Colorado Department of Transportation
Roadway Design Guide

Chapter 14 Bicycle and Pedestrian Facilities
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01/24/2013	Table 14-4 replaced

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CHAPTER 14

BICYCLE AND PEDESTRIAN FACILITIES

14.0 INTRODUCTION

Multimodal transportation is a key element of CDOT's mission in providing improvements to the statewide transportation system. CDOT has adopted a Policy Directive and a Procedural Directive to improve the accommodation of bicycles and pedestrians in CDOT programs. Additionally, federal surface transportation law places a strong emphasis on creating a seamless transportation system that persons of all ages and abilities can utilize for safe and convenient access to jobs, services, schools and recreation.

The design requirements set forth in this chapter apply to all new construction and reconstruction projects. Although optional, they will also be considered for other projects when funding is available and where appropriate as determined by the Project Manager. Pursuant to Chief Engineer Policy Memo 7, *"it is imperative that surface treatment dollars are optimized in regards to maintaining the pavement surface. In that light, surface treatment dollars are not to be used to fund enhancements or other project related costs."*

The designer should also adhere to the requirements of CDOT Policy Directive 548.0 and the corresponding CDOT Design Bulletin "Safety Considerations on 3R Projects (Revised) 2005 Number 1, Page 1 of 7, Revised July 20, 2006" when considering improvements for bicycle and pedestrians as part of a 3R project. When bike and pedestrian facilities are warranted or requested, project managers will investigate other funding sources to supplement the primary funding for the project. If funds are not available, the Project Manager will document with a letter to the design file. The letter will specifically state what efforts were made to obtain other funding. Additionally, the project manager should determine if other sidewalk or bikepath projects are planned in the same area to determine if there are opportunities to consolidate the projects.

14.0.1 Intent of Chapter 14 - Design of Bicycle and Pedestrian Facilities

This chapter provides detailed design criteria, standards, and guidance for the development of bicycle and pedestrian facilities. The material in this chapter is derived from the AASHTO *Policy on the Geometric Design of Streets and Highways* (*PGDSH)* **(1)**, the AASHTO *Guide for the Development of Bicycle Facilities* **(2)**, the AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities* **(3)**, the *Manual of Uniform Traffic Control Devices (MUTCD)* **(4)** and other federal documents or research as noted throughout this chapter. It is the intent of this chapter to be consistent with all of the criteria provided in federal or CDOT standards. This chapter is intended to provide those standards in one location and provide additional guidance (if possible) where none exists in the current standards or guidance documents.

14.0.2 CDOT Bike and Pedestrian Policy Directive 1602.0

In October of 2009, the Colorado Transportation Commission adopted Policy Directive 1602.0, Subject: Bike and Pedestrian. The purpose of this policy is

> *… to promote transportation mode choice by enhancing safety and mobility for bicyclists and pedestrians on or along the state highway system by defining the policies related to*

education and enforcement, planning, programming, design, construction, operation and maintenance of bicycle and pedestrian facilities and their usage.

With the adoption of this policy

It is the policy of the Colorado Transportation Commission to provide transportation infrastructure that accommodates bicycle and pedestrian use of the highways in a manner that is safe and reliable for all highway users. The needs of bicyclists and pedestrians shall be included in the planning, design, and operation of transportation facilities, as a matter of routine. A decision to not accommodate them shall be documented based on the exemption criteria in the procedural directive.

14.0.3 CDOT Bike and Pedestrian Procedural Directive 1602.1

CDOT Procedural Directive 1602.1 requires the incorporation of bicycle and pedestrian considerations throughout CDOT's Planning, Programming, Design, Construction and Maintenance operations (as well as Educational and Enforcement efforts). Specifically with respect to design, the procedural directive states the following:-

DESIGN

A wide range of options can serve to enhance bicycle and pedestrian mobility. Bicycle and pedestrian accommodation comes in many sizes and styles from signage and striping to sidewalks and shoulders. Context sensitive solution practices are encouraged to determine the appropriate solution for accommodating bicyclists and pedestrians within the project area so that they are consistent with local and regional transportation plans. Bicycle and pedestrian accommodations shall be integrated into the overall design process for state highway projects that begin the scoping process after the approval date of this procedural directive. Consideration of bicycle and pedestrian accommodations in on-going projects will be incorporated as reasonable and feasible given budget and schedule constraints.

Current AASHTO and MUTCD standards for bicycle and pedestrian facilities shall be used in developing potential facility improvements. To provide consistent information on accommodating bicyclists and pedestrians on the state highway system, staff shall develop a chapter on bicycle and pedestrian design guidelines as part of the existing CDOT Design Manual.

It is recognized that in some limited cases bicycle or pedestrian facilities may be impractical. Consequently the procedural directive provides the following:

EXEMPTION

CDOT will utilize FHWA exemption guidance in situations where one or more of the following occur:

- *Bicyclists and pedestrians are prohibited by law from using the roadway*
- *The cost of establishing bikeways or walkways would be excessively disproportionate to the need or probable use. (Excessively disproportionate is defined as exceeding twenty percent of the cost of the larger transportation project.)*

- *Where scarcity of population or other factors indicate an absence of need.*

Requests for an exemption from the inclusion of bikeways and walkways shall be documented with supporting data that indicates the basis for the decision. Exemption requests shall be submitted to the Region Transportation Director and the headquarters Bicycle Pedestrian Coordinator. Review and response will be done within 30 days following submittal.

14.0.4 Design Exceptions

It is not the intent of this chapter to create a new process for documenting design variances and exceptions. A design letter will be used to document when any of the design criteria of this chapter cannot be met on a project. In addition to the Regional Transportation Director approval, when the exception is for a bicycle or pedestrian criteria, the headquarters Bicycle Pedestrian Coordinator must also acknowledge being provided an opportunity to comment on the request for an exception.

14.0.5 Federal Guidance Concerning Bicycle and Pedestrian Facilities

14.0.5.1 US DOT Policy Statement

In a policy statement dated March 11, 2010, the US Secretary of Transportation stated the following

The DOT policy is to incorporate safe and convenient walking and bicycling facilities into transportation projects. Every transportation agency, including DOT, has the responsibility to improve conditions and opportunities for walking and bicycling and to integrate walking and bicycling into their transportation systems. Because of the numerous individual and community benefits that walking and bicycling provide — including health, safety, environmental, transportation, and quality of life — transportation agencies are encouraged to go beyond minimum standards to provide safe and convenient facilities for these modes.

And from Title 23 U.S.C. 217 the following is stated

Bicycle transportation facilities and pedestrian walkways shall be considered, where appropriate, in conjunction with all new construction and reconstruction of transportation facilities, except where bicycle and pedestrian use are not permitted.

14.0.5.2 Restrictions on Severing Bicycle and Pedestrian Facilities

In addition to encouraging the provision of bicycle facilities, FHWA is prohibited from funding projects that would sever or have a significant adverse impact on the safety of nonmotorized transportation. Title 23 of the United States Code includes the following (§109(m)):

Protection of Nonmotorized Transportation Traffic. --The Secretary shall not approve any project or take any regulatory action under this title that will result in the severance of an existing major route or have significant adverse impact on the safety for nonmotorized transportation traffic and light motorcycles, unless such project or regulatory action provides for a reasonable alternate route or such a route exists.

14.0.6 Context Sensitive Design

Context Sensitive Design applies to a transportation project's engineering design features, and may include design features that help the project fit harmoniously into the community and consider the particular needs of the community. Context Sensitive Design is particularly relevant for pedestrian and bicycle related facilities.

14.0.7 User Counts

CDOT has a comprehensive short-duration and continuous-count motorized as well as non-motorized travel monitoring program of the active transportation modes. New or reconstruction projects, as well as facilities requiring non-motorized evaluation usage, should consider the installation of non-motorized permanent continuous counting stations or implementing short-duration counting methods within the project boundaries.

By counting bicyclists and pedestrians CDOT can obtain benchmark information on how many users there are on Colorado facilities. This information can be used for setting priorities for new facilities or identifying potential routes. It can also be used to measure increases in bicycling and walking as the Colorado network is improved. Additionally, counts provide a denominator for crash rates.

Coordination and support resources for selecting a site, purchasing counting equipment, and providing data are provided by CDOT's Traffic Analysis Unit (TAU) within the Division of Transportation Development's Mobility Analysis Section. Where new counting equipment is being installed, the installation should be coordinated with TAU.

General specifications for purchasing bicycle and pedestrian counting equipment should include the following:

Only equipment that can meet or exceed the following specifications:

- Weatherproof and compliant with the IP 68 (or current equivalent) weatherproof standard
- Battery operated with at least a 5 year battery life
- Contain a clock capable of detecting and storing time in a 24 hour period (minimally, 1 hour increments of data must be stored and retrievable by the counting equipment-15 minute increments is preferred)
- Counter device must be capable of storing one year of data and store data on the counter after retrieval Provide directional data (minimally, hourly counts should provide data by direction and totals for the site). Example:
    - North bound (11:00am 50 bicycles and pedestrians) and
    - South bound (11:00am 40 bicycles and pedestrians)
    - Total Count (11:00am is 90 bicycles and pedestrians)
    - Data collected by the counter must be able to export into a spreadsheet
    - Counter must have a way to display the number of counts on the counter, the retrieval device, and the networked personal computer (data storage location)

- Counter must provide a way to download data that can be loaded to CDOT's networked traffic data warehouse for storage, retrieval, and reporting purposes
- Detection Range of the counter should be a minimum of 15 feet
- Counter must include all installation equipment including the enclosure, and any installation screws, bands, etc. specifically required for the supplies enclosure mounting.
- Counter must be capable of connecting to a modem to download data
- Counter must not have any speed restrictions on capturing data such as only traffic traveling greater than 20 miles per hour can be detected
- Counter must use passive infrared detection sensor technology not requiring multiple sensors to be installed on both sides of detection location
- Infrared detector must be able to discriminate a 1 deg. C temperature differential between subject to be counted and ambient air
- Counts must have an accuracy of +/- 5%
- Equipment must be highly portable and demonstrate the capability to be mounted on a light pole, fence post or tree with minimal tool requirements
- Counter must have an operating temperature range of -40 to 120 degrees

14.1 BICYCLE FACILITIES

Bicyclists should be expected on all of Colorado's state roadways except those where their use is prohibited. All design on CDOT facilities, except those roadways where cyclists are prohibited, shall include accommodations for bicyclists.

