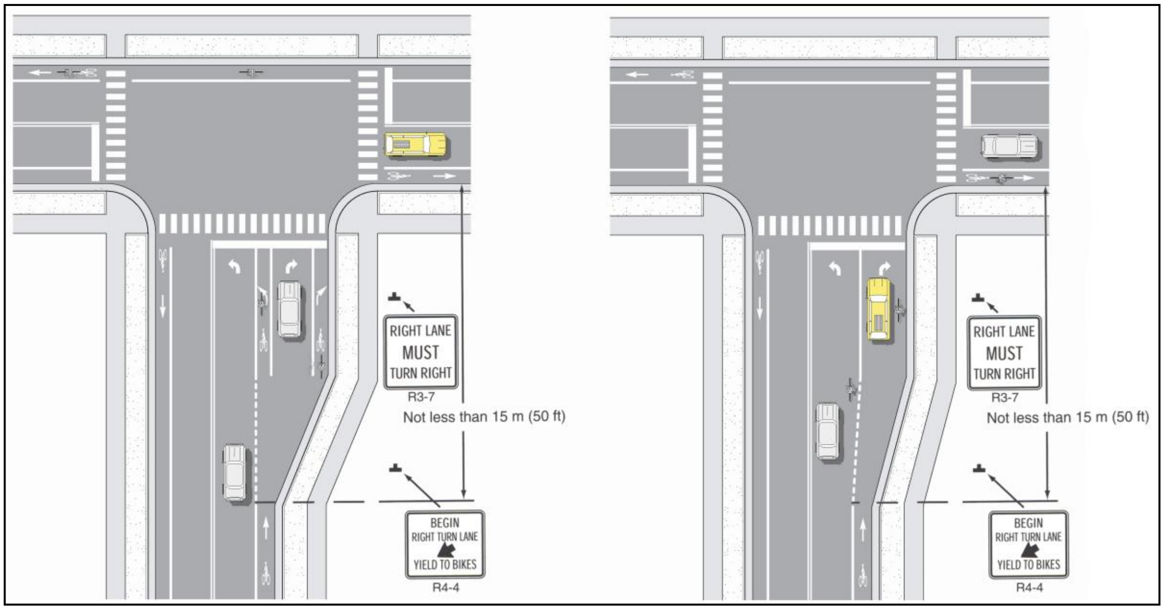


Figure 30: Separate left and right turn bike lanes should be provided at T-intersections, as shown in the illustration to the left. Where pavement width prevents this, a wide left shared left turn lane should be provided, as shown to the right.

Complex Intersections

Intersections that have offset or skewed approaches, or multiple streets entering from different angles, can create confusion for all roadway users. Skewed intersections can reduce bicycle visibility at angles and can increase the distance across the intersection. This often results in a long, confusing path for cyclists. Ideally, approaches to skewed intersections should be realigned to meet at right angles. Where re-alignment is not possible, ample sight distance must be achieved at the intersection. Bike lanes may be dashed through the intersection to guide cyclists and to keep motorists from encroaching into the path of travel of cyclists.

Multiple streets entering an intersection create difficulties for cyclists due to an increased number of conflict points, a larger intersection with a longer distance to cross, reduced visibility of bicycles, and more unpredictable movements by motorists. It may be possible to redesign this type of intersection so that only two roads cross at one point, and the additional approaches intersect the road at another location. Also, redesigning this type of intersection as a roundabout may be appropriate. Where redesigning the intersections is not possible, dashed bike lanes may be continued through the intersection.

Bike Lanes at Roundabouts

Roundabouts can be problematic for cyclists, although low-speed roundabouts tend to accommodate both motor vehicle and bicycle travel fairly well. Higher-speed roundabouts, and roundabouts with multiple lanes or flared entry points, create more points of conflict for cyclists.

In general, bicycle travel is accommodated at roundabouts by providing separate bicycle paths outside of the roadway or by bicycles sharing conventional travel lanes with motorists. Bicycle lanes through roundabouts are not recommended. At locations where bicycle lanes lead to roundabouts, the bike lane should end between 35 and 65 feet ahead of the roundabout.

Bike Lanes at Interchanges

Because of their high-speed, free-flowing motor vehicle traffic, freeway or interstate interchanges can be one of the most difficult areas for cyclists to navigate. Conflicts can occur when cyclists traveling at lower speeds must weave or merge with motorists traveling at much higher speeds. Problems that occur at entrance and exit ramps include:

- Visibility problems caused by the acute angle at which vehicles are approaching
- Accelerating motorists merging into traffic, which increases the speed differential with bicyclists
- Motorists exiting to the right sometimes do not use turn signals, making it difficult for cyclists to predict their movements
- Motorists concentrating on merging may be distracted and not as attentive as normal to the presence of cyclists
- Because they may be exiting bicycle-restricted roadways, motorists may not be anticipating bicycle traffic

While design recommendations for bike lanes at intersections provide suitable solutions for signalized interchange ramps, many interchange designs allow for uncontrolled vehicular movements which require special attention for non-motorized users. The bicycle lane designs shown in Figures 31 and 32, help to increase safety and comfort at interchanges which have uncontrolled movements by minimizing the distance that cyclists must cross, by improving sight distance, and by moving the conflict point to a location where motorists are not concentrating on merging with traffic. As shown in the figures, the bike lanes are pulled away from the through lane of the roadway and curve around to intersect the road at near-right angles. Portland, Oregon has also experimented with using colorized bike lanes at entrance and exit ramps to increase visibility.

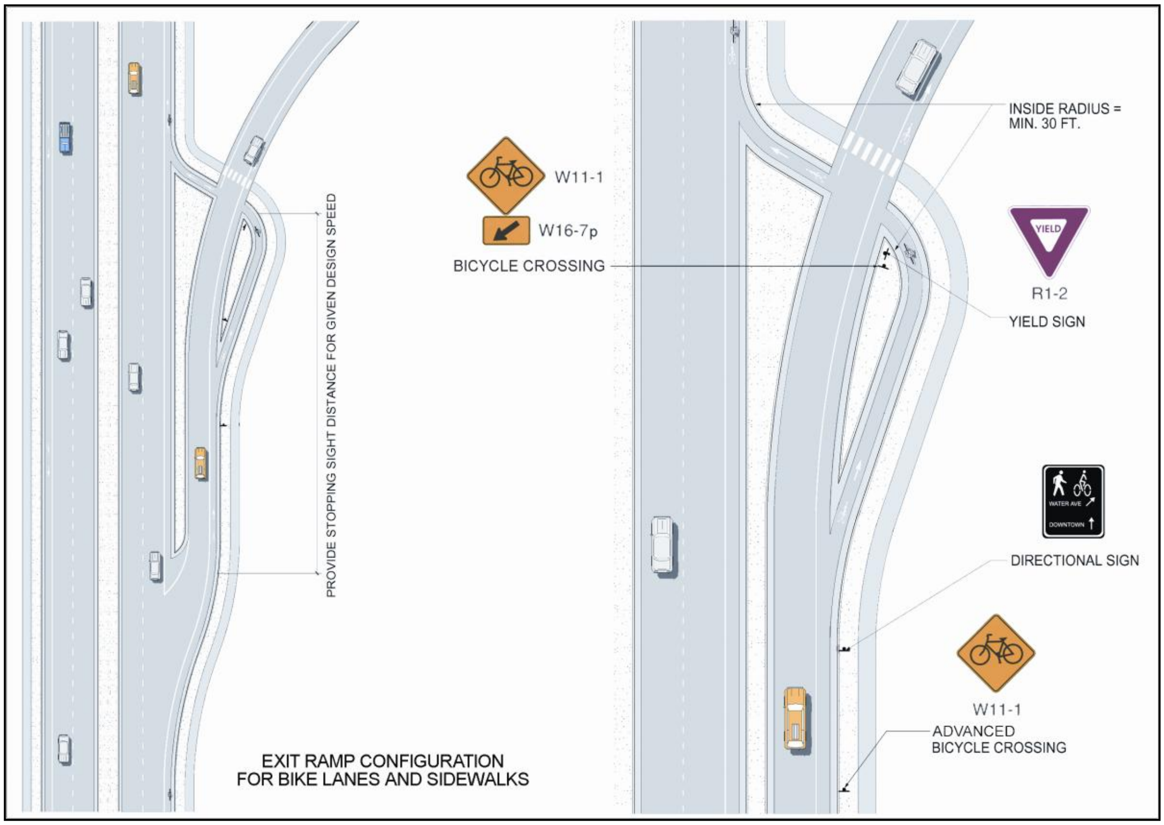


Figure 31: The bike lane at the entrance ramp shown in the figure intersects the ramp at nearly a right angle before the motorist must merge into traffic.
Source: ***Oregon Bicycle and Pedestrian Plan***

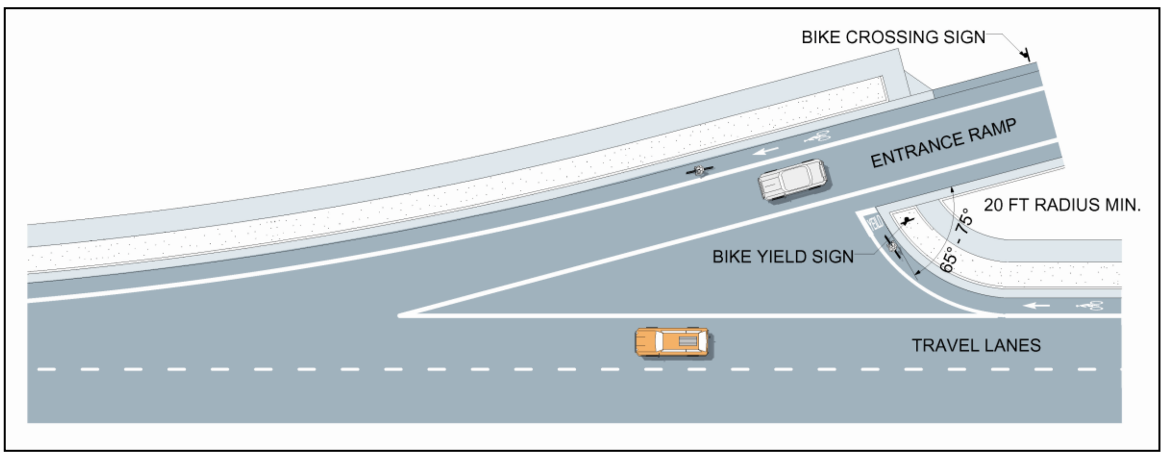


Figure 32: Bike lanes at exit ramps should be pulled away from the roadway to allow nearly right angle crossings at the ramp, as shown above.
Source: ***Oregon Bicycle and Pedestrian Plan***

Interchange-type intersections, such as single point urban interchanges (SPUI) occasionally occur on urban roadways where bicycle travel is permitted. Single point urban interchanges (SPUI) are constructed in areas where there is restricted right-of-way since this type of interchange requires less land. SPUI's are designed to move high volumes of traffic through the interchange at relatively high speeds. With this type of motor vehicle design it is important for the interchange to include a design that allows for safe bicycle movement. At these intersections, bicycle lanes should be designed to enable cyclists to safely cross the intersection, as well as enter and exit the roadway. The design should include small controlled crossings, a geometry that creates tight, close to right angle crossings, and one that is clearly marked for bicyclists.

<u>Advanced Stop Line/Bicycle Box</u>

At intersections with high volumes and frequent turning conflicts, advanced stop lines, or bike boxes, enable cyclists to move ahead of motorists to position themselves for a turn. As shown in Figure 33, bike lanes lead into the bike box, which is located between the motor vehicle stop line and the crosswalk. Bicycle markings should be placed in the box and signage should be provided to indicate where cyclists and motorists should stop.

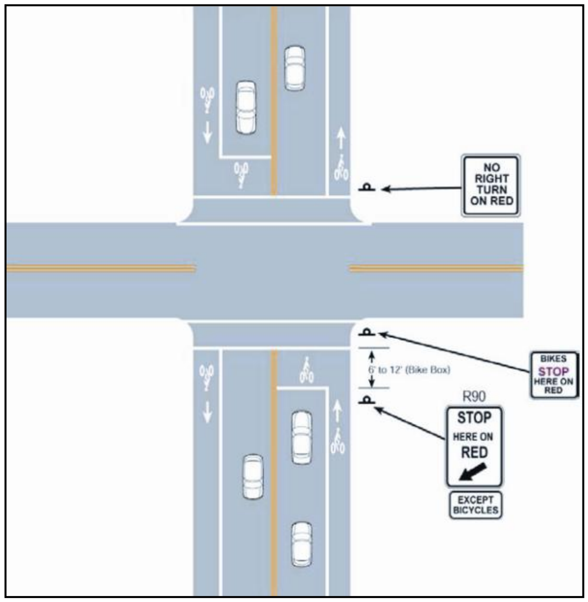


Figure 33: Bike boxes, as shown above, allow cyclists to move ahead of motorists to position themselves for a turn.

Bike boxes can improve bicycle visibility and decrease turning conflicts with motorists without significant delay to motor vehicle traffic. The downside to bike boxes is that motorists will be restricted from right turns on red, and bike boxes will not help cyclist turning movements during the green signal phase. Also, if the signal turns green before a cyclist has a chance to position themselves, the cyclist may be trapped in an unsafe location. Until they are more common, motorists may be unfamiliar with, and may be confused by, bike boxes. Therefore, bike boxes should be used with caution.

Bike boxes have been used in many cities. Some of these cities include Portland and Eugene, Oregon; Cambridge, Massachusetts; and various cities in the United Kingdom and the Netherlands.

3.3 SHARED ROADWAYS

Roadways where cyclists and motorists share the same travel lanes are considered shared roadways. Shared roadways do not provide exclusive space for bicyclist and may require motorists to weave into adjacent lanes to pass a cyclist safely. Types of shared roadways include:

- Wide Outside Lanes,
- Bicycle Boulevards,
- Signed Shared Roadways, and
- Local Roadways.

Wide Outside Lanes (WOL)

Wide outside lanes (WOL) are a preferred alternative for arterial and collector streets that do not have adequate room for bike lanes and do not have paved shoulders. WOLs should be designed to provide adequate room for a standard automobile to pass a cyclist within the travel lane. While some cyclists may feel less comfortable on WOLs than on bike lanes, WOLs are a significant improvement over standard 11 to 12-foot wide travel lanes in accommodating bicycle traffic.

Example of the Shared Lane Pavement Marking also called a "sharrow", proposed in the 2008 amendments for the MUTCD

The shared lane pavement marking, also referred to as "sharrow", is called out in the proposed 2008 amendments to the MUTCD to identify WOLs. This marking indicates a presence of cyclists to motorists and also provides a guide to cyclists as to where they should position themselves. It can be especially effective in WOLs that are adjacent to parking lanes.

Many times, WOLs can be accomplished on multi-lane roadways by reducing the existing width of other travel lanes and reallocating it to the outside lane. It is recommended that WOLs be a minimum of 14 feet wide, measured from the gutter pan seam. Where on-street parking is provided, an adjacent WOL that is 15 to 16 feet wide is recommended. The parking lane should be striped to encourage motorists to park close to the curb. If WOLs are 15 feet or wider for continuous periods, striped bike lanes should be considered.

Bicycle Boulevard

Typically placed on low volume or residential streets parallel to high volume arterials, bicycle boulevards serve as through streets for cyclists. As shown in Figure 34, motor vehicle traffic is allowed on bicycle boulevards. However, traffic calming devices are used to discourage cut-through traffic and slow motor vehicle traffic. Treatments used on bicycle boulevards, such as medians, traffic circles and chokers, are intended to reduce conflicts between motorists and cyclists, while prioritizing bicycle travel. For example, in order to favor bicycle travel, stop signs are placed on the side street, except at locations where stop control on the bicycle boulevard would benefit cyclists at busy intersections.

Streets on a grid system often are the best candidates for bicycle boulevards, since they are typically direct routes and provide better connectivity than winding streets. While bicycle boulevards offer advantages to cyclists and pedestrians by decreasing motor vehicle speeds and volumes, careful planning is needed to avoid increasing traffic volumes on nearby streets, impeding emergency vehicles, and other negative impacts. It is also important to collaborate with residents on streets that a bicycle boulevard may impact.

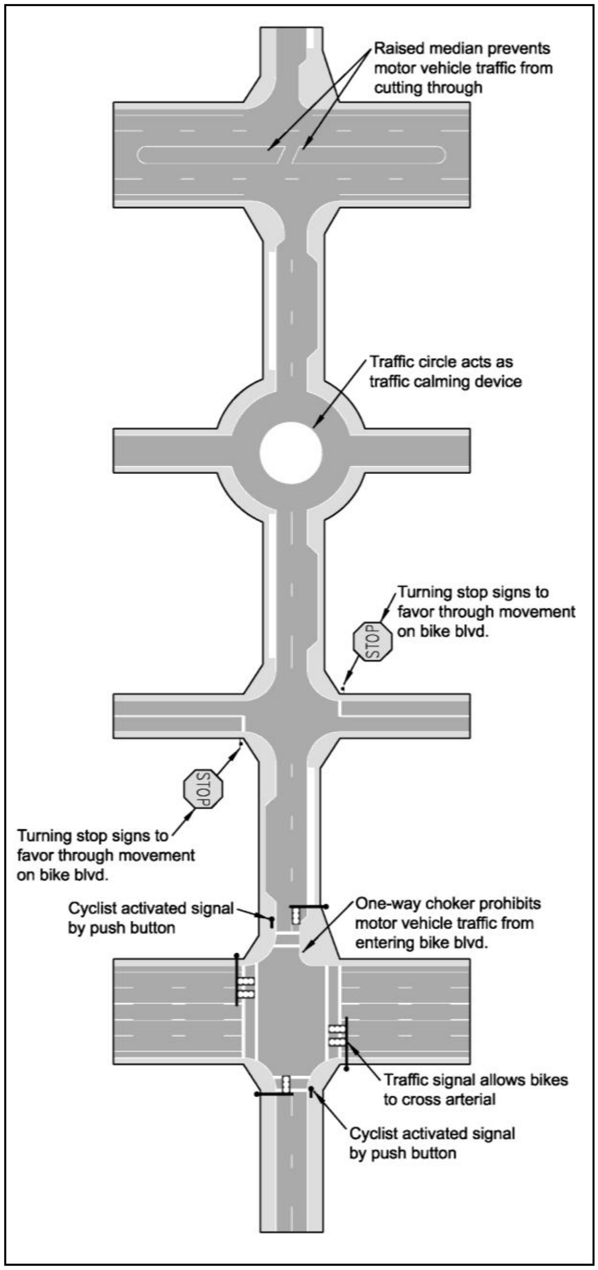


Figure 34: Bicycle boulevards, as shown above, are roadways that emphasize bicycle travel.
Source: ***Oregon Bicycle and Pedestrian Plan***

Bicycle Boulevard with a Traffic Circle

Signed Shared Roadways (SSR)

Signed shared roadways are roadways that are identified by signage, and where appropriate pavement markings, as preferred bike routes. SSRs are recommended for roadways with limited pavement width and where adding width to support preferred bicycle facilities, such as bike lanes or wide outside lanes, is not possible. Roadways that carry a relatively high volume of bicycle traffic, a low volume of motor vehicle traffic, or that provide critical connectivity between bicycle routes or common destinations may be good candidates to be SSRs. When establishing a roadway as an SSR, the outside lane should be re-striped to provide as much additional pavement width for bicycle travel as possible. In some cases, the roadway should be marked with a "sharrow". The pavement marking is used to alert motorists of the presence of bicyclists and to indicate to the bicyclist where to ride.

It is important to note that SSRs require more than just signage and pavement markings. Care should be taken to ensure that other elements of the roadway are as bicycle-friendly as possible. Regular maintenance to the roadway should be conducted, and common hazards to cyclists should be eliminated. For example, roadway maintenance should include regular street sweeping to clear debris. It should also improve other roadway conditions for cyclists, such as storm grates, potholes, railroad crossings, and other facilities. Common hazards facing cyclists are discussed in detail in the *Other Design Considerations* section of the *Bicycle Facilities Design Guidelines*.

In general, "Share the Road" signs are recommended, unless the SSR is a short section between bike lanes or WOLs. It is recommended that the speed limit on SSRs not exceed 35 mph.

Local Roadways

Due to their low traffic volumes and reduced vehicle speeds, special treatments are often not required for motorists and cyclists to share local roadways. At times, local roadways tend to endure more traffic and at higher speeds than is planned. When this is the case, bike lanes are recommended to increase comfort and safety for roadway users if adequate width is available.

3.4 MULTI-USE PATHS AND GREENWAYS

Multi-use paths, often referred to as greenways or shared-use paths, are usually paved pathways that are designed for two-way travel. They serve non-motorized travel modes, including cycling, walking, running, and in-line skating.

Generally, it is not necessary to provide centerlines on greenways. However, in high traffic or hazardous areas, lane striping may be warranted to reinforce proper positioning. A solid yellow line is recommended for no-passing zones, and a broken yellow line should be used in areas where passing is permitted.

Transportation Uses

While multi-use paths appeal to recreational users, they may also serve a non-motorized transportation function. Multi-use facilities can serve transportation functions by providing connections to the various destinations along a greenway corridor. They can be especially effective in providing links to destinations off limited-access highways that prohibit bicycle travel.

In order to maximize transportation functions, multi-use paths should not be provided in lieu of a street-based bicycle network. Rather, multi-use facilities should be designed to complement on-street bicycle facilities by providing additional transportation routes. In fact, determining whether a multi-use facility can function as a transportation facility should be considered when prioritizing multi-use facilities development. If so, multi-use facilities should be designed to maximize access to destinations and connectivity.

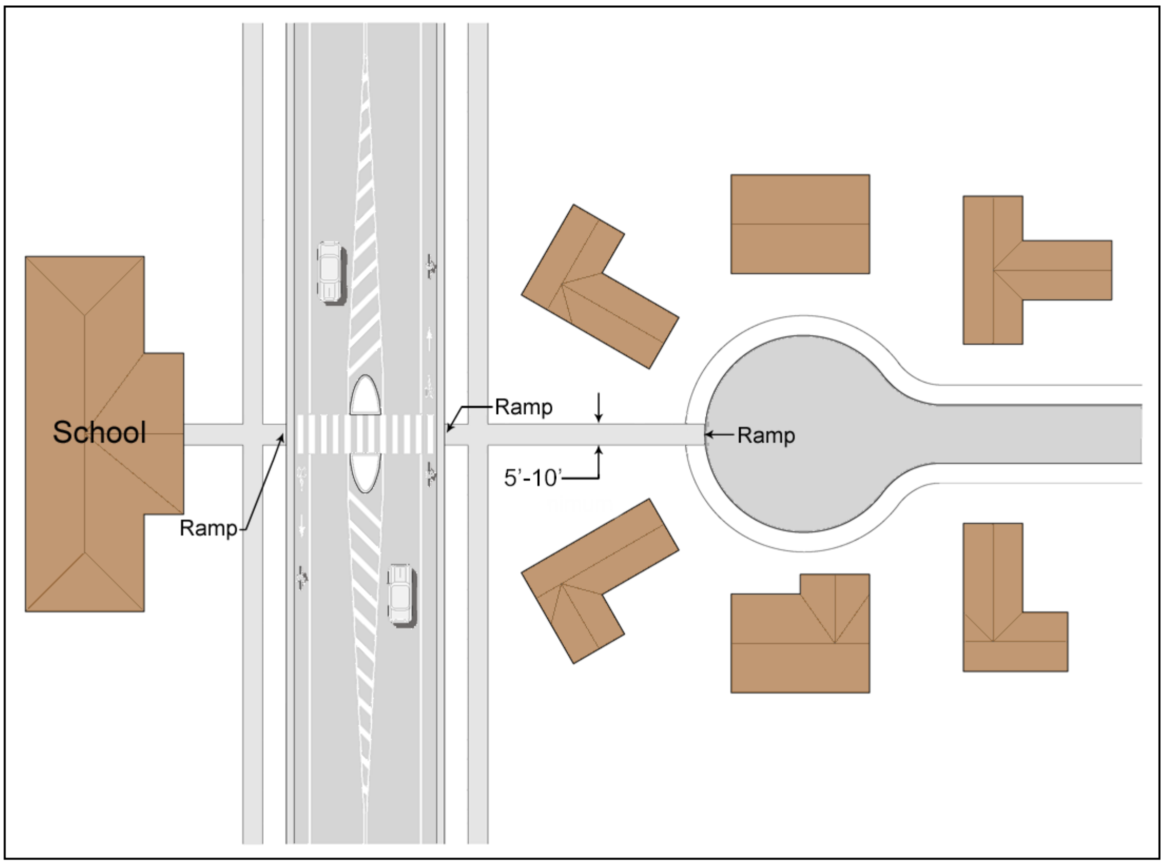


Figure 35: Off-street bicycle connectors can save cyclists significant out-of-direction travel.