A map showing those roadways where bicyclists are prohibited is available on the internet at http://www.coloradodot.info/programs/bikeped/colorado-bicycling-maps/scenicbywaysbikemap.pdf/view.

14.1.1 Accommodating Bicycles

Bicycle accommodations can take any number of forms. Most often these will be represented by in-street facilities such as shared lanes, wide curb lanes, paved shoulders, or bike lanes. Separated shared used paths are another class of facility which may be provided for bicyclists.

When a corridor is being improved to accommodate bicyclists, the length of the corridor should provide a consistent design to the maximum degree possible. Alternating facilities, such as from bike lanes to sidepaths back to bike lanes, can cause confusion for both bicyclists and motorists.

Roadway improvements for bicycles should be continued to logical termini. Where the improvement is a bike lane, bike route, or shared use path, advanced signage should be provided to inform bicyclists that the improvement is coming to an end.

14.1.1.1 Sharing Roadway Space

Bicycles operating on Colorado roadways are considered vehicles **(5)**. Consequently, when bicyclists operate on the roadway they are subject to the same rules of the road as the operators of other vehicles. The design criteria and treatment guidance provided in this chapter are intended to support the operation of bicycles as vehicles.

In-street facilities will be the most common facilities provided on CDOT roadway projects. In most cases the accommodation will be a bike lane or paved shoulder (See Section 14.1.3.5 below). If, however, this design chapter is applied on facilities that are not CDOT roadways, or if a project is constrained, other facilities may be appropriate. Additionally, if a community or agency has adopted a minimum level of accommodation (level of service), bike lanes or shoulders that are wider than the minimum may be required to meet that level of accommodation. Where practical, the bicycle facility provided on CDOT roadway projects should comply with adopted bicycle plans.

14.1.1.2 Role of Design Factors

The level of accommodation for bicyclists can be measured by a number of methods ranging from subjective to objective. The 2010 *Highway Capacity Manual (HCM)* **(6)** now establishes an objective method for determining the level of bicycle accommodation based upon the geometric and operational characteristics of the roadway being analyzed. This method is based upon numerous research projects which quantified what factors influence how bicyclists perceive a roadway's safety and comfort. The model for links (roadway segments between intersections) includes the following factors:

- width of the outside through lane,
- presence and width of a paved shoulder or bike lane,
- encroachments into the bike lane,
- presence and width of a parking lane,
- percent of parking occupied by parked cars,
- pavement condition,
- operating speeds on the roadway,
- traffic volume on the roadway, and
- percent heavy vehicles on the roadway.

The primary geometric conditions that are influenced by design are the width of the outside lane, the presence of a paved shoulder or bike lane, the width of the paved shoulder or bike lane, and encroachments into the bike lane or shoulder. As stated above in Section 14.1.1.1, on new CDOT construction projects, it is likely that shoulders and bike lanes will be the facility of choice for accommodating bicycles. However, in some cases a shared lane, or wide outside through lane may be adequate to accommodate bicyclists. On some projects pavement cannot be widened or restriped to provide shoulder or bike lane width. On these roads, the available roadway space and traffic conditions should be analyzed to determine if the minimum adopted level of service for bicycles can be achieved by adjusting lane widths to provide wide curb lanes.

14.1.1.3 The Bicycle as a Design Vehicle

As with the design of roadways, the design vehicle is an important consideration for bicycle facilities. Most design criteria for roadways, beyond the addition of extra space for the bike lane or paved shoulder, will not be impacted by the bicycle as a design vehicle. On a shared use path, however, the bicycle and other non-motorized users are used as design vehicles. Their characteristics dictate numerous design values and criteria such as design speeds, stopping sight distances, maximum degree of horizontal curvature, minimum vertical curve lengths, etc. The design values used in this chapter are based upon those in the AASHTO *Guide for the Development of Bicycle Facilities* **(2)**, with supplemental information provided from the FHWA *Characteristics of Emerging Road and Trail Users and Their Safety* **(7)**.

With regard to calculated design values such as stopping sight distance or the minimum length of vertical curves, the equations used to calculate the design values are the same for non-motorized operators as they are for motorized vehicles. Appropriate assumptions and input values will be provided in the chapter section related to specific design values (Section 14.2.3.3).

14.1.2 Bike Routes

Bike routes are not an actual facility type. A bike route is a designation of a facility, or collection of facilities, that links origins and destinations that have been improved for, or are considered preferable for, bicycle travel. Bike routes include a system of route signs that provide at least the following basic information:

- Destination of the route
- Distance to the route's destination, and
- Direction of the route.

Bike routes can be designated in two ways: General Routes and Number Routes. General Routes are links with a single origin and a single destination. Number Routes form a network of bike routes that connect several origins to several destinations.

14.1.2.1 General Bike Routes

General Routes connect users to destinations within a community. Typical destinations include the following:

- Attraction Areas (i.e. stadiums, parks, etc.)
- Neighborhood Areas (i.e. downtown, historic neighborhoods, etc.)
- Trail Networks or trailheads (i.e. Glenwood Canyon Trail)

BICYCLE GUIDE signs may be provided along designated bicycle routes to inform bicyclists of bicycle route direction changes and to confirm route direction, distance, and destination. Typical signs that convey the basic wayfinding information for general routes are shown below in Figure 14-1. The *MUTCD* provides a number of different types of signs that can be used to provide guidance along bike routes. Some of these are shown below.

Figure 14-1 Examples of BICYCLE GUIDE Signs

14.1.2.2 Numerically Labeled Bike Routes

Some communities may implement a numerically labeled system of bike routes. These routes should be designated using BIKE ROUTE signs (Figure 14-2). BICYCLE ROUTE signs can be customized by adding a specific community logo in the upper portion of the ellipse.

Figure 14-2 Examples of BIKE ROUTE Signs

A subset of numerically labeled bike routes is the U.S. Bicycle Route system. Where a designated bicycle route extends through two or more states, a coordinated submittal by the affected states for an assignment of a U.S. Bicycle Route number designation is sent to the American Association of State Highway and Transportation Officials (AASHTO) **(8)**. A system of proposed U.S. Bicycle

Routes is being developed. Colorado has not yet defined its U.S. Bicycle Routes; however, the AASHTO task force leading this effort has proposed several corridors through Colorado. For these routes the U.S. BIKE ROUTE (Figure 14-3) sign should be used to designate the routes.

M1-8a

Figure 14-3 U.S. BIKE ROUTE Sign

14.1.3 Shared lanes

A *shared lane* is a lane of a traveled way that is open to bicycle travel and vehicular use. In this *Roadway Design Guide* it refers to a lane of less than 14 feet in width. Lanes 14 feet wide or wider are considered *wide curb lanes*.

The *Highway Capacity Manual* method can be used to determine what accommodations are necessary to meet a minimum level of accommodation for bikes along a bike route. On local roadways with low volumes and speeds, a shared lane may be all that is needed to comfortably accommodate bicyclists. On other roadways, a higher level of accommodation might be desirable; however it may be infeasible to provide bike lanes or paved shoulders, or to adjust lane widths to provide a wide curb lane. In these later cases, particularly if the roadways are identified as priority routes in an adopted bicycle plan, the following potential traffic control devices could be considered:

14.1.3.1 Bicycle May Use Full Lane Sign (R4-11)

The BICYCLE MAY USE FULL LANE sign (R4-11) may be used on roadways where the lanes are too narrow for bicyclists and motorists to operate side by side within a single lane **(9)**. On roadways with significant volumes, following motorists would likely be delayed while waiting for a gap to pass the bicyclist. On such roadways, the BICYCLE MAY USE FULL LANE sign should be considered to inform users that bicyclists have the legal right to claim the lane if the right-hand lane available for traffic is not wide enough to be safely shared with motor vehicles **(10)**. Guidance on the BICYCLE MAY USE FULL LANE sign is provided in the *MUTCD*. On roadways with frequent passing opportunities, the SHARE THE ROAD SIGN (see Section 14.1.2.2.2) may be more appropriate.

Figure 14-4 Bicycles May Use Full Lane Sign

A SHARED LANE MARKING (see Section 14.1.2.2.1) may be used in conjunction with the BICYCLES MAY USE FULL LANE sign.

14.1.3.2 SHARE THE ROAD Sign Assembly (W11-1 + W16-1P)

In situations where there is a need to warn drivers to watch for bicycles traveling along the highway, the SHARE THE ROAD sign assembly may be considered (see Figure 14-5).

The SHARE THE ROAD sign assembly may be installed on State maintained roadways at the discretion of each region's Traffic Engineer. To have maximum effect, these signs should be used with discretion. Consideration for placement should be given where

- A relatively high number of cyclists can be expected on the roadway,
- The roadway cannot be improved for cyclists,
- The road narrows for a short distance and a motorist and bicyclist may unexpectedly find themselves using the same roadway such as at the end of a bike lane or bridge approach, or
- There has been a significant history of bicycle crashes.

In addition to these reasons, the Share the Road sign assembly may be appropriate where ***(11)***

- Designated bicycle trails that are placed on short stretches of a major roadway that has not been improved for bicycling,
- Roadway where a known courtesy problem exists, or
- Roadway sections adjacent to shared use paths where public input suggests that, for the safety of other path users (e.g., pedestrians, children) and the bicyclists' own safety, some bicyclists choose to ride on the roadway.