Off-street bicycle connectors can be used at strategic locations to provide direct access between land uses, as shown in Figure 35. Overland bicycle connectors are short, direct routes that provide access to a destination or on-street bicycle facilities, without requiring the cyclists to travel out-of-direction along the roadway network. The directness of travel for an overland bicycle connector enhances its use for transportation.

Off-street connector between a neighborhood and school

Separation from Roadways

For the most part, multi-use facilities are located in independent right-of-way, parks, or easements. They can also be located adjacent to roadways. However this is generally not recommended, as it creates a number of safety concerns. For example, cyclists may be riding adjacent to traffic traveling in the opposite direction, which can be especially problematic at the end of the path or at intersections. In addition, cyclists that prefer traveling on the roadway may encounter motorists who expect all cyclists to travel on the adjacent path when one is provided. Multi-use paths adjacent to roadways may be considered under certain circumstances:

- The adjacent roadway has high speeds and volumes or is otherwise unsuitable for bicycle travel
- The section of multi-use paths adjacent to the roadway will connect to bike facilities at one or both ends
- The multi-use paths will be at least five feet from the edge of roadway pavement
- If the multi-use path is less than five feet from the edge of pavement, a barrier should be provided between the road and pathway
- There are a limited number of at-grade intersections or driveways, but there is access to roadways along the path
- There is a high demand by cyclists and pedestrians at the location

When a structural barrier between a greenway and a roadway is required, AASHTO recommends that they be at least 42 inches high. AASHTO also recommends that they be designed in a manner that will not obstruct sight distance or create hazards to motorists.

Design Principles

Successful multi-use paths often share similar design characteristics. These include:

- Separation from traffic, preferably along scenic routes
- Minimal at-grade street crossings
- Frequent access to bicycle facilities on roadways, which decreases out-of-direction travel and improves connectivity
- Shorter travel distances than roadways, including connections between cul-de-sacs and cut-through routes
- Connection to multiple destinations
- Located in proximity to residential or business areas, thereby increasing visibility and safety
- At-grade street crossings that provide bicycle and pedestrian facilities, as well as signage warning motorists of bicycle and pedestrian crossings
- Termination points of multi-use paths that provide safe access from roadways, preferably at streets that are equipped with bicycle facilities.

Multi-use facilities accommodate both cyclists and pedestrians, and, therefore, must meet all ADA design standards. These standards are described in more detail in the *Pedestrian Facilities Design Guidelines* section.

Width

In general, the recommended width for two-way, shared-use paths is ten feet. In rare instances, a reduced width of eight feet may be permissible. An eight-foot width should only be used in areas with low bicycle volumes, low pedestrian volumes, and good vertical and horizontal alignment. Along the same lines, a 12 to 14-foot wide path may be desirable at certain locations where high use is expected, or in areas with steep grades. One-way paths are not recommended since they are often used as two-way facilities. However, when a one-way path is the only available option, the minimum width should be six feet. Figure 36 shows the recommended width for multi-use paths.

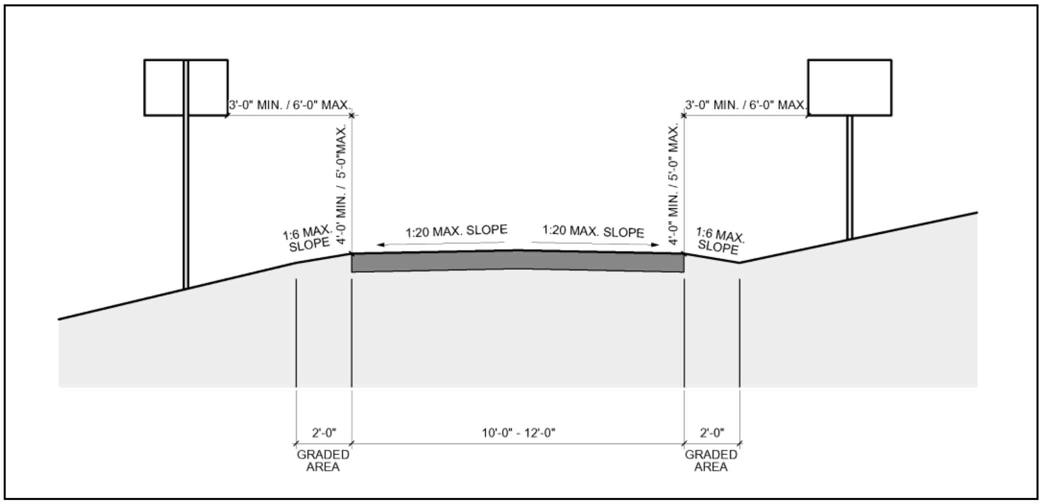


Figure 36: The figure above illustrates the recommended width, lateral clearance and slope standards for multi-use paths.

Clearance

Shoulders measuring a minimum of two-feet in width and maintaining a maximum cross-slope of 1:6 should be provided on both sides of a greenway. Obstructions, such as trees or fences, should not overhang the shoulder area. Figure 36 illustrates the recommended lateral clearance for multi-use paths.

Overhead clearance should be a minimum of eight feet to accommodate cyclists. However, a clearance of ten feet is generally recommended to allow for emergency and maintenance vehicles. At tunnels and underpasses, overhead clearances should be at least ten feet.

Design Speed

In general, AASHTO recommends that multi-use paths be designed to meet the needs of faster cyclists. AASHTO recommends a minimum design speed of 20 mph under normal conditions and 30 mph on a downgrade of at least four percent. However, multi-use paths must comfortably accommodate cyclists of varying skill levels, as well as pedestrians, so multi-use paths should not be designed to encourage speeding.

Running Slope and Cross Slopes

As previously stated, design standards for shared-use paths must comply with current ADA standards. While specific ADA regulations regarding trails are not in place, the *Draft Final Accessibility Guidelines for Outdoor Developed Areas* report, dated October 2009, includes recommendations for accessible trail design. The report includes the following recommendations for running slope and cross slopes:

- Running slope should be a maximum of 1:10
- Running slopes of 1:12 may be permitted for a maximum of 200 feet (with resting intervals at least every 200 feet)
- Running slopes of 1:10 may be permitted for a maximum of 30 feet (with resting intervals at least every 30 feet)
- Running slopes of 1:8 may be permitted for a maximum of 10 feet (with resting intervals at least every 10 feet)
- A running slope exceeding 1:12 is permitted along a maximum of 30 percent of the trail
- Cross slopes of the trail should be a maximum of 1:48

Trails are recommended to be banked low on the inside of a curve to help cyclists keep their balance. Figure 36 illustrates the recommended cross-slopes for multi-use paths.

Curve Radii

For a design speed of 20 mph, the minimum recommended curve radius is 100 feet. For a 30 mph design speed, the minimum radius is 225 feet, with a 15-degree lean angle. Supplemental signs should be used to alert path users where topography or right-of-way dictates that curve radii must be smaller than recommended. Safety at sharp curves can be improved by providing centerline striping and increasing the pavement widths through the curve.

Multi-use Facility/Roadway Intersections

In general, grade-separated crossings are preferable to at-grade intersections, especially at high-speed, high-volume roadways. Furthermore, multi-use path users usually expect separation from motor vehicle traffic. At-grade intersections are often a barrier for those path users unprepared to encounter motor vehicles.

Grade-Separated Crossings

A grade separated crossing should not require significant out-of-direction travel by path users. In addition, access to the crossing should not require a steep or winding climb. The same width and clearance dimensions apply to grade-separated crossings as the rest of the pathway.

Overpasses typically provide more visibility and security. However, care must be taken to ensure that approaches are not so steep that the overpass becomes undesirable to use. More gradual grades can often be achieved with underpasses, although care must be taken to maximize security and visibility.

At-grade Crossings

Where grade-separated crossings are not possible, at-grade intersections between roadways and greenways should be located in areas with light vehicular traffic or at controlled intersections. All intersections should include suitable pavement markings and signage. Furthermore, if cyclists are given the right-of-way at an intersection, installation of a raised crosswalk and flashing signal may be needed to warn motorists. At signalized intersections with loop detection for motor vehicles, bicycle detectors should also be provided.

Multi-use facility approaches should intersect the roadway at angles as close to 90 degrees as possible, and care should be taken to provide good visibility to users on all approaches.

Occasionally, at mid-block crossings or wide roadways, the use of a curbed center median is recommended to help greenway users cross safely. As shown in Figure 37, median islands should be angled toward oncoming traffic to improve visibility when crossing the roadway. The median will allow users to cross the roadway in stages by providing refuge halfway across the roadway. It is recommended that the median be at least six feet wide to provide clearance for one cyclist, or ten feet wide to accommodate a bike with a trailer or a group of cyclists.

Mid-block crossings should be carefully evaluated. Mid-block crossings on high-volume streets should be avoided whenever possible.

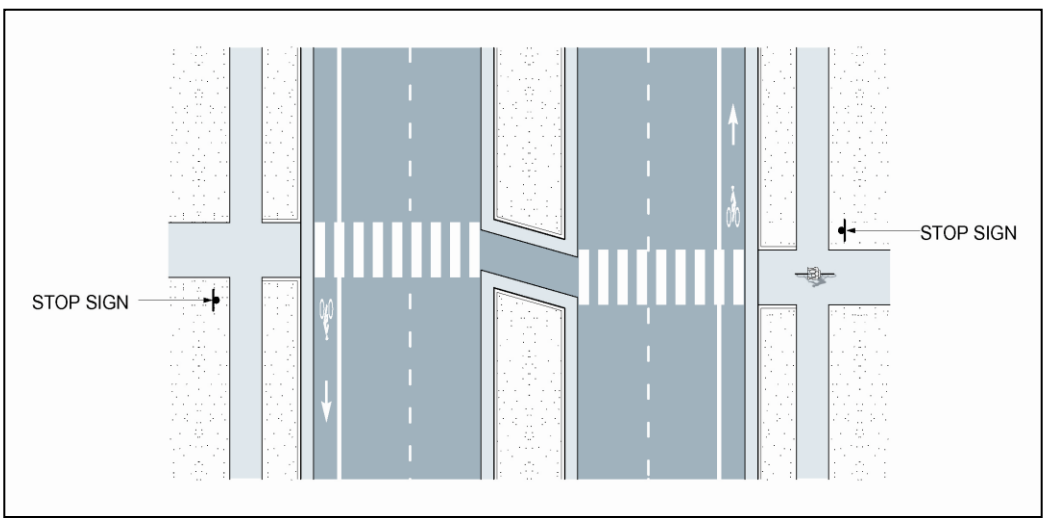


Figure 37: Median islands, as shown above, should be angled toward on-coming traffic to improve visibility when crossing the roadway.

Railings and Fences

To protect path users from potential hazards along the travelway, such as a steep hillside or water, railings or fences, as shown in Figure 38, may be necessary. AASHTO recommends a minimum height of at least 42 inches for these barriers. However, a height of 54 inches may provide cyclists more protection from falling over the fence or railing. At the point where cyclist's handlebars may brush against the railing or fence, approximately 36 inches from the ground, installation of a smooth surface, or "rub-rail" is recommended. Spacing between bars of the railing or fence should be no more than six inches apart.

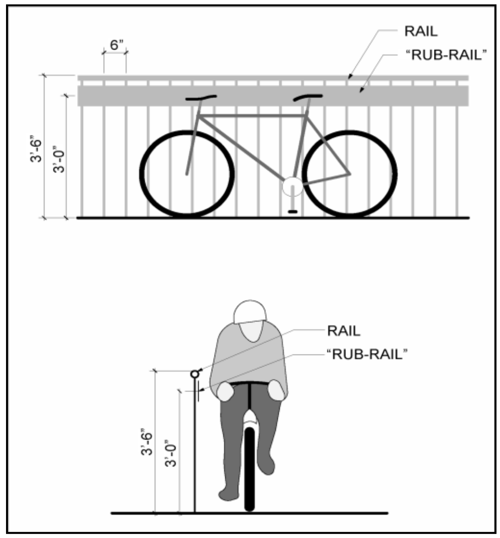


Figure 38: An alternative to bollards, such as the one illustrated here, may be used at trail intersections.

Railings and fences located within the shoulder of the path reduce the usable width of the path, and, therefore, should not be placed into the shoulder width. When there is no option other than the shoulder, the overall width of the pathway should be increased, if possible.

Motor Vehicle Barriers

To prevent motor vehicle traffic from entering pathways, bollards are barriers that are commonly placed at roadway intersections. Bollards can be unexpected and difficult to see, and should be painted in bright colors and reflectorized, for increased visibility. Spacing between bollards should be at least four feet wide. If bikes with trailers are anticipated, the width between the bollards should be increased to five feet.

At intersections, bollards should be set back from the roadway, beyond the clear zone, or be designed as breakaway posts. Placing the bollards several feet from the roadway will also enable cyclists to clear the bollard before or after reaching the intersection, rather than at the intersection, where attention should be focused on roadway traffic.

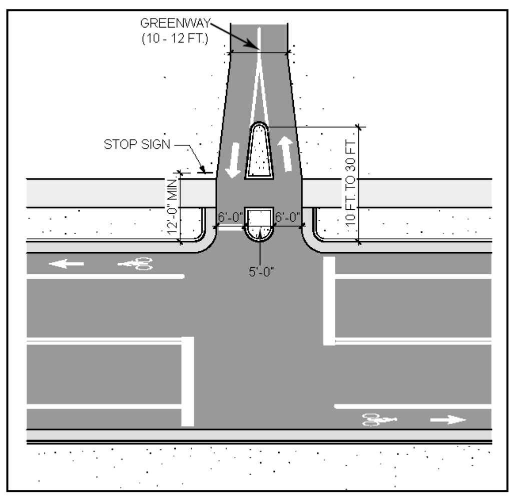


Figure 39: Railing heights should be a minimum of 42 inches and rub-rails should be provided at a height of 36 inches, as shown above.

In locations where more than one bollard is needed, an odd number should be used to create an even number of passageways for each direction of travel. Bollards should also not be placed within the path of travel of users, since this may force them to the center of the pathway, possibly causing head-on collisions.

Another approach to restricting motor vehicle traffic is to split the entrances of the pathway into two one-way paths, separated by an island with low landscaping as shown in Figure 39. This type of alternative increases safety for cyclists and is more aesthetically pleasing than bollards. Furthermore, access is improved for large maintenance and emergency vehicles, which are able to straddle and clear the landscaping without needing to remove a bollard.

3.5 TRAFFIC SIGNALS

Like motorists and pedestrians, cyclists must abide by traffic signals. Therefore, the signal timings should be designed to accommodate cyclists and detection must be designed to detect bicycles.

Traffic Signal Timing

Traffic signal timings that are based solely on motor vehicle traffic may not provide adequate time for cyclists to clear an intersection. Signal clearance intervals should be programmed to allow cyclists enough time to react, accelerate, and proceed through an intersection on the clearance interval. At intersections where bicycle travel is anticipated, the average bicyclist speed of six to eight mph, and perception/reaction/braking time of one second should be considered when programming signal timings. At large intersections, such as multi-lane or skewed intersections, cyclists may also require additional time to cross.

Traffic Signal Detection

At actuated intersections where bicycle travel is expected, detector loops should be designed to detect bicycles in addition to motor vehicles. For this reason, detectors should be located within cyclists' expected path of travel in bike lanes,

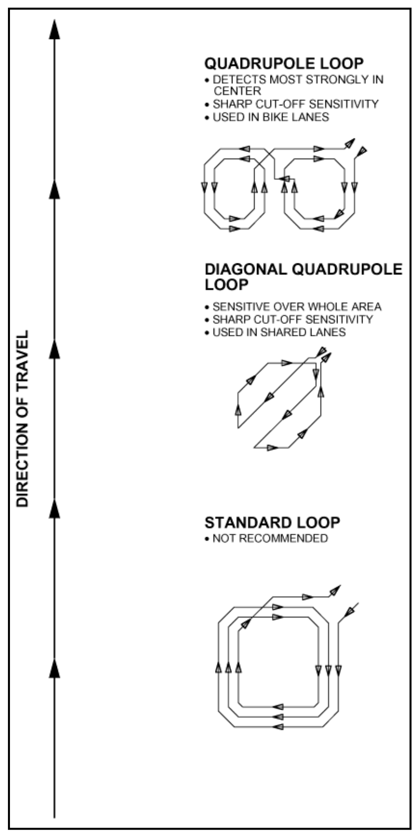


Figure 40: Detector loops designed to detect bicycles should be used at signalized intersections where bicycles are expected.

Pavement Marking indicating Bicycle Detector Loop Location

shoulder bikeways, and conventional travel lanes. Left turn lanes and outside through lanes, or shared through/right turn lanes, may need special consideration since the cyclist may be located on the right side of the lane, outside the typical detection area. At these locations, bicycle detection symbols should be provided to indicate to the cyclist the proper position at which to activate the signal detector.

The various types of detector loops are shown in Figure 40. Quadrupole and diagonal quadrupole loops are generally best for bicycle detection, since they are more sensitive throughout the loop. Standard loops are more difficult to adjust for bicycle detection and are not recommended.

Video detection can also be used for bicycle detection. This type of detector is typically seen at intersections where a designated bike lane is striped and where video detection is used for automobiles. The technology uses detection zones to determine the presence of a bicycle.

Pushbutton-type detectors are generally discouraged for bicycle facilities. However, when a loop or video detector is not an option, a pushbutton may be appropriate if cyclists are able to access the pushbutton without having to dismount or lean and they can remain in the proper position for the direction they wish to travel at the intersection, including left and through movements.

Bicycle Signals

Bicycle signals can be used to help guide cyclists through high-volume, high-conflict intersections by providing a separate signal for cyclists. Bicycle signals protect cyclists at signalized intersections by separating conflicting movements and giving priority to cyclists making certain movements. Also, the overall flow of the intersection may be improved, but may result in additional delays for motorists.

Guidelines for bicycle signals are not provided in MUTCD and are not widely used. However, they have been implemented in cities such as Davis, California; New York, New York; Tucson, Arizona; and in various cities throughout Europe and Australia.

3.6 SIGNAGE

Bicycle facilities will often require signs directed at motorists, cyclists, or both. Additional signage directed at motorists may be required in some instances, such as complex intersections or locations with high bicycle traffic and insufficient bicycle facilities. Signs directed at cyclists are typically smaller versions of standard roadway signs since cyclists travel at lower speeds, and are often traveling closer to the signs. In addition to bike-specific signs, standard roadway signs usually also apply to cyclists.

Signs used for bicycle facilities, like standard roadway signs, should be easy to understand by all roadway users. The use of symbols is preferred over text on signs in general.

The 2003 edition of the MUTCD and the proposed 2008 amendments provide guidance on signage, placement and pavement markings for bicycle facilities. Signs included in the MUTCD as well as the signs included in the 2008 proposed amendments are shown in Figure 41. The latest edition of the MUTCD should be consulted when installing signs and pavement markings.

Signage Guidelines

<u>Shared-Use Trails (Greenways)</u>
At intersections between shared-use trails and roadways, a “Bicycle Warning” sign (W11-1) should be placed on the roadway in advance of the intersection. Signs directed at cyclists on the shared-use path approach to an intersection, should only be visible to path users, not to motorists.

<u>Bicycle Lanes</u>
“Bicycle Lane” signs (R3-17) should only be used on designated bike lanes, which are marked by the “Bicycle Lane Symbol” marking. Supplemental bike lane plaques “Ahead” (R3-17a) and “Ends” (R3-17b) should be used in conjunction with the “Bike Lane” sign (R3-17) before the beginning of a marked bike lane, or before the bike lane ends. The “Bicycle Warning” sign (W11-1) and the “Share the Road” plaque (W16-1) should both be used just after the “Bike Lane Ends” signage. Where bike route signs (D11-1, M1-8, M1-9, and supplemental plaques) are used, they should include directional information, or information identifying the bikeway. On roadways with bike lanes, this type of informational signage is only needed at major intersections or where the route changes streets.

In locations where sections of bike lanes are discontinuous, bike route signs should be provided to guide cyclists from one bike lane to the next. Also, bike route signs are recommended to direct cyclists to destinations. For example, “Bike Route: XX Street Bikeway” or “Bike Route: Zoo.”

"No Parking Bike Lane" signs (R7-9, R7-9a) may be necessary in areas where parking within bike lanes is a recurring problem. However, in most cases, adequate pavement markings in bike lanes reduce the need for these signs.

On roadways where motorists must transition across bike lanes into right turn lanes, "Begin Right Turn Lane Yield to Bikes" signs (R4-4) should be installed at the beginning of the taper, or, if none, at the point where merging begins.

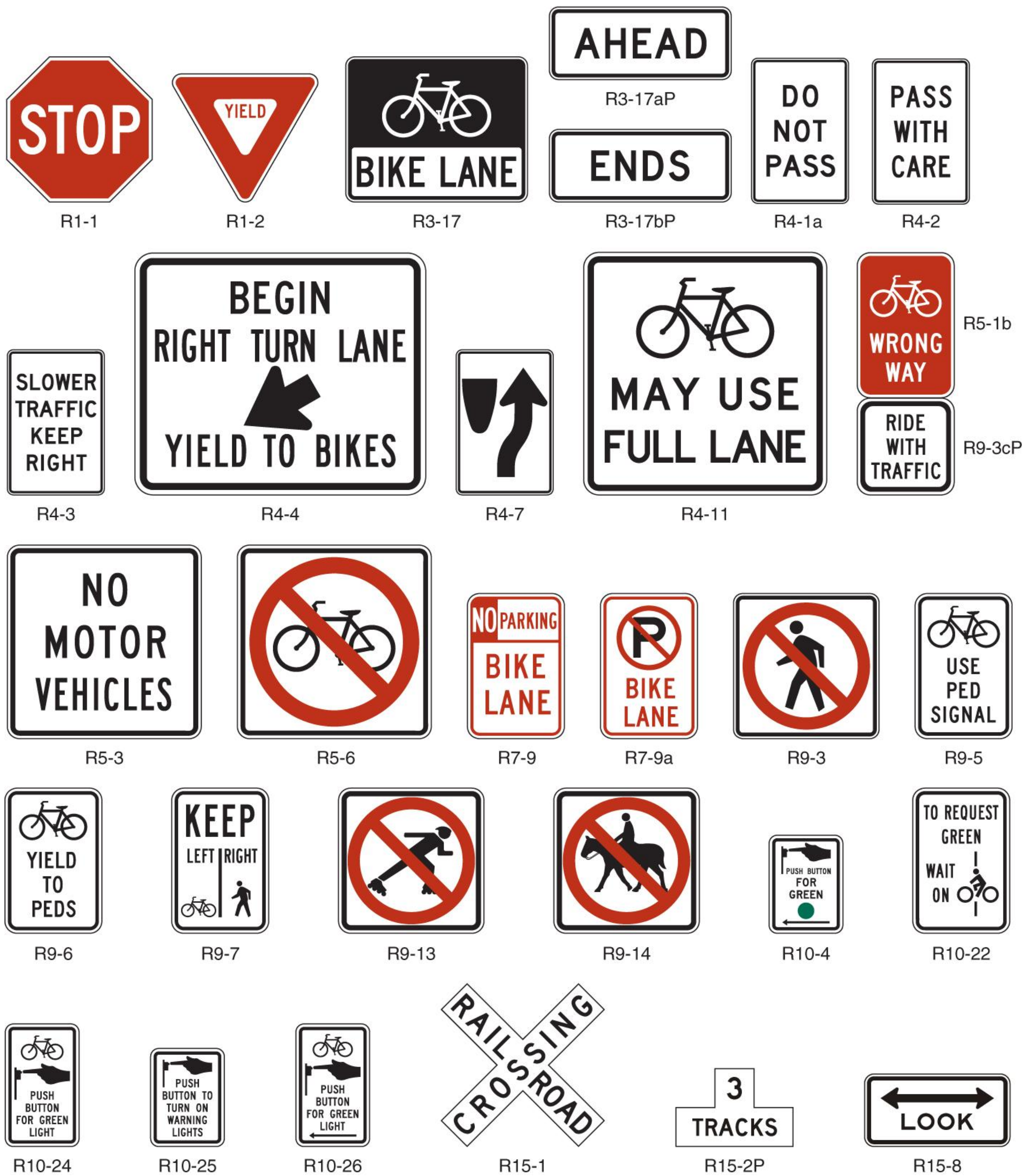


Figure 41: Bicycle facilities signage from the 2003 edition of the *Manual on Uniform Traffic Control Devices* and the 2008 Proposed Amendments.