Figure 14-5 SHARE THE ROAD Sign Assembly

On approaches to bridges, tunnels or any other section where motorists and bicyclists have reduced sight distance or where operating widths must be less than desirable due to right of way or actual roadway geometry restrictions, a SHARE THE ROAD assembly may be appropriate. In these cases consider adding flashing beacons to the assembly that can be either actively or passively triggered by bicyclists. The duration of the flashing beacon's activation should be such that a motorist passing the active flashing beacon will be likely to pass bicyclists who activated the treatment within the area of limited sight distance. This duration can be calculated using the following equation:

$$t_f = 1.47\left(\frac{l_c}{S_b} - \frac{l_c}{S_m}\right)$$

Where

t_f = duration of flashing (time in seconds)

l_c = length of constrained area, feet

S_b = speed of bicyclist, mph

S_m = speed of motorists, mph

The recommended assumed speed of the bicyclist on flat terrain for this application is 10 mph. This is the observed average speed of bicyclists **(7)**. Adjustments for grade should be made; this is particularly important on uphill sections where bicyclists will be traveling slower than average speeds.

A SHARED LANE MARKING (see Section 14.1.2.2.3) may be used in conjunction with the SHARE THE ROAD sign assembly.

14.1.3.3 Shared Lane Markings

SHARED LANE MARKINGS (Figure 14-6) are intended to perform any of several functions **(12)**:

- assist bicyclists with lateral positioning in a shared lane with on-street parallel parking in order to reduce the chance of a bicyclist impacting the open door of a parked vehicle,
- assist bicyclists with lateral positioning in lanes that are too narrow for a motor vehicle and a bicycle to travel side by side within the same traffic lane,
- alert road users of the lateral location bicyclists are likely to occupy within the traveled way,
- encourage safe passing of bicyclists by motorists, and
- reduce the incidence of wrong-way bicycling.

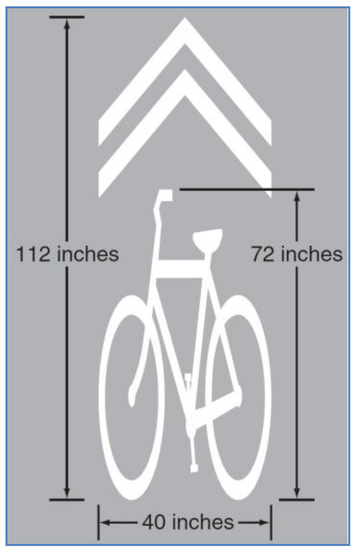


Figure 14-6 Shared Lane Marking

Refer to the *MUTCD* for proper placement of SHARED LANE MARKINGS.

14.1.4 Wide Curb Lanes

In restricted urban conditions, where it is not possible to include bike lanes or paved shoulders or on lower volume, lower speed collector streets, a wide curb lane can help accommodate both bicycles and motor vehicles in the same lane. The *Highway Capacity Manual* established methods can be used to identify the minimum wide curb lane width that will meet a target level of accommodation. Fourteen feet is the recommended minimum lane width for a wide curb lane, and within which a motorist may safely pass a bicyclist without encroaching into an adjacent lane.

The SHARED LANE MARKING and/or SHARE THE ROAD assembly may be used in wide curb lanes.

14.1.5 Paved Shoulders

Including paved shoulders during roadway construction or adding paved shoulders to an existing roadway without curb and gutter, or restriping a roadway to obtain a paved shoulder outside the travel lane can be an effective and relatively inexpensive way to improve a roadway for bicyclists.

Gravel shoulders are not acceptable as bicycle facilities. Adding or widening of paved shoulders may be subject to Municipal Separate Storm Sewer System (MS4) permitting requirements which could substantially increase retrofit costs.

To accommodate cyclists, paved shoulders at least 4 feet wide should be provided. Table 4-1 Geometric Design Standards (in Chapter 4), provides CDOT's minimum standard shoulder widths.

14.1.5.1 Additional Width

Some jurisdictions may have adopted a minimum paved shoulder width above those required for Type C or D roadways ("type" refers to details shown in Figures 4-1 through 4-4, in Chapter 4) within their bicycle master plans. When these local shoulder widths exceed the planned or typical CDOT shoulder for this type of location, the Project manager should consider accommodating local requirements when additional funding is provided by the local community to supplement the available budget.

Other communities or agencies may have adopted a minimum bicycle Level of Service that is to be met on their roadways. CDOT projects within these jurisdictions should be designed to meet the adopted minimum bicycle Level of Service unless the available budget prohibits this action. Table 14-1 below uses the aforementioned *HCM* method to provide the maximum design daily traffic for which a given shoulder width can provide a given bicycle Level of Service.

Scenic Byways plans for roadways may also specify wider shoulders. These plans should be accommodated during design.

Adopted Bicycle Level of Service = B

	Speed Limit (or Design Speed) 35						Speed Limit (or Design Speed) 45					
	Percent Heavy Vehicles						Percent Heavy Vehicles					
Shoulder width, ft	2	4	6	8	10	12	2	4	6	8	10	12
4	13300	7500	4500	3600	3100	2700	11200	6200	3900	3400	3000	2500
6		26400	10100	4800	3700	3200		16400	6600	4200	3500	3000
8				27000	8100	3700				12200	3900	3400

	Speed Limit (or Design Speed) 55						Speed Limit (or Design Speed) 65					
	Percent Heavy Vehicles						Percent Heavy Vehicles					
Shoulder width, ft	2	4	6	8	10	12	2	4	6	8	10	12
4	9900	5600	3800	3300	2800	2400	8900	5200	3700	3200	2700	2300
6		12200	6100	3900	3400	2800	29900	10300	5600	3800	3300	2800
8			29900	7600	3800	3300			22400	5200	3800	3200

Adopted Bicycle Level of Service = C

	Speed Limit (or Design Speed) 35						Speed Limit (or Design Speed) 45					
	Percent Heavy Vehicles						Percent Heavy Vehicles					
Shoulder width, ft	2	4	6	8	10	12	2	4	6	8	10	12
4			12700	5100	3700	3100		21200	7100	4400	3500	2900
6				24900	7300	3700				11600	3900	3400
8											22400	4700

	Speed Limit (or Design Speed) 55						Speed Limit (or Design Speed) 65					
	Percent Heavy Vehicles						Percent Heavy Vehicles					
Shoulder width, ft	2	4	6	8	10	12	2	4	6	8	10	12
4		15800	6500	4100	3400	2800		12700	6100	3900	3200	2700
6			27600	7100	3800	3200				5200	3700	3100
8					12000	3800					7600	3600

Adopted Bicycle Level of Service = D

	Speed Limit (or Design Speed) 35						Speed Limit (or Design Speed) 45					
	Percent Heavy Vehicles						Percent Heavy Vehicles					
Shoulder width, ft	2	4	6	8	10	12	2	4	6	8	10	12
4					9300	3700				14700	4100	2900
6						13900					20700	4400
8						15100						

	Speed Limit (or Design Speed) 55						Speed Limit (or Design Speed) 65					
	Percent Heavy Vehicles						Percent Heavy Vehicles					
Shoulder width, ft	2	4	6	8	10	12	2	4	6	8	10	12
4				9000	3900	3200			26200	6200	3800	3100
6					11300	3700					7100	3500
8						16600						9500

Table 14-1 Maximum motor vehicle service volumes for given Bicycle LOS grades

Notes:

Volumes are based upon a two-lane roadway. For maximum service volumes on a four-lane or six-lane roadway double or triple the values accordingly.

Values are established using the *HCM* methodology for roadway links.

Table assumes the following

K = 0.10, D= 0.53, PHF = 1 PavCon = 4 utside lane width = 12 feet

14.1.5.2 Shoulders on Steep Grades

The additional effort required of bicyclists riding uphill frequently results in their having a greater side-to-side sweep width than those riding on a flat roadway. A bicyclist riding downhill may also need additional space to maintain a comfortable distance from the edge of the pavement and potential adjacent motorists. Consequently, on roadways with significant grades, or long grades, shoulders of 6 feet or greater width should be provided.

14.1.5.3 Rumble Strips

Where deemed appropriate, rumble strips should be installed per CDOT Standard Plan No. M-614-1. On roadways identified as bicycle routes continuous rumble strips shall not be used. Rumble strips shall not be installed on shoulders less than 6 feet wide when guardrail is placed at the back of the shoulder.

Rumble strips should be placed as closely as possible to the right edge of the roadway edge line. A minimum of 4 feet clear shoulder should be provided to the right of the rumble strips. A warning marking as shown in Figure 14-7 should be placed in advance of each rumble strip installation.

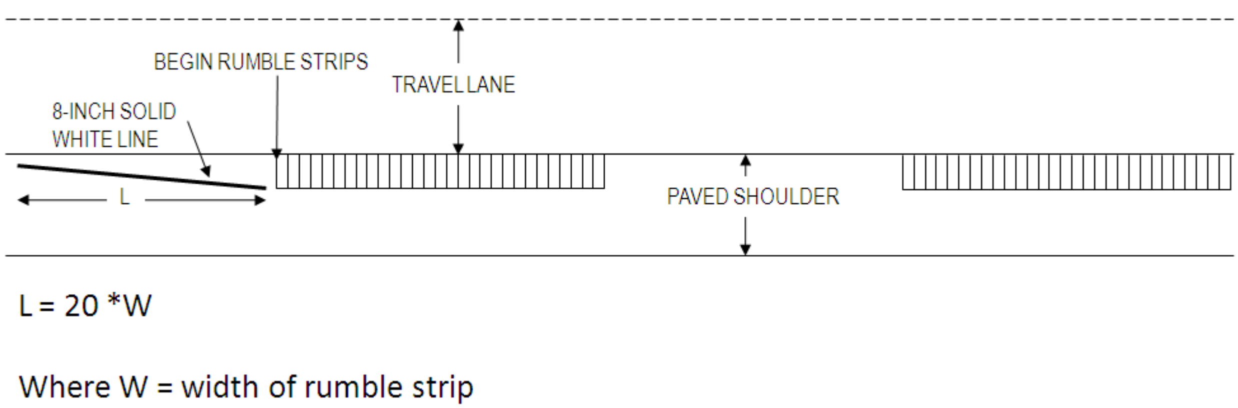


Figure 14-7 Advance Warning Stripe for Rumble Strips

14.1.5.4 Shoulders at Intersections

At intersections with right turn lanes, a paved shoulder is typically continued along the outside of the right turn lane. Some through bicyclists may continue to ride along the shoulder even though it compromises their safety at the intersection. Consequently, a 4-foot minimum space (undesignated bike lane) should be striped between the right turn lane and the through lanes. See intersection striping examples in Section 14.1.6.4.

14.1.6 Bike Lanes

Bike lanes are lanes that have been designated with pavement markings for the preferential use of bicyclists. They are typically one-way facilities located to the right of the general travel lanes on both sides of two-way streets. They may be placed on the left side of one-way streets if predominant travel paths or conflict points suggest this is a desirable option.

Contraflow bike lanes on the right side (with respect to direction of travel) are permissible. Contraflow bike lanes require that all appropriate traffic control (STOP signs, traffic signal heads, pavement markings, guide signage) be provided for bicyclists using the contraflow bike lane.

14.1.6.1 Bike Lane Width

The minimum bike lane width on a roadway with no curb and gutter is 4 feet. On roadway with curb and gutter, the minimum width of a bike lane is 5 feet measured from the face of curb. If a 2-foot gutter is used a 6-foot bike lane measured to the face of curb is recommended. As with paved shoulders (Section 14.1.2.4.1), adopted bicycle plans and Scenic Byway plans should be consulted to determine if wider bike lanes are specified or if a wider bike lane is needed to meet an adopted Level of Service standard.

On roadways with narrow parking lanes, wider bike lanes (six or seven feet wide) should be considered. This allows more space for bicyclists to ride clear of potential opening car doors. On roadways with on-street parking where there is high parking turnover 13 feet minimum is recommended between the face of curb and the left side of the bike lane.

On roadways where significant volumes of bicyclists are expected, creating a potential need for passing maneuvers, six- or eight-foot bike lanes should be considered.

Wide shoulders or bike lanes may be interpreted by motorists as additional general purpose travel lanes or parking lanes. This can be discouraged through the use of designated or buffered bike lanes (Section 14.1.6.3).

As with paved shoulders, additional width should be considered on roadways with significant or long grades. Another option on significant grades is to remove the bike lane on the downhill side of the road, reducing but not eliminating the shoulder, and to install BICYCLE MAY USE FULL LANE signs (R4-11) and SHARED LANE MARKINGS. The additional space gained from removing the bike lane on the downhill side of the road should be used to increase the bike lane width on the uphill side of the road. That this will reduce the available clear zone and should be considered prior to implementing this treatment.

14.1.6.2 Designating Bike Lanes

Bike lanes shall be designated with the bicycle symbol with the directional arrow being optional (Figure 14-8). Although using the directional arrow is optional, it’s strongly encouraged to better communicate the requirement for bicyclists to ride with traffic as the law requires.

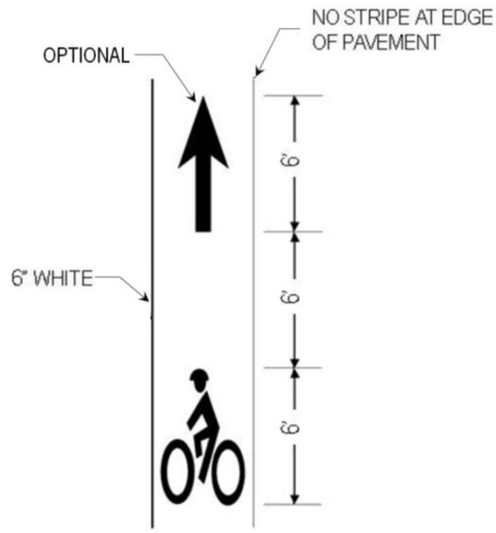


Figure 14-8 Detail of Bike Lane Designation

Bicycle lane markings should be placed after intersections and major driveways. In rural areas the maximum spacing of bike lane markings should not exceed 1320 feet. In urban areas the spacing should not exceed 600 ft.

The 6 inch white stripe on the left of the bike lane should become a dotted (2-foot line with a 4-foot gap) at improved bus stops with alighting pads to clarify that buses are to move right to allow transit riders to disembark off of the roadway.

14.1.6.3 Buffered Bike Lanes

A buffered bike lane is a bike lane that is separated from adjacent through lanes by a striped out buffer area (Figure 14-9). In some locations it may be desirable to use less than the full space available for a bike lane. Such locations include sections of roadway where a wide bike lane might be perceived as on-street parking or another travel lane. In these locations a buffered bike lane may be considered. A buffered bike lane may also be considered where a bike lane of six or more feet is being provided to meet a minimum level of accommodation. At midblock locations the buffered bike lane is separated from the travel lanes by a chevroned buffer (Figure 14-9). The width of the buffer will vary depending upon such conditions as motor vehicle speed, percent heavy vehicles, roadway cross slopes, and desired level of accommodations of bicycles.

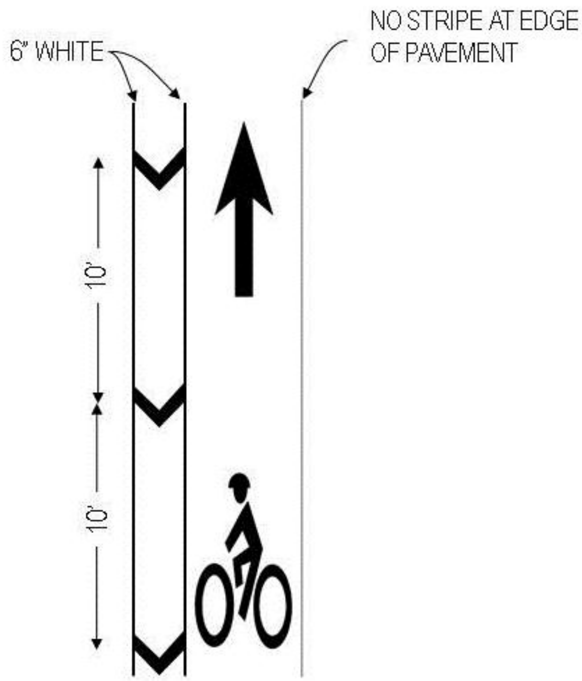


Figure 14-9 Detail of Buffered Bike Lane Designation

14.1.6.4 Bike Lanes at Driveways and Intersections

In Colorado, bicycles are vehicles and are required to follow the rules of the roadway when riding on the street **(5)**. Consequently, the striping and marking of bike lanes at intersections should support the operations of bicycles as vehicles, and the safe mixing of bicyclists with motorists at conflict points such as driveways and intersections. Some of the basic concepts of vehicular bicycling are described in this section. This discussion is followed by typical drawings for bike lanes at driveways and intersections.

Bicyclists are required to ride on the right hand side of the rightmost lane that is intended for the direction they are travelling. Thus they typically will ride toward the right side of a through lane, but may use left and right turn lanes when making the respective movements. Bicyclists are not required to ride at the right edge of the pavement; they may move left when passing slower vehicles, to make a left turn, or to avoid debris or obstacles on the pavement **(10)**.

Both the approach for a right turn and a right turn shall be made from as close as practicable to the right-hand curb or edge of the roadway **(14).** Prior to moving into the bike lane, the motorists must yield to bicyclists who are using the bike lane. Additionally, on the approach to driveways or intersections that do not have right turn lanes, through bicyclists often move further from the edge of the roadway; this helps communicate to motorists their intentions to continue as through vehicles. To support appropriate motorist and bicyclist behavior, bike lane striping is either terminated or becomes dotted on the approach to intersections. This change in line pattern changes the lane line from discouraging right turning motorists from crossing into the bike lane to providing edge-of-lane guidance **(15)**.

By riding in the roadway in a position that signals their intended path of travel, bicyclists who ride in the roadway are where motorists are looking for traffic. This improves bicyclists' visibility and has been shown to reduce crashes when compared to riding on a sidewalk or a pathway next to the roadway **(16, 17, 18, 19, 20)**.

When motorists cross a bike lane to move into a right turn lane, motorists are required to yield the right of way to bicyclists in the bike lane **(21)**. This means the use of the BEGIN RIGHT TURN LANE YIELD TO BIKES sign (R4-4) (shown in Figure 14-11) is appropriate when it's added to a roadway where a turn lane is added (Figures 14-11, 14-13, 14-17, 14-18, 14-20). However, in the trap lane condition (Figures 14-15, 14-16) the through bicyclists must cross the motorists' path to continue through the intersection. In this case the bicyclists must yield to the motorist before moving left; therefore the R4-4 is not appropriate in these conditions.

Typical examples of intersection striping to support the above concepts are provided below in Figures 14.10 - 14.20. These drawings are intended to provide guidance for bike lane striping only. The width of bike lanes shown in the graphics are recommended minimums and wider bike lanes or shoulders may be considered as discussed in section 14.1.5.1. The presence of lane use designation symbols and ONLY pavement markings are to provide clarification of motor vehicle movements. Through movement arrows may not be required and directional arrow spacings are not shown to scale.

14.1.6.4.1 Bike Lanes at Continuous Flow Intersections

At continuous flow intersections, just as with other intersections, the bike lane is provided for through bicyclists. Two options are available for left turning cyclists:

Left turning bicyclists may ride through the intersection in the left turn lanes. Additional bike lanes for left turning cyclists should be considered.

Left turning cyclists may make two consecutive through movements obeying all traffic control devices **(23).** A staging area for the bicyclists to wait between through movements should be provided for bicyclists making this maneuver.

14.1.6.4.2 Bike Lanes at Roundabouts

At roundabouts, bike lanes are to be terminated 100 feet in advance of the crosswalk. In the absence of a crosswalk, bike lane markings are to be terminated 100 feet in advance of the yield line. Bike lanes shall not be marked on the circulating roadway of a roundabout **(22)**.