Figure 9B-3. Warning Signs and Plaques for Bicycle Facilities *(Sheet 1 of 2)*

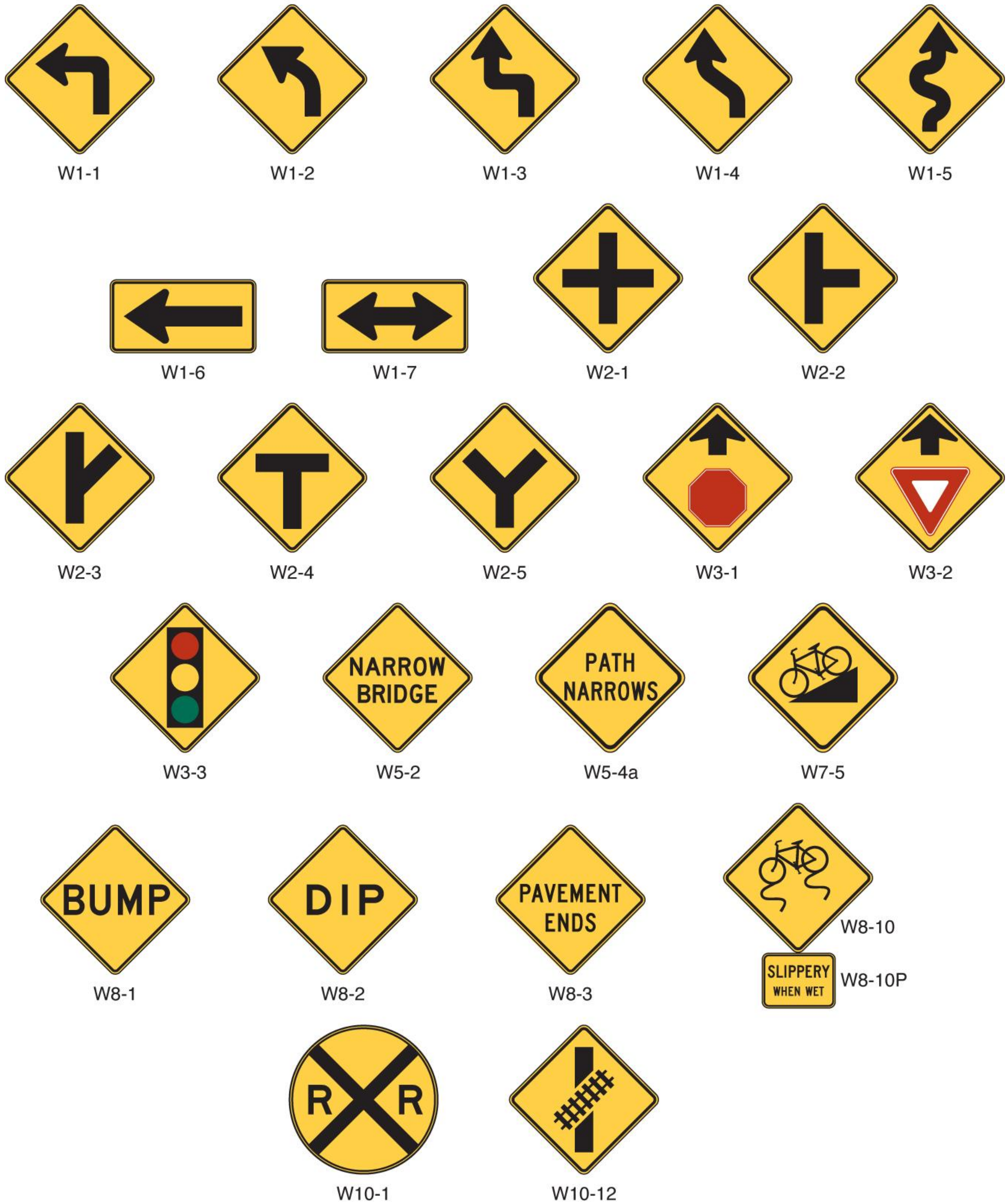


Figure 41 (cont). Bicycle facilities signage from the 2003 edition of the *Manual on Uniform Traffic Control Devices* and the 2008 Proposed Amendments.

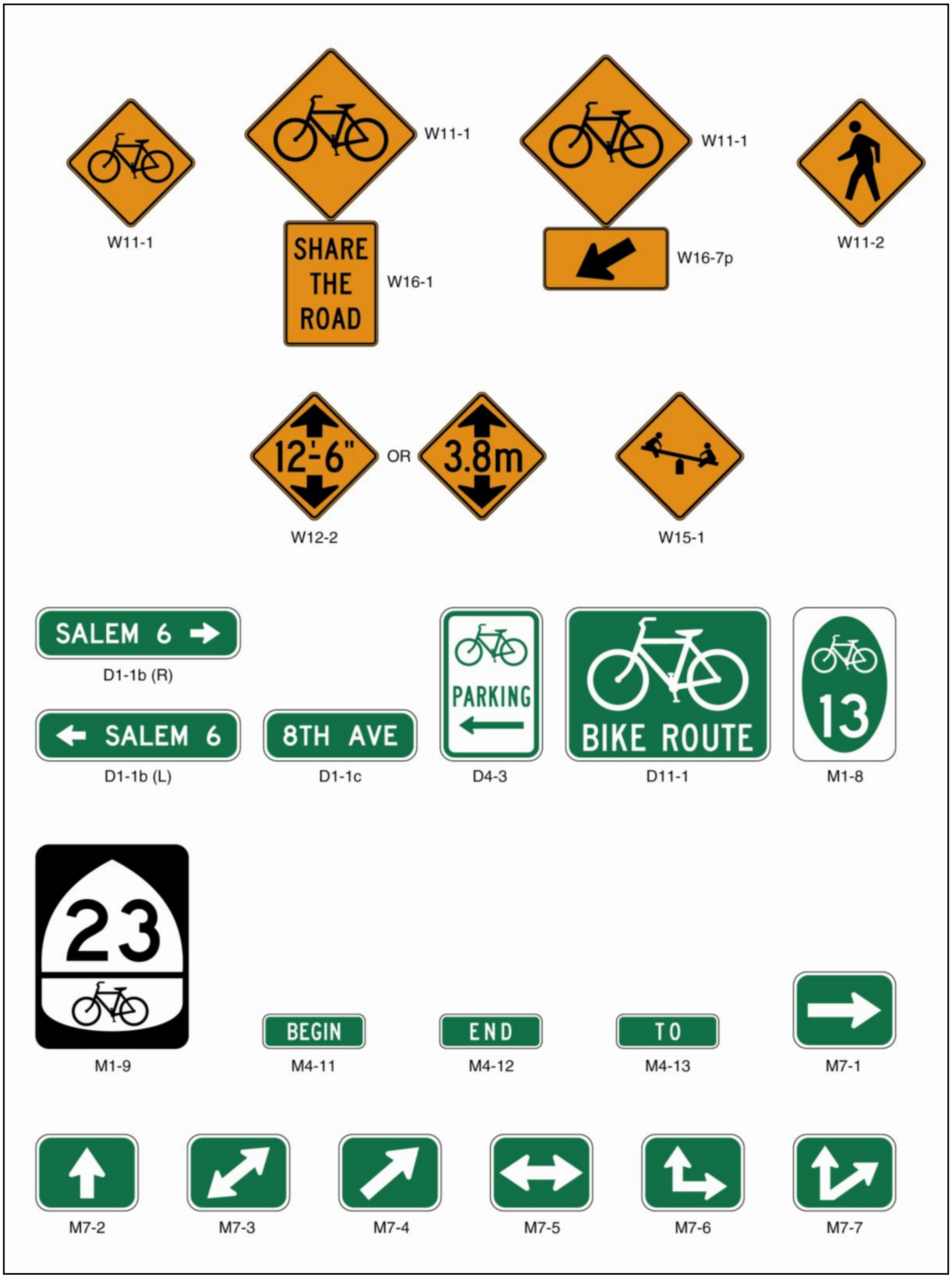


Figure 41 (cont). Bicycle facilities signage from the 2003 edition of the *Manual on Uniform Traffic Control Devices* and the 2008 Proposed Amendments.

Shared Roadways

It is recommended that bicycle route signs (D11-1, M1-8, M1-9 and supplemental plaques) be placed at all major intersections where routes change direction and on streets with a minimum spacing of 1,000 feet. As previously mentioned, bike route signs should include information, such as destinations, directions or identifying bikeways.

3.7 OTHER DESIGN CONSIDERATIONS

Pavement Surface Quality

The quality of the pavement surface is an important consideration for cyclists. Potholes, joints, raised pavement or other surface irregularities can trap a bicycle wheel, or even cause cyclists to swerve or lose control, especially when they occur in the path of travel. These types of pavement problems should be repaired quickly and carefully, while making certain that the repairs do not actually leave conditions worse, such as leaving a ridge or loose gravel.

Storm Grates

Storm grates can pose a serious threat to cyclists depending on their design and location. For this reason, storm grates and utility covers should be kept out of the path of bicycle travel as much as possible. When it is not possible to relocate storm grates out of the path of travel, efforts should be made to maximize the safety of the existing storm grates in place.

Storm grates that are not flush with the frame of the grate and grates with long slots parallel to the path of travel can trap bicycle wheels, which can result in serious injury to the cyclist. These types of grates should be replaced with storm grates that are bicycle-compatible as well as hydraulically efficient, as shown in Figure 42. If replacing storm grates cannot be achieved immediately, a temporary solution is to weld steel cross straps or bars to an existing grate, perpendicular to the path of travel, spaced a maximum of six inches apart.

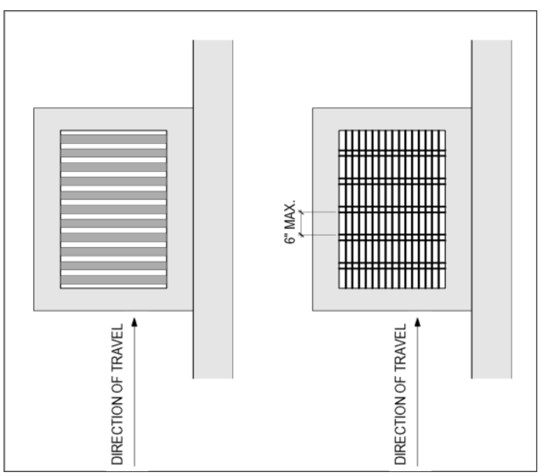


Figure 42: Bicycle-friendly storm grates, such as those illustrated above, are recommended.

Another hazard to cyclists is created by storm grates that have not been raised as the street has been resurfaced and, as a result, are significantly lower than the surrounding pavement. When resurfacing a street, it is recommended that the grate be no more than one-quarter of an inch offset from the new pavement. If this is not possible, the pavement should be tapered into the grate to avoid leaving a severe edge.

In general, bicycle-safe storm grates are recommended for all streets, not just those identified for bicycle travel. Likewise, when resurfacing streets, storm grates should be nearly level with the pavement on as many streets as possible, not just those designated for bicycle use.

Rumble Strips

Rumble strips are sometimes used on higher-speed roadways to alert motorists that they have veered onto the shoulder or to warn of an approaching intersection. However, for cyclists, they can be unsafe and uncomfortable. For cyclists, the safest option is to prohibit the use of rumble strips on roadways where bicycle travel is expected.

If it is determined that rumble strips will offer safety benefits on a roadway, there are techniques that will minimize their impact on cyclists. There should be at least five feet of space between the rumble strip and the edge of pavement. On roadways with wide outside lanes, rumble strips should be located on the right side of the lane line. Rumble strips should not be used on roads with bike lanes, unless they are placed outside the bike lane, to the right.

Construction Zones

Bicycle travel should be maintained through construction zones to the greatest extent possible. Any provisions that are made for motorized traffic should also include provisions for maintaining bicycle travel.

Where bicycle facilities are interrupted for a significant distance, temporary bicycle facilities, such as bike lanes or wide outside lanes, should be provided. In locations where no temporary facilities can be provided, a reasonable detour should be identified and signed. Where bicycle facilities will be interrupted for a shorter distance, cyclists may be routed to conventional travel lanes. Cyclists should not be re-routed onto sidewalks unless no other options exist.

Metal plates that are used on roadways in construction sites may be difficult to see under certain conditions, and can have surfaces that can be slippery for cyclists. If metal plates are used, they should have an edge less than one inch high. If the edge is greater than one inch, an asphalt lip should be provided.

Construction signs should not obstruct the path of travel for cyclists or pedestrians. Also, construction information, especially regarding route changes, is recommended to be provided by local media or websites to the public. It is also recommended that groups affected by the construction such as neighborhood associations, or bike clubs be notified prior to the start of construction.

Bridges

Roadway bridges are as important to cyclists as they are to motorists in providing connectivity across highways or waterways. However, typical bridge elements such as open grate decking, expansion joints and narrow lanes can present problems for cyclists.