At some roundabouts, where speeds are high and bicyclists may be uncomfortable riding through the circulating roadway, ramps from the bike lane into the roundabout may be appropriate. These ramps should be designed to facilitate an optional transition of the bicycle from the bike lane onto the sidewalk area. If the ramp option is provided, sidewalks should be widened to at least eight feet to provide for mixed bicycle and pedestrian use. Bicycle ramps at roundabouts can be confusing for pedestrians with vision impairments. When possible, they should be constructed outside the pedestrian walkway with the required detectable warnings at the top of the ramp. The angle of the ramp and steepness of the ramp can also help distinguish bike ramps from pedestrian ramps.

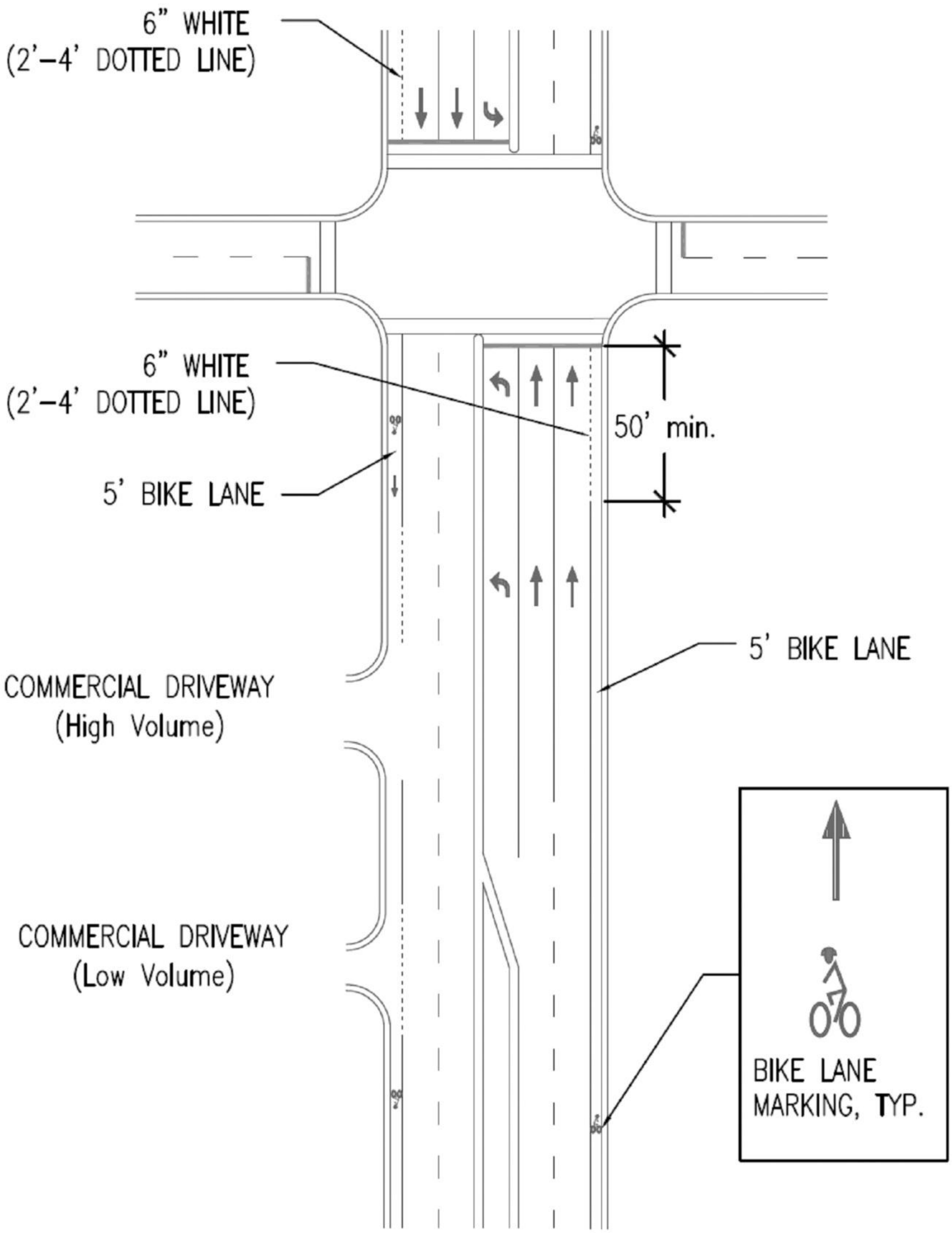


Figure 14-10 Typical Bike Lane - Major Intersection, No Right Turn Lane, Curb and Gutter

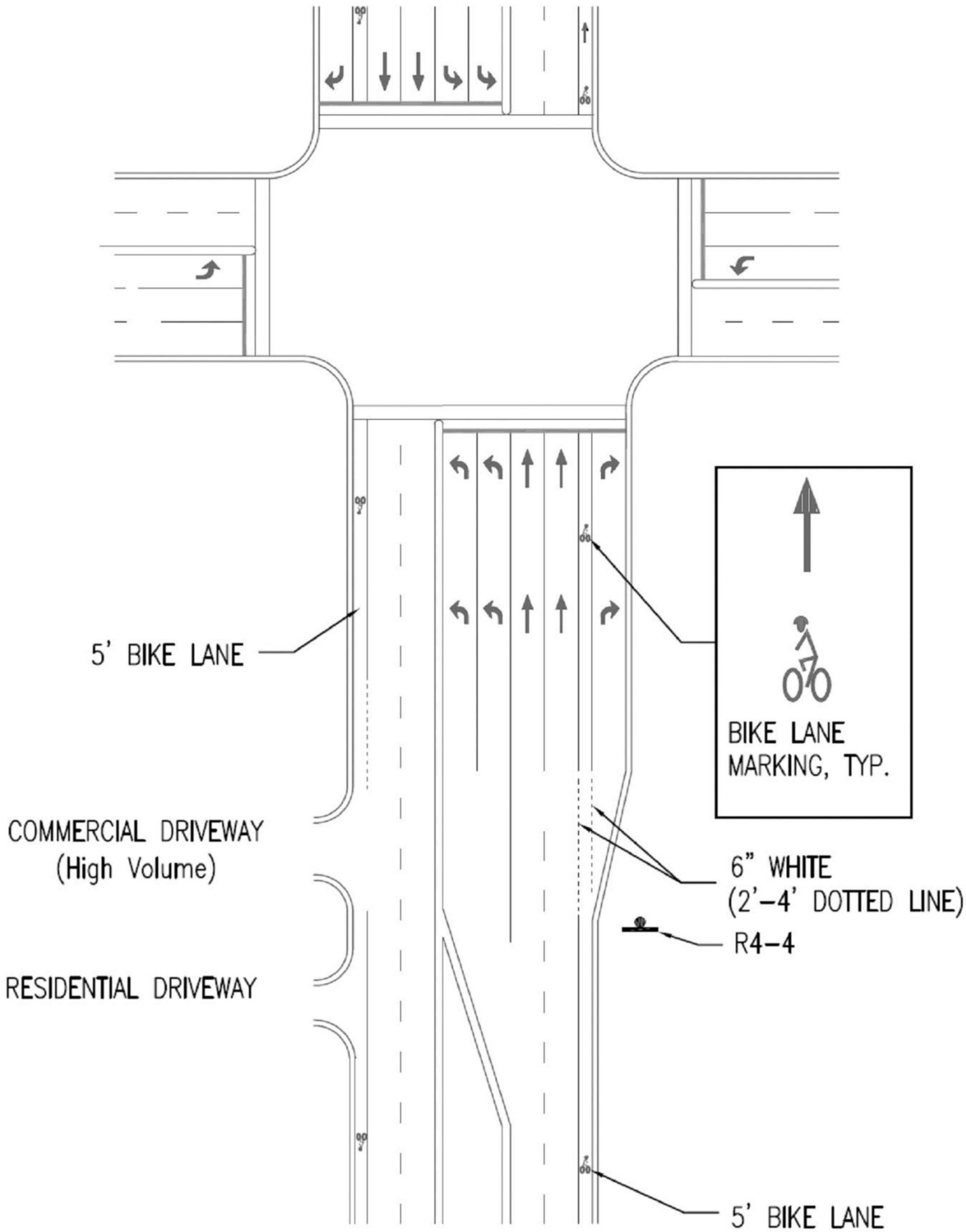


Figure 14-11 Typical Bike Lane - Major Intersection, Right Turn Lane, Curb and Gutter

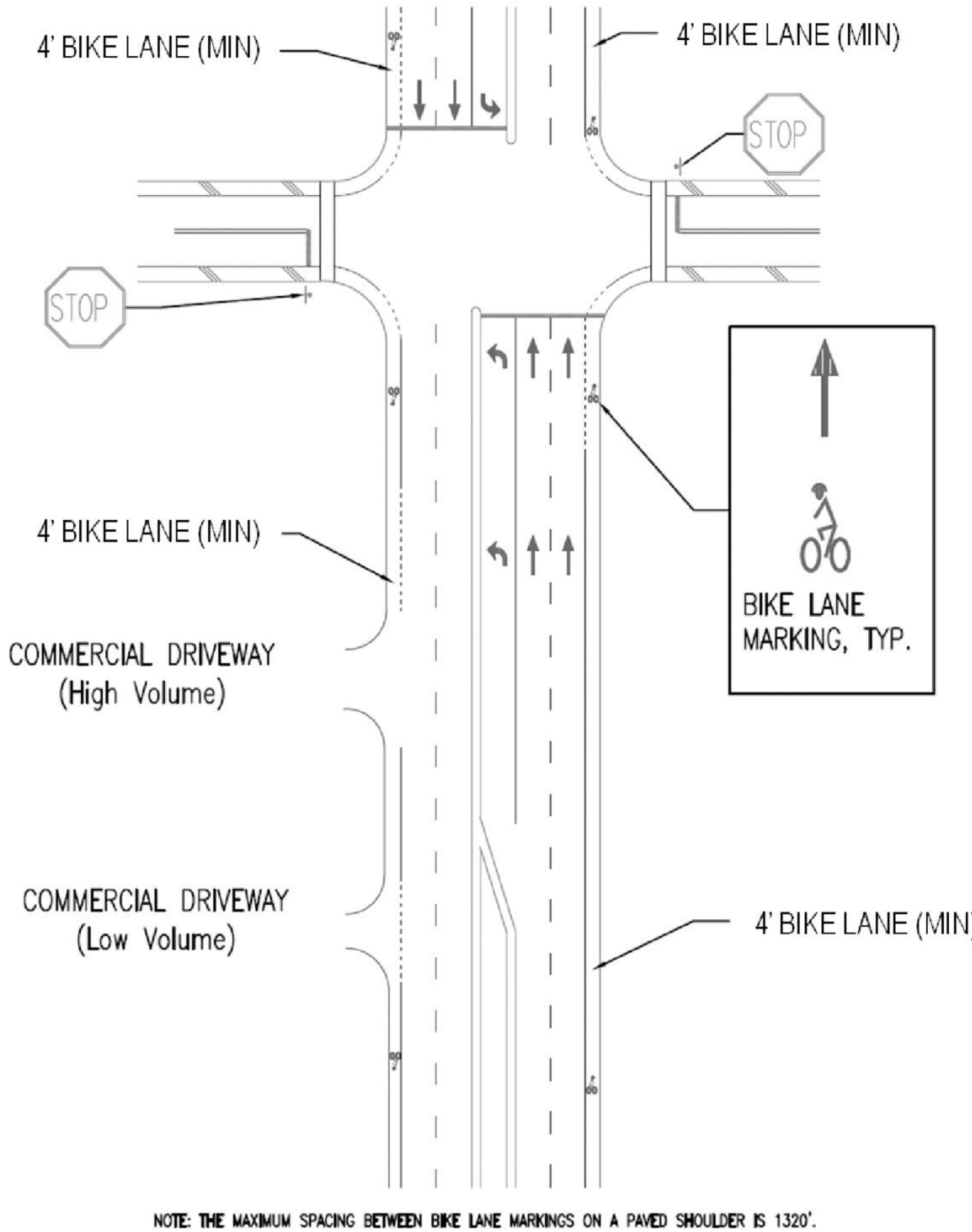


Figure 14-12 Typical Bike Lane - Major Intersection, No Right Turn Lane, No Curb and Gutter

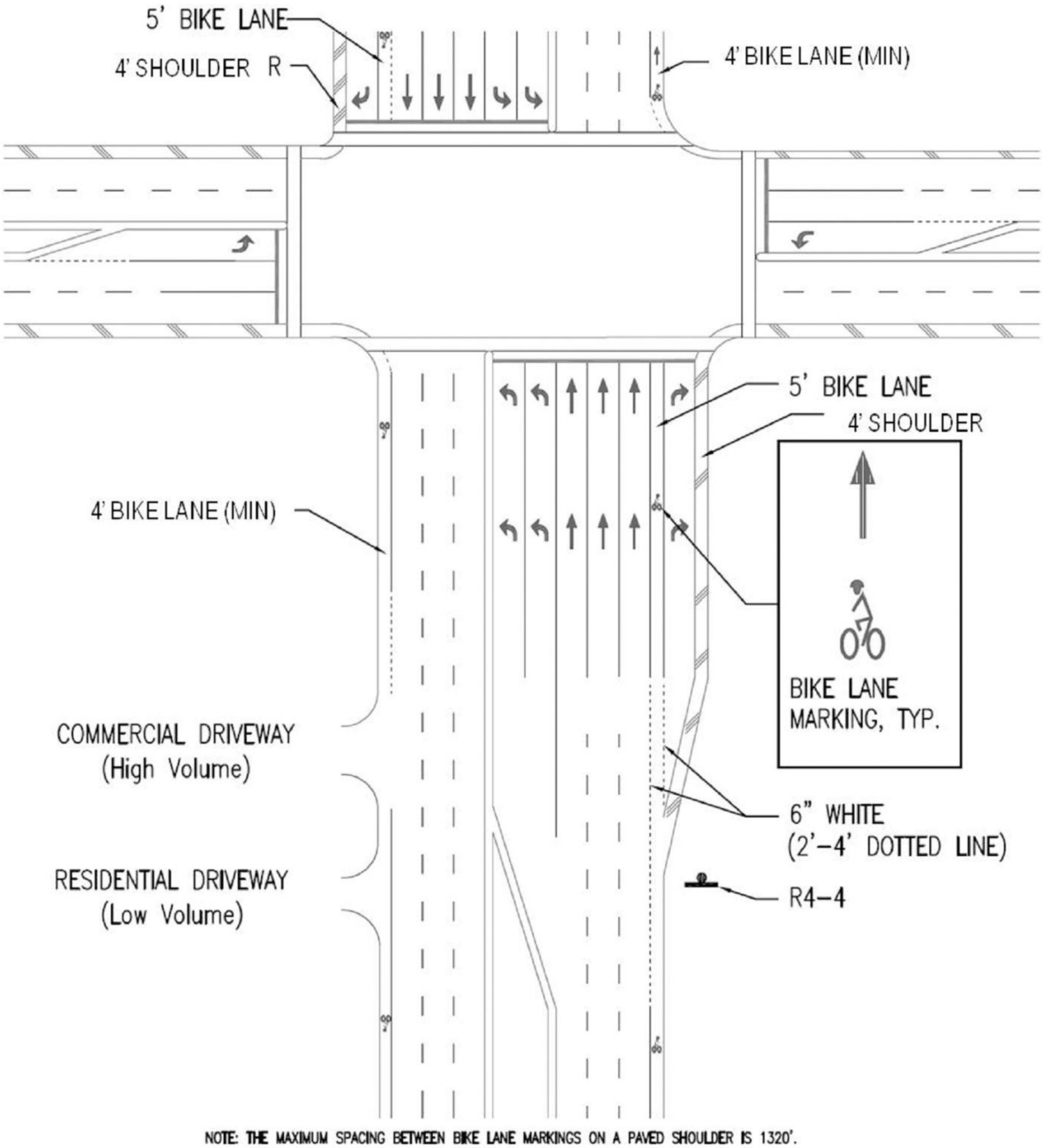


Figure 14-13 Typical Bike Lane - Major Intersection, Right Turn Lane, No Curb and Gutter

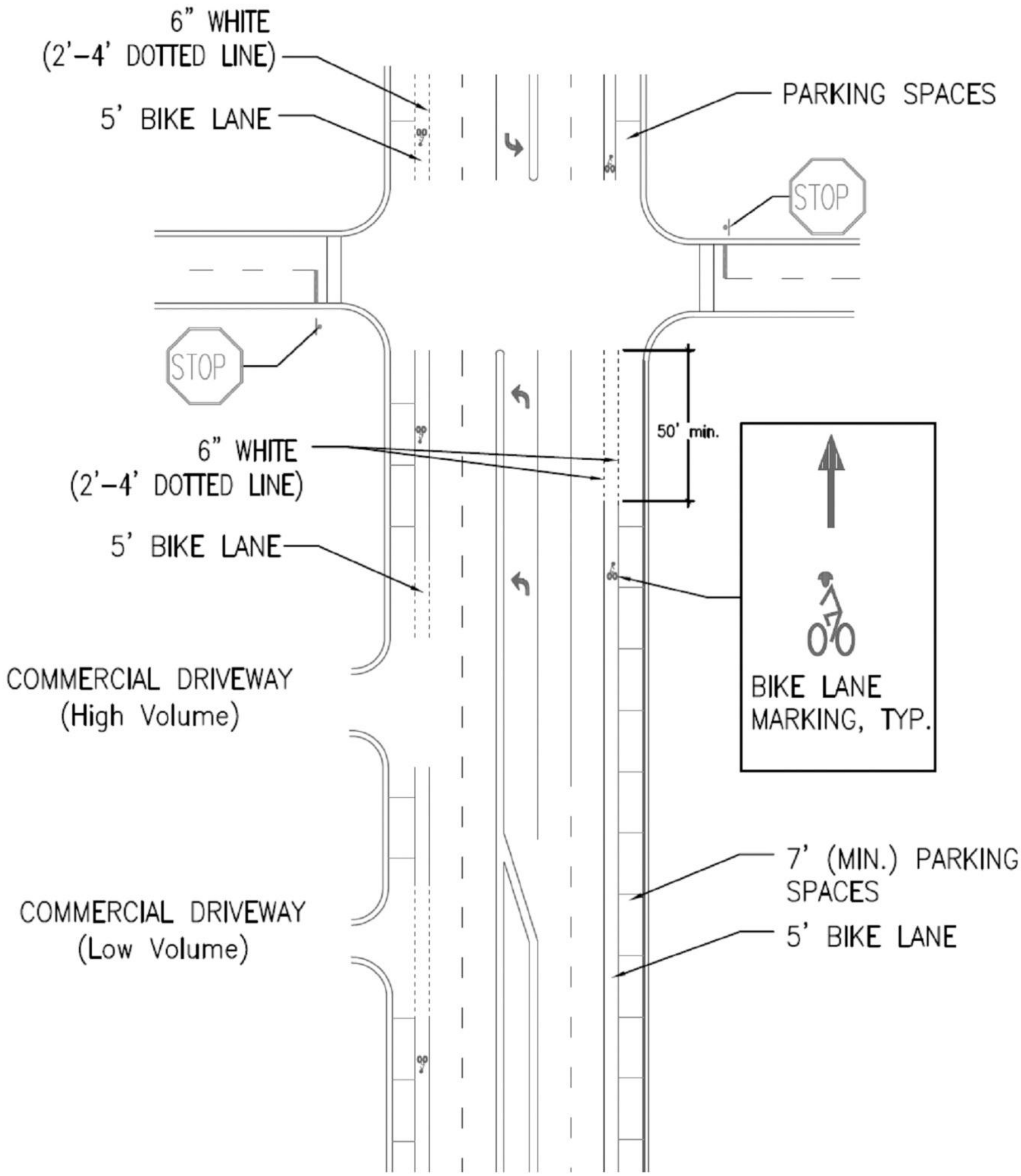


Figure 14-14 Typical Bike Lane - Major Intersection, No Right Turn Lane, On-Street Parking