Bridges should be improved to safely accommodate bicycle travel as part of routine bridge maintenance or as major work is scheduled for the bridge. For example, bridges should be retrofitted with bicycle-compatible decking and expansion joints to improve conditions for cyclists.

On new bridge construction, six-foot wide bike lanes are desirable to provide cyclists with additional room to maneuver on bridges with high volumes or steep grades. The width of the bridge should be at least as wide as the approaching roadways, including bike lanes, shoulders, curb and gutter, and sidewalks.

Bridges should be as bicycle-friendly as possible, even in locations where designated bicycle facilities are not provided. All new bridges should be designed to accommodate bicycle travel.

Railroad Crossings

At-grade railroad crossings are most difficult for cyclists where they are forced to cross at an angle, especially if the surface at the crossing is rough. The channel between the flange and pavement can catch a bicycle tire and throw the cyclist.

Bikeways are recommended to cross railroad tracks as close to a right angle as possible. Angled crossings can result in a trapped bicycle wheel and can cause a loss of control for the cyclist. If the projected path of the bikeway will meet the railroad at less than a 45-degree angle, it is generally recommended that the bikeway should be realigned to provide a more perpendicular approach, as shown in Figure 43.

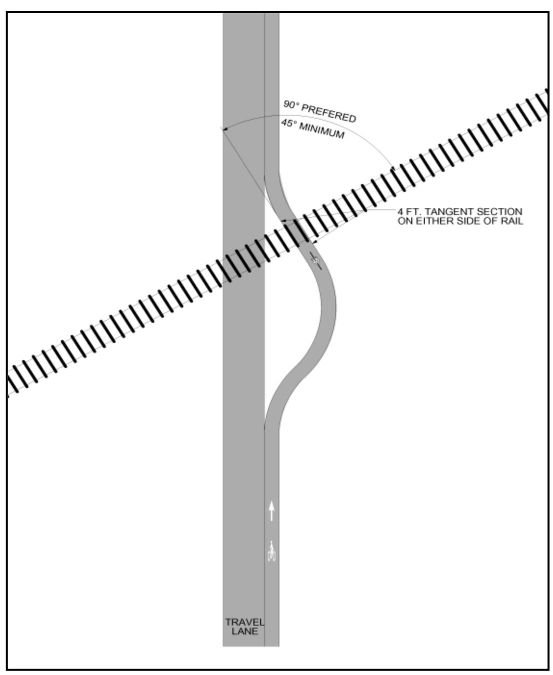


Figure 43: Realigned bike facilities can allow cyclists to cross the railroad at near perpendicular angles.

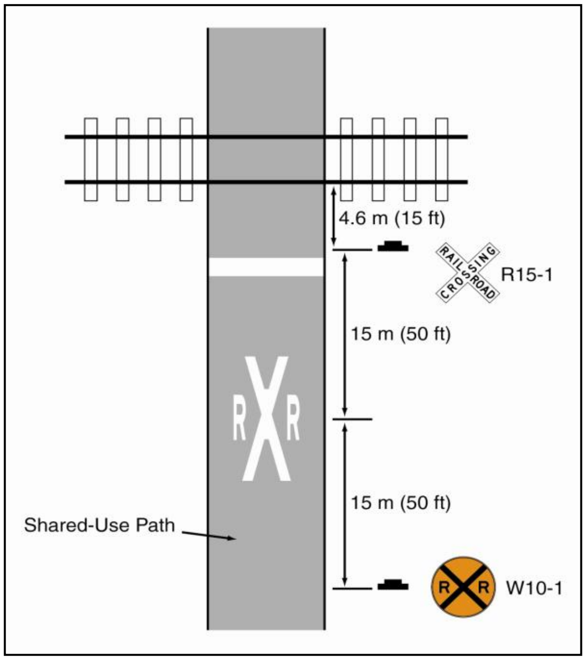


Figure 44: Advanced warning signs and pavement markings should be provided prior to a railroad crossing. (MUTCD)

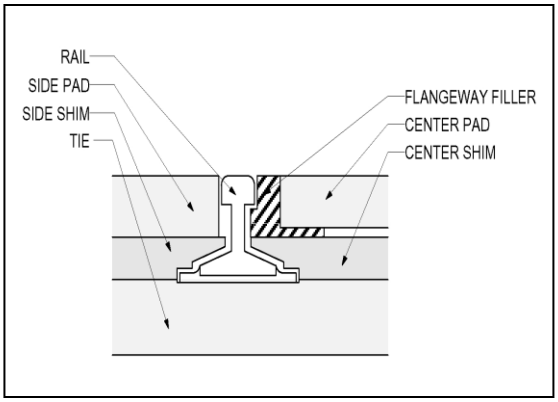


Figure 45: Flangeway fillers can improve a rough railroad crossing surface by minimizing the gap between the rail and the pavement.

Advanced warning signs and pavement markings should be installed in advance of a railroad crossing, as stated in the MUTCD and as shown in Figure 44. Pavement markings should also be used to indicate the safest crossing angle to cyclists.

The pavement of the bikeway should be level with the rails in order to provide a smooth crossing. Crossings should be constructed of concrete panels with steel reinforcements. Rubberized crossing mats may also be used. However, they are not recommended on roadways with high volumes of heavy vehicles. Neither asphalt nor timber is recommended for crossings since asphalt has a tendency to develop ridges next to the rails, and timber can be slippery and is not as durable.

A rough railroad crossing can also be caused by the gap that can exist between the rail and the adjacent pavement, known as the flangeway. It is recommended that the width of the flangeway be as narrow as possible. Flangeway fillers, as shown in Figure 45, which are usually made of rubber or concrete, can be used to reduce the flangeway width. Flangeway fillers should not be used on high-speed railroad tracks, as they may cause trains traveling at faster speeds to derail.

Stairway Channels

Stairwells can be an obstacle for cyclists. Stairway channels are a small ramp that is wide enough for a bicycle tire to fit that is installed along the side of the stairwell. These are typically seen at transit stations to make it easier for cyclists to maneuver on stairs.

3.8 TRAFFIC CALMING

Traffic calming involves the introduction of physical elements into the streetscape that encourage appropriate motor vehicle speeds and can also, if desired, encourage through-motorists to select a different route. Traffic calming is used to improve neighborhood livability, by reducing negative impacts of traffic, and to enhance the environment for non-motorized travel modes. Typically, traffic calming devices are installed on local and collector streets.

Speed humps, pedestrian bulbs, chokers, neckdowns, chicanes, and traffic circles are among the types of devices installed for traffic calming purposes. Although most of these devices are of benefit to bicyclists, care must be taken to ensure that the specifics of their design and application do not create new bicycle safety problems.

Speed Humps
Speed humps should generally be constructed with a longitudinal length of 14-22 feet, with a crown height of three to four inches. When used in a series, humps should be placed 300 to 600 feet apart.

Curbed Medians
Curbed medians with refuges provide safety for bicyclists and pedestrians crossing multi-lane roadways. Medians designed for bicycle crossings should be no less than six feet wide. A ten-foot wide median will accommodate a bicycle with a trailer, or multiple bicyclists, and should be the standard for trail crossings. See Figure 36. If a refuge is intended for bicycle use, it should be placed on alignment with the bicycle path of travel on either side of the intersection. The refuge should be either ramped, or flush with the roadway surface.

Pedestrian Bulbs, Chokers, Chicanes & Neckdowns
Pedestrian bulbs and some other traffic calming devices decrease curb-to-curb width in order to slow traffic. The design of these features should not require bicyclists to weave into adjacent traffic or force drivers to "squeeze" bicyclists while driving through the intersection. To slow traffic without creating safety problems for cyclists the following is recommended:

Striped chicanes allow bicyclists to continue on their normal path of travel

- On low-volume, low-speed streets without a centerline stripe, no special pedestrian bulb design considerations are generally necessary.
- At bulbs, when bike lanes are present, the conventional travel

lane should not be less than ten feet wide, and the bike lane should not be less than four feet wide.

- On streets with a centerline stripe, the pedestrian bulbs should be placed so that 12-foot outside lanes are maintained, or 14 feet if WOLs are present.

Traffic Circles

The design of traffic circles varies depending on the intersection. The center island should be wide enough that even traffic continuing straight through the intersection is horizontally diverted. The larger turning radii of emergency response vehicles, busses, and other large vehicles should be accounted for when traffic circles are being considered for installation. Center islands can be designed with cut-outs in the curb or have low curbs that area mountable by large vehicles. The inside of the island is sometimes landscaped to enhance the appearance of the area or completely paved to allow larger vehicles to mount the curb while passing through the circle.

Where traffic circles are used, they should be designed to incorporate adequate deflection on each approach to enforce appropriate entry speed for motor vehicles, and discourage motorists from trying to overtake bicyclists in the intersection.

Diverters

For general traffic calming purposes, diverters should be utilized sparingly. Diverters restrict motor vehicle access and can displace traffic onto nearby streets. When utilized, there should be a clear understanding of where traffic is likely to be diverted in order to ensure that traffic problems are not unintentionally shifted to another location.

Where used, diverters should incorporate a bicycle cut-through, or gap, not less than five feet wide (to accommodate bicycle trailers) and not greater than six feet wide (which could attract through-attempts by motorists). A pavement marking identifying the gap can help guide cyclists, as shown in Figure 46.

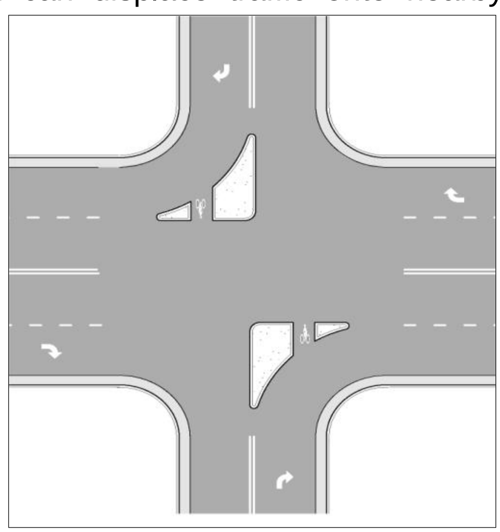


Figure 46: Diverters can be designed with a cut-through for bicycles.

3.9 DESIGN PRACTICES TO BE AVOIDED

Sidewalk Bikeways

Sidewalks for bicycle travel are generally not recommended for several reasons. These include:

- Sidewalks are not designed for higher-speed use by bicycles, which can lead to conflicts with slower-moving pedestrians or with fixed objects, such as poles, benches, and other street furniture.
- At intersections, motorists will expect pedestrians from a sidewalk, but may not be looking for a fast-moving cyclist to emerge from the sidewalk.
- Cyclists face conflicts at intersections where they are unable to follow vehicular traffic rules, but may also not follow pedestrian rules, resulting in confusion for all roadway users.
- Sight distance on sidewalks can be limited by buildings, trees, walls, or other obstructions.

In areas where bicycle travel on sidewalks is expected and allowed, such as locations where children ride on the sidewalk, sidewalks should not be signed as bicycle facilities. In general, cyclists should function as vehicles, and bicycle facilities should be appropriately designed to encourage this practice.

Two-Way Bike Lanes on One Side of the Street

Potential hazards are created for cyclists when two-way bike lanes are installed on one side of the roadway. Cyclists next to the travel lane are traveling between motorists and cyclists who are moving in opposite directions. Cyclists using these lanes may cause confusion by being in unexpected locations at intersections, and they may be forced to make awkward and unsafe movements when moving to and from traditional bicycle lanes.

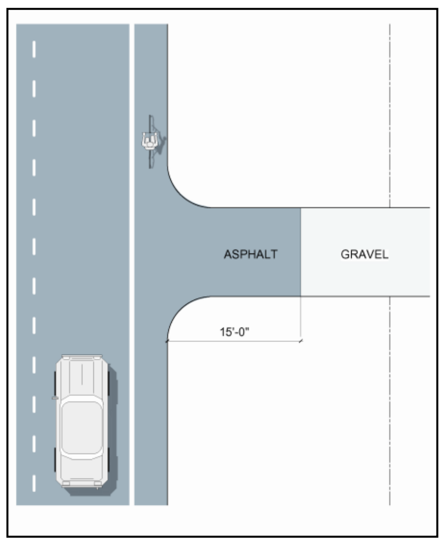


Figure 47: A paved apron at gravel approaches helps prevent gravel from spilling onto bicycle facilities.

Gravel Driveways and Alleys

Gravel can be very unstable for cyclists and can result in loss of control. To prevent gravel from drifting onto bicycle facilities, gravel approaches should be paved back at least 15 feet, as shown in Figure 47.

Pavement Reflectors

When hit by a bicycle wheel, pavement reflectors can cause a cyclist to lose control. Therefore, they are not generally recommended for roadways with bicycle facilities. If reflectors are required on certain roadways, they should have a beveled front edge and should be installed on the side of the stripe away from the bike lane. Placement of reflectors should end approximately 50 feet prior to intersections since cyclists may be changing into an appropriate lane for a turn.

Continuous Right-Turn Lanes

Cyclists riding on streets with continuous right turn lanes are forced to ride either to the right of the right-turn lane, where they may be in the path of the right-turning traffic, or to the left of the right-turn lane, where they are in the path of traffic moving into and out of the turn lane.

Instead of a continuous right-turn lane, providing multiple right-turn lanes, as shown in Figure 48, that serve specific intersections may be preferable. Eliminating the continuous right-turn lane will prevent vehicles on the

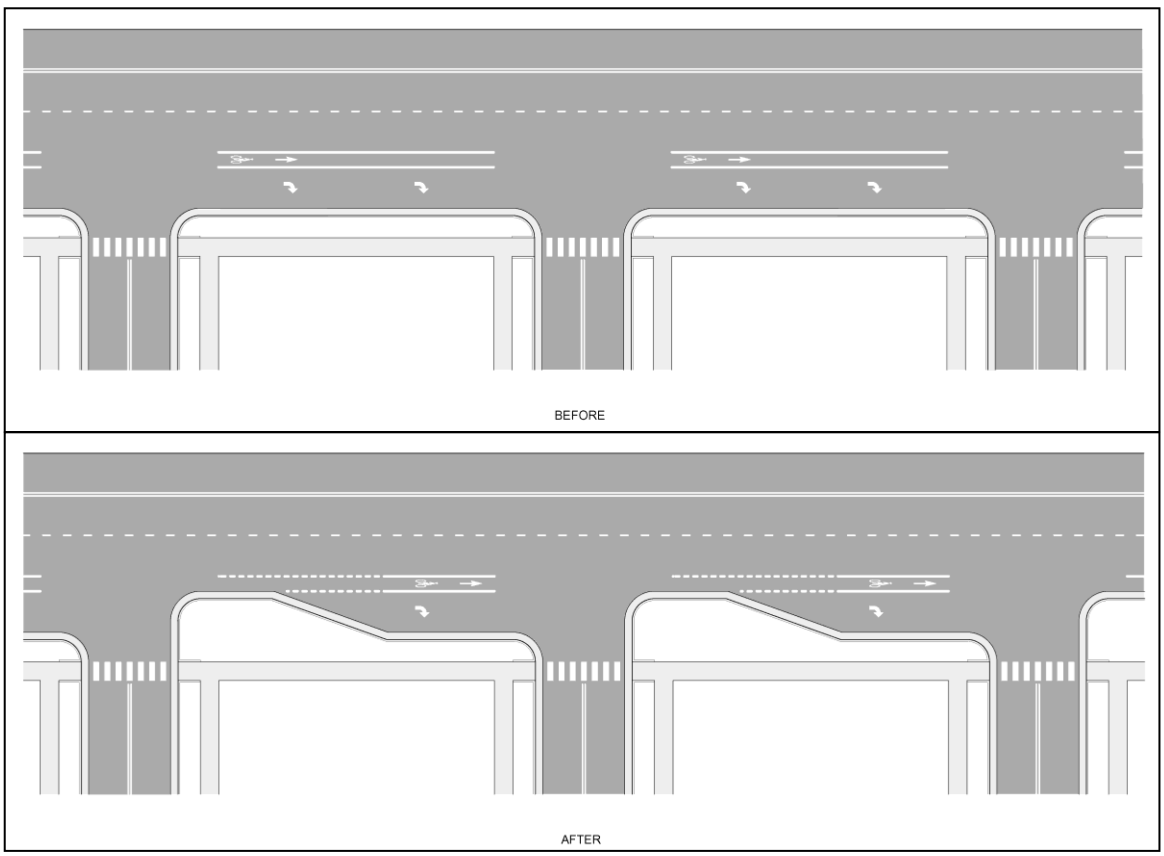


Figure 48: The illustration at top shows a roadway with a continuous right turn lane, which allow constant merging conflicts. The bottom illustration provides separate right turn lanes, which can increase safety for cyclists.

approaching roadway from turning right into the continuous turn lane, resulting in fewer vehicles merging out of the continuous turn lane. Also, multiple turn lanes will create a defined space for motor vehicles to move into the right-turn lane prior to an intersection. Bike lanes should be installed to the left of the right-turn lanes.

Rumble Strips on Urban and Suburban Roadways

Shoulder rumble strips have been implemented by many highway agencies and State Departments of Transportation (DOTs) across the United States as an effective countermeasure to single-vehicle run-off-the-road accidents. In 2001, the FHWA issued a technical advisory on roadway shoulder rumble strips to address the conflict between the use of shoulder rumble strips on non-controlled access roadways and cyclists. FHWA technical advisory recommends rumble strips normally not be used in urban or suburban areas on non-controlled access roadways or along roadways where prevailing speeds are less than 50 mph. Additionally, FHWA recommends rumble strips not be used when their installation would leave a clear shoulder pathway less than 4-feet wide (or less than 5-feet wide if there is an obstruction such as a curb or guardrail) to the right of the rumble strip for bicycle use. The use of shoulder rumble strips on non-access controlled facilities should be limited to locations that an engineering study or crash analysis suggests that the number of these crashes would likely be reduced by the presence of rumble strips which is consistent with FHWA's policy guidance.

Research has been conducted to determine types of rumble strips that are considered bicycle friendly and continue to warn drivers they are too close to the edge of pavement. It was determined that rumble strips should be 3/8" deep or shallower for cyclists to remain in control. Also, the rumble strips should be constructed so that there is an interruption, or gap, at a pre-determined interval that allows cyclists to maneuver between the rumble strips.

3.10 MAINTENANCE

Cyclists travel on two, high-pressure wheels and are even more vulnerable to poor roadway conditions than motor vehicles. Therefore, bicycle facilities should be maintained to the same high standard as roadways for motor vehicle traffic.

Bicycle facilities require routine maintenance just as roadways do. Because of their design, bicycles can be even more susceptible to accidents or damage caused by poor roadway conditions than motor vehicles. Debris on the roadway can deflect bicycle wheels, causing cyclists to lose control, and potholes can bend the rim of a bicycle wheel.

Surface Repairs

Cyclists should be provided with smooth riding surfaces. Therefore, surface imperfections should be maintained. Irregularities, such as potholes, ridges, cracks, and other surface defects, should be identified as part of regular maintenance and repaired promptly, especially when they are located within the bicycle path of travel. Also, an effort should be made to respond quickly to complaints of a specific hazard made by facility users.

Repaving

Repaving projects often present an opportunity to add or improve bicycle facilities on a roadway. Repaving may result in additional room for shoulders or bike lanes, adjustment of conventional travel lanes or the repair of surface irregularities.

Pavement overlays should extend across the entire pavement width (e.g. travel lanes, turn lanes, shoulder area, etc.) to prevent surface problems, like a ridge or edge, within the bicycle travel path.

As part of the repaving project, certain roadway features, such as manhole covers and storm grates, should be raised to offset the pavement surface by no more than one-quarter inch.

As previously mentioned, gravel driveways should be paved at least 15 feet back from the roadway to prevent gravel from spilling into the bicycle travel path. This portion of gravel driveways can be paved during roadway repaving projects.

Debris Removal

Routine inspection and maintenance programs should be organized to guarantee that litter and debris are removed from bicycle facilities on a regular basis. Streets that are equipped with bicycle facilities may require even more attention than roadways without bike facilities. Areas of the roadway between through and turning traffic often collect debris and are often in the path of bicycle travel. In order to keep them functioning properly and to keep water out of the bicycle path of travel, drainage areas should be kept clear of debris.

Maintenance schedules may need to be modified depending on the season. For example, frequent sweeping to remove leaves in the fall may be necessary. Individuals should be discouraged from blowing grass or leaves into the public right-of-way because, in addition to littering the path of bicycle travel, this practice creates increased workload and burden for the government agencies charged with keeping the right-of-way clean.

Utility Cuts

The cut lines of utility cuts on a roadway should be parallel with the flow of traffic and should be located outside the path of bicycle traffic to the greatest extent possible. Cut lines that must be placed within the travel path of cyclists should be filled and made flush with the surface of the pavement.

Vegetation

Vegetation along bicycle facilities should be trimmed periodically to avoid sight distance limitations and to provide a minimum of two feet of clearance, especially at curves or intersections. In addition, care should be taken to ensure that signage is not hidden by vegetation. Preventative maintenance should be performed to keep tree roots from breaking up pavement.

Spot Improvements Program

In many cases, the users of a bicycle facility are the first to be aware of a maintenance problem on a bikeway. Spot improvement programs, where cyclists communicate problems directly to responsible government agencies, provide early detection of problems. This allows needed repairs to be performed quickly. However, spot improvement programs should not be expected to replace routine maintenance and inspection of bicycle facilities.

Providing forms on the government website can be a good way for cyclists to contact the appropriate government agency. The maintenance request can be forwarded to the proper department, which will then be able to follow-up with the citizen who made the request. Paper forms should also be made available to those without internet access, and should be provided at bike shops or other easily accessible locations to cyclists. The government agencies need to have adequate staff and funding available to address maintenance problems as they arise.

3.11 ADDING BICYCLE FACILITIES TO EXISTING ROADS

Space within the roadway right-of-way should accommodate motor vehicle, bicycle, and pedestrian travel. However, many existing streets were originally constructed without bike lanes. For this reason, creating space for bicycle facilities on roadways can be one of the more challenging aspects of developing a bicycle network.

Bike facilities can be added to existing roadways by paving the shoulder as a bike lane, re-striping the roadway, or widening the roadway. Typically, re-striping or adding bike lanes to the shoulder are the preferred methods of incorporating bike facilities to existing streets since physical constraints often make widening roads not feasible.

Paving the Shoulders

As discussed in the shoulder bikeways section, the shoulder area on roadways without curb and gutter can often be used for bike facilities. However, unpaved or gravel shoulders, or shoulders paved with a rough bituminous surface, should be repaved to provide a stable riding surface for cyclists.

Shoulders should be paved to match the adjacent roadway structure and can function as either bike lanes or wide outside lanes. Minor shoulder grading may be able to provide additional width for paving, improving the comfort and safety of shoulder bike facilities.

Re-stripe the Roadway

<u>Reduce Travel Lane Width</u>
Space can be created for bicycle facilities by narrowing existing travel lanes, turn lanes, or parking lanes. Occasionally, wide lanes can be narrowed and still maintain 11 or 12-foot wide lanes. On lower-speed streets, travel lanes can be reduced to ten feet without compromising safety or operation and can still remain within AASHTO guidelines.

<u>Reduce the Number of Travel Lanes</u>
In some cases, removal of a conventional travel lane may be warranted and can provide roadway space for bike lanes. An engineering study should be conducted to determine levels of service for motor vehicles based on a reduction of travel lanes. Depending on the roadway, the demand for enhanced bicycle facilities may outweigh a reasonable reduction in motor vehicle capacity.

The practice of reducing the number of conventional travel lanes has actually been effective in improving traffic flow in many locations and is now commonly referred to as a "road diet." A common example of a road diet is a two-way roadway with a four-lane cross-section that is re-striped as a three-lane cross-section to include a single travel lane in each direction, a center turn lane, and, of course, space for bike lanes. This configuration has been used successfully in cities throughout the United States and Canada and can effectively improve traffic operations by reducing speeding, conflicts and crashes, especially on streets with high turning volumes.

<u>Reduce On-Street Parking</u>
Additional width for bike facilities may be obtained by reducing the amount of pavement width allotted to on-street parking. The width of parking lanes can be reduced to seven feet. However, when seven-foot parking lanes are used, adjacent bike lanes are recommended to have a minimum width of six feet.

Removing a parking lane from one side of the street may be appropriate where there is moderate parking demand. Another alternative would be to allow parking in bike lanes during off-peak periods or during special events, such as at night or during a nearby worship service.

The benefits of on-street parking and its effect on pedestrians and nearby businesses should be considered before reducing or eliminating parking lanes. For example, many businesses rely on on-street parking for their customers, and parking lanes increase pedestrian comfort by providing a buffer between the sidewalk and travel lanes.