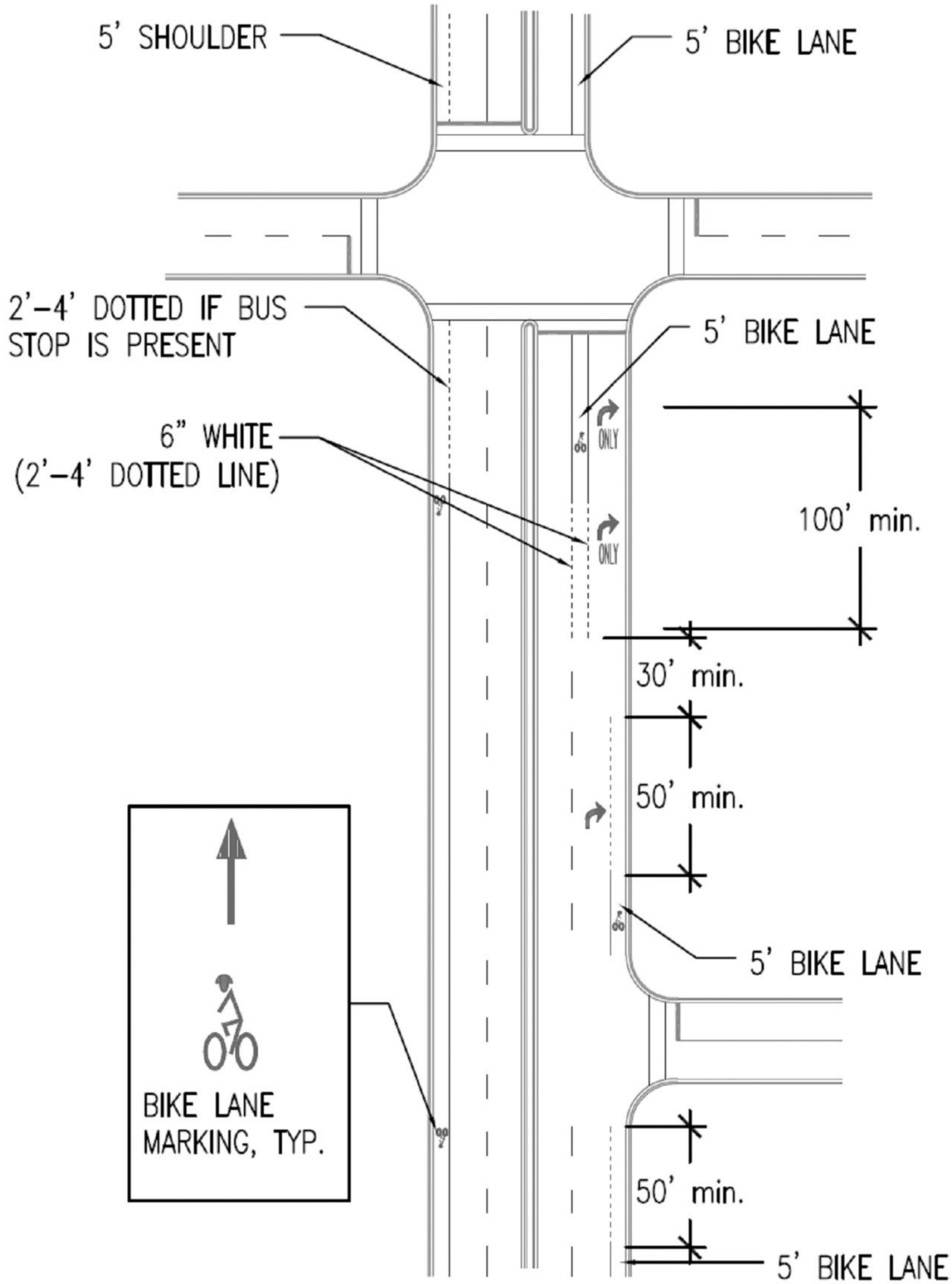


Figure 14-15 Typical Bike Lane - Major Intersection, Right Turn Trap Lane, Bus Stop

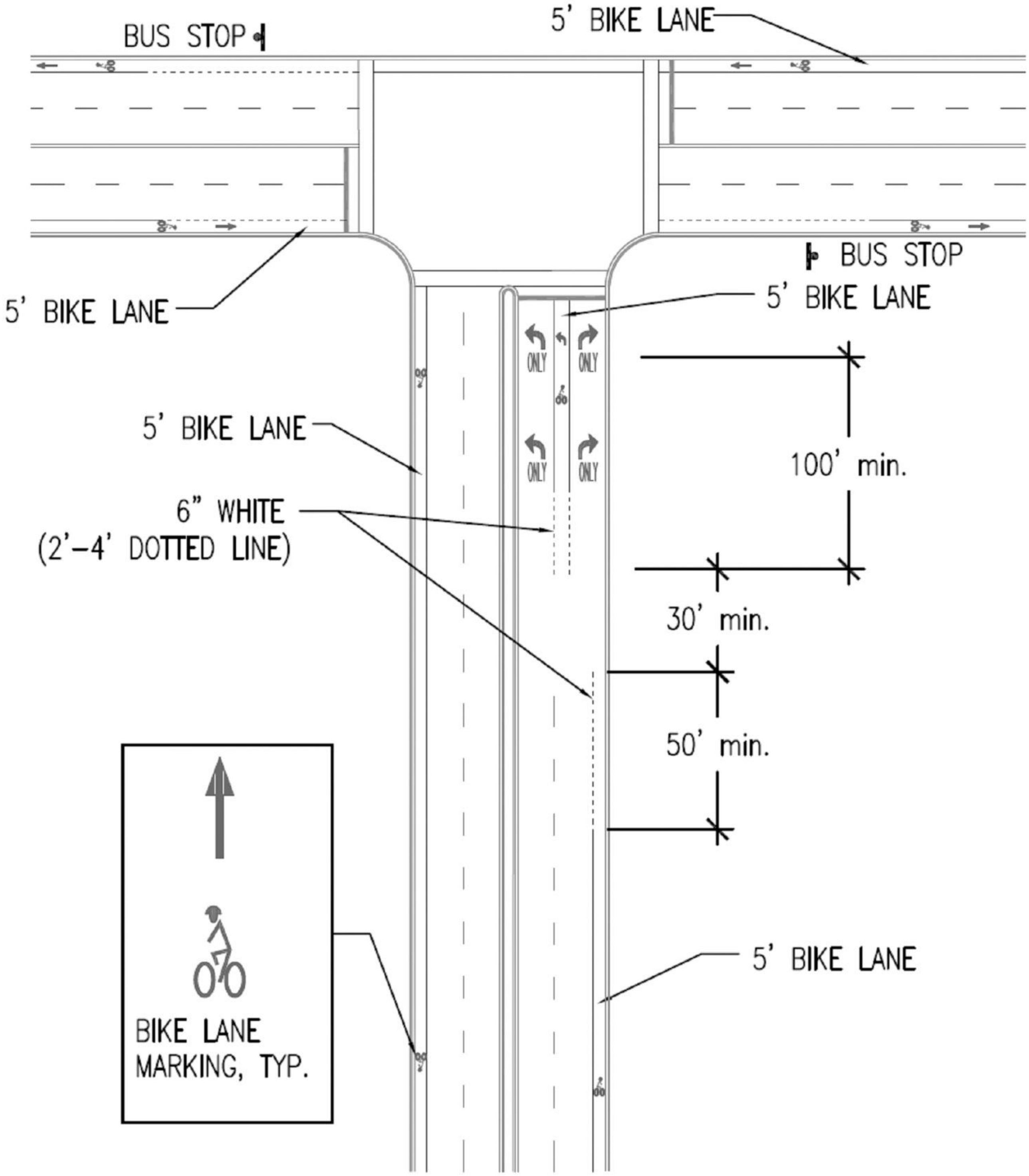


Figure 14-16 Typical Bike Lane - Tee Intersection, Right Turn Must Turn Right Lane, Bus Stop