Re-stripe for Wide Outside Lanes

Whenever possible, "extra" roadway width should be applied to outside lanes, even in locations where extra width will not result in the standard 14-feet required for WOLs. Cyclists benefit from any additional space in the outside lane, and motorists are provided with more room to pass cyclists without weaving into adjacent lanes. When additional width is provided for wide outside lanes, roadway features, such as storm grates, manhole covers, sign posts, or other obstructions, should be bicycle-compatible or should be relocated, if possible.

3.12 BICYCLE PARKING

Parking is as important to cyclists as it is to motorists and should be well-located, secure, and plentiful. Insufficient bicycle parking can actually discourage a potential cyclist from riding.

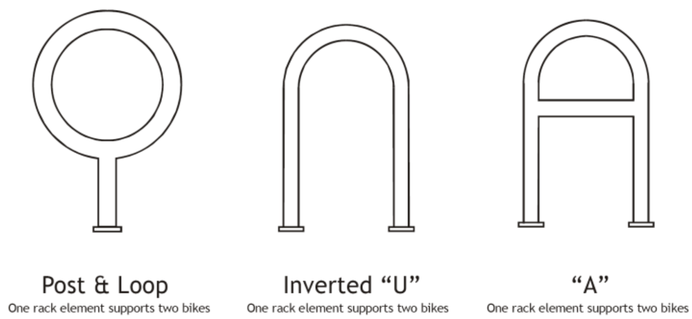
Benefits of bicycle parking are not limited to cyclists. Approximately ten bicycles can be parked in the amount of space provided for a single motor vehicle. Therefore, if installed properly, the use of bicycle parking may lessen overcrowding in parking lots and help satisfy parking demand.

To ensure adequate parking for cyclists, many cities are implementing specific ordinances related to bicycle parking, usually based on the land use and size of the development. These guidelines may be used as a foundation for the development of this type of ordinance.

In general, bicycle facilities are classified as either short-term or long-term facilities. These facilities are discussed below.

Short-Term Parking

Parking facilities that are used for a couple of hours, such as one used by a customer at a store or by a student going to class, are referred to as short-term parking facilities. Bike racks fall into this category of bicycle parking.



Examples of Bike Racks

The design of bike racks should allow the cyclist to lock both the bicycle frame and wheel, and they should be able to accommodate U-type bike locks. They should also be securely anchored to the ground or other object. Although in many cases bike racks are not covered, it may be a good idea to provide shelter for a bike rack in a location where bikes may be left for an extended period of time. Bike racks are not equipped with storage for bicycle gear, such as tools or bags.

"Comb", "Toaster" or similar styles of bike racks tend to bend bicycle wheels and also allow only a bicycle wheel to be secured. For these reasons, these types of racks are generally passed up for higher-quality racks.

Bike racks should be positioned with adequate spacing between other bike racks and buildings to allow enough room to maneuver a bicycle. When bike racks are placed in public right-of-way, like sidewalks, they should be positioned to avoid blocking pedestrian traffic and should comply with ADA accessibility guidelines.

Clearances for bike racks should be based on the dimensions of bicycles rather than bike racks, which often have varying design and dimensions. Average bicycles measure approximately six feet long and two feet wide. Bike racks should be positioned to provide at least two feet of clearance parallel to a parked bicycle and five feet of clearance perpendicular to the bike.

Bike racks should be located in visible, well-lit locations. As a general rule, they should be located at least as close as the nearest motor vehicle parking space, and no further than 50 feet from an entrance. At buildings with several entrances, a few racks, each with fewer parking positions, should be installed instead of one rack at the main entrance with several parking positions.

Examples of Short Term Bicycle Parking

Long-Term Parking

Cyclists who will be storing their bicycle usually for at least the entire day, or possibly for longer, will be better served by long-term parking facilities. These facilities are typically placed in locations that are used by commuters, such as park-and-ride lots or parking garages. Facilities for long term parking should also include storage for bike gear.

Long-term parking facilities, such as bike lockers, caged shelters, or storage rooms located within buildings, should provide total security as well as protection from the weather. At universities, major employers, or multi-family residential developments, long-term parking may be provided by sheltered, gated areas with, or in, lockable, indoor rooms.

In most buildings, some unused space exists at the end of hallways or underneath staircases. Often, these areas can provide just enough space for some indoor bicycle parking facilities. Either stands or wall mounted racks can be used at indoor parking facilities. Where indoor parking facilities are used, the route of cyclists through a building to access the storage facility should be considered.

Because plastic can be more susceptible to vandalism, most long-term parking facilities are constructed with metal. Long-term parking facilities should be situated in secure locations, preferably in areas that are not secluded, but are full of activity. Ideally, the area would be monitored, by either camera or security guard.

Bicycle stations can be used for long term bicycle parking which are attended or automated parking areas. Sometimes other services are offered at bicycle stations which include bicycle repairs, sharing, rentals and retail sales.

While long-term parking facilities should be placed within relative proximity to commuter destinations, the location of long-term facilities is not as critical as it is for short-term parking. It is generally assumed that cyclists are willing to travel slightly further to a location where their bicycle will be protected.

3.13 RELATED PLANNING ISSUES

Land Use

Like walking, the convenience of bicycling for travel is often determined by the pattern in which land is developed. In fifteen minutes, most cyclists can cover about two miles, making bicycles a versatile mode of travel.

Land use patterns that encourage bicycling include:

- Development densities that allow people to live close to destinations such as schools and stores
- Mixed-use zoning that allows commercial and residential land uses in the same area, along with standards that ensure compatible building design
- Locating building fronts close to the street, which can slow traffic and offers easier bicycle access

Some common land development practices that discourage bicycle travel include:

- Segregated land uses that create long distances between destinations
- Commercial properties set far back from the street with large parking lots in between. Such sites also typically include access and parking facilities for automobiles only.
- Large lots in residential areas that create greater distance between home and other destinations

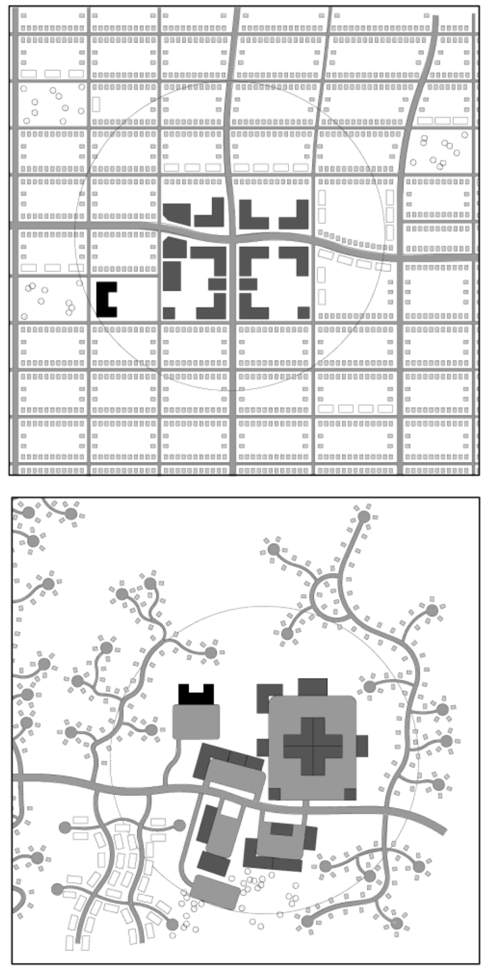


Figure 49: The top illustration shows a half-mile radius around the commercial center of a densely developed, mixed-use area with grid network of streets. This development pattern encourages walking and bicycling. The illustration at bottom shows a low-density, segregated development pattern, which limits practical pedestrian and bicycle travel.

The top example in Figure 49 illustrates a land use pattern that encourages various types of travel. As shown, the mixed-use development within the grid pattern, and the proximity to residential areas, promotes walking or biking to various destinations. The illustration at bottom of Figure 49 shows how segregated developments discourage walking and bicycling to these destinations because of the distances from homes and between the destinations themselves.

Roadway Network

In the decades following World War II, roadway network planning practices shifted from traditional urban patterns to more strictly hierarchical, non-grid road systems with cul-de-sacs and other such features. This approach tends to concentrate traffic on collector and arterial streets, can result in single points of access to many destinations, and often requires significant out-of-direction travel. While indirect travel routes are not always a major deterrent to drivers, they can result in added travel time and inconvenience for cyclists. An interconnected grid of streets offers many routes and points of access to destinations for cyclists, pedestrians, and motorists. When retrofitting a non-grid network, off-street connector trails can sometimes provide the directness that the street system doesn't offer. For example, providing a connector trail from the end of a neighborhood cul-de-sac to a library can decrease parking demands at the library and reduce the vehicular load on nearby roadways.

Access Management

Urban collectors and arterials with commercial frontage are attractive to both bicyclists and drivers because they usually provide the best access to destinations and the most direct routes through a community. Although traffic speeds and volumes on such roadways can discourage cyclists, it is at the intersections and driveways where accidents are most likely to occur. As shown in Figure 50, unlimited access creates many conflicts between cars entering or leaving the roadway, and cyclists riding along the roadway.

Limiting or consolidating driveways, and using other access management design tools such as curbed medians benefits both cyclists and drivers. Advantages include:

- The number of conflict points is reduced.
- Vehicles are redirected to intersections with appropriate traffic control devices.
- Improved traffic flow can reduce the need for road widening, perhaps allowing part of the right-of-way to be reclaimed for bicycle facilities.

Access management design also needs to consider the potential for negative impacts on cyclists. For example, redirecting motor vehicle traffic should not significantly increase out-of-direction travel for cyclists.

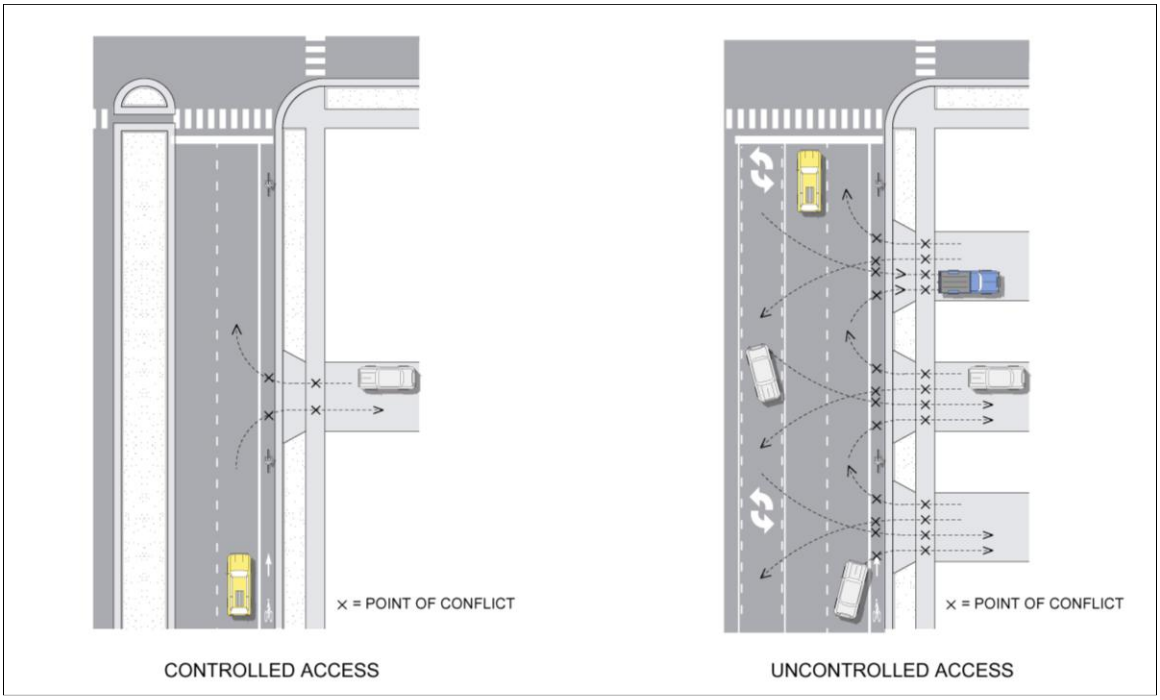


Figure 50: Access management reduces the number of conflict points between motorists, bicyclists, and pedestrians.

Roadway Design Standards & Land Development Regulations

Local jurisdictions within the Nashville MPO should adopt roadway design standards that include cross-sections to accommodate the bicycle facilities. Additionally, local jurisdictions should update their local subdivision and zoning regulations to encourage provisions and standards that promote bicycle accommodations as part of the land development process.