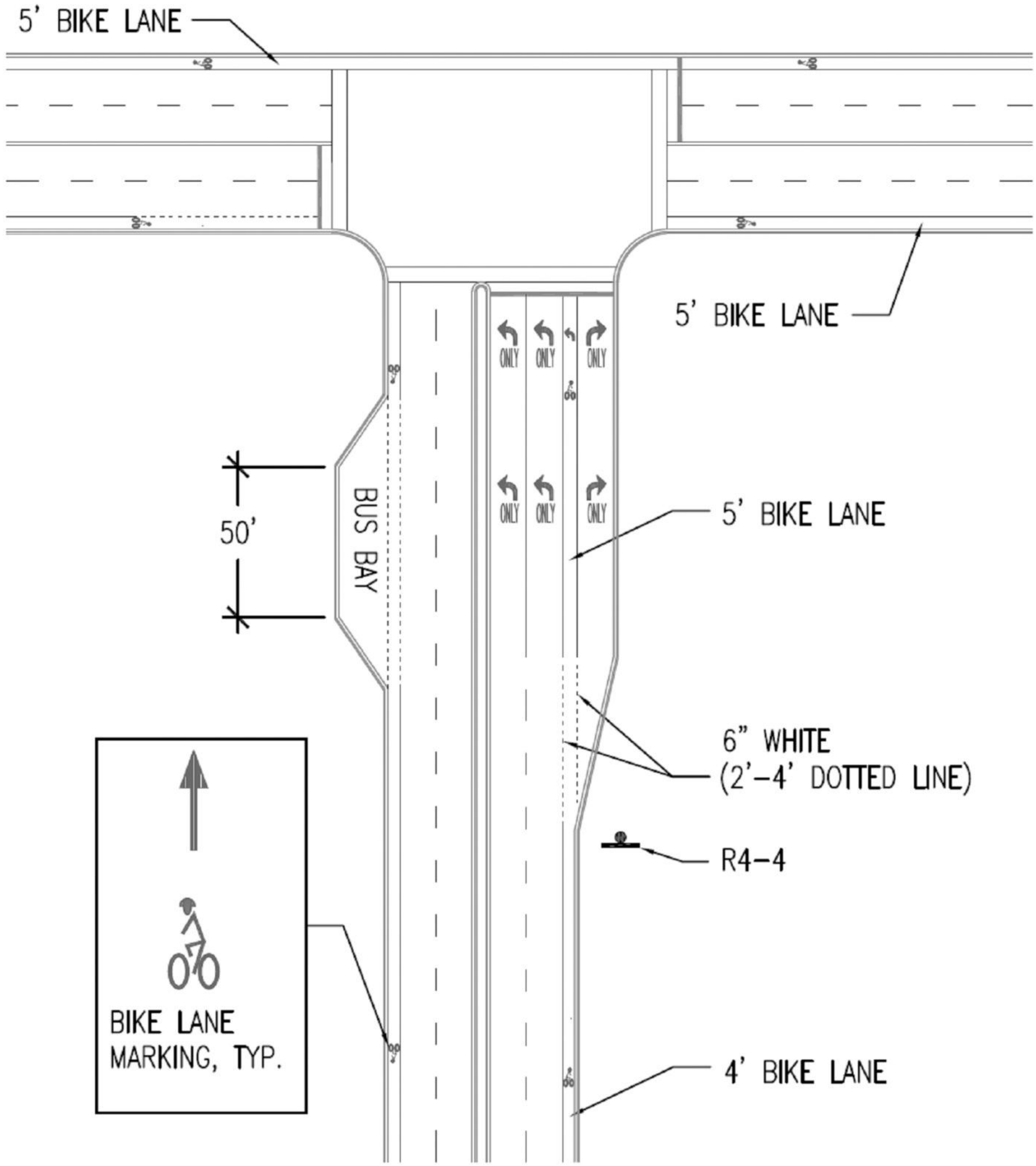


Figure 14-17 Typical Bike Lane - Tee Intersection, Right Turn Lane, Bus Bay

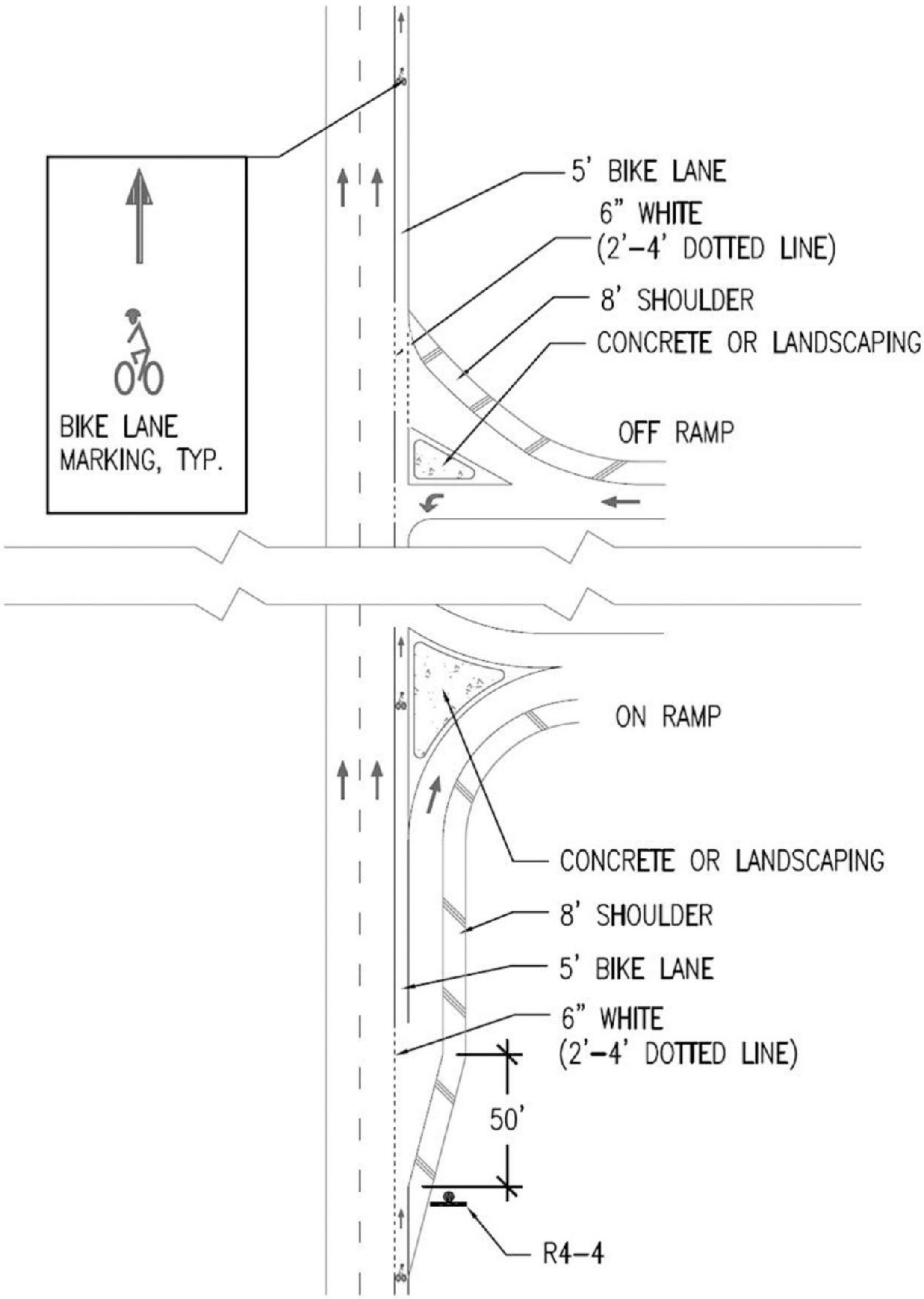


Figure 14-18 Typical Bike Lane - Compact Interchange

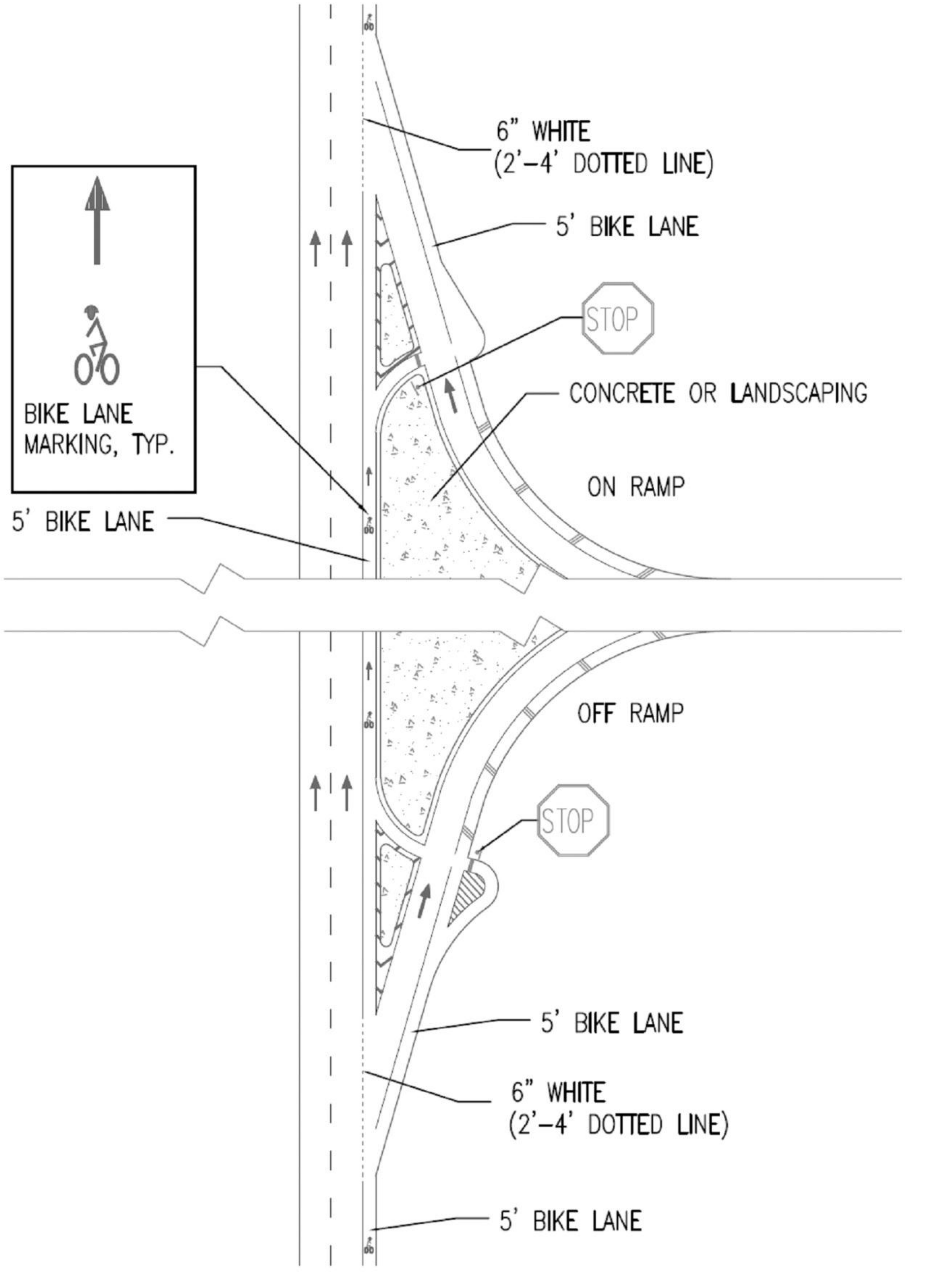


Figure 14-19 Typical Bike Lane - Rural Interchange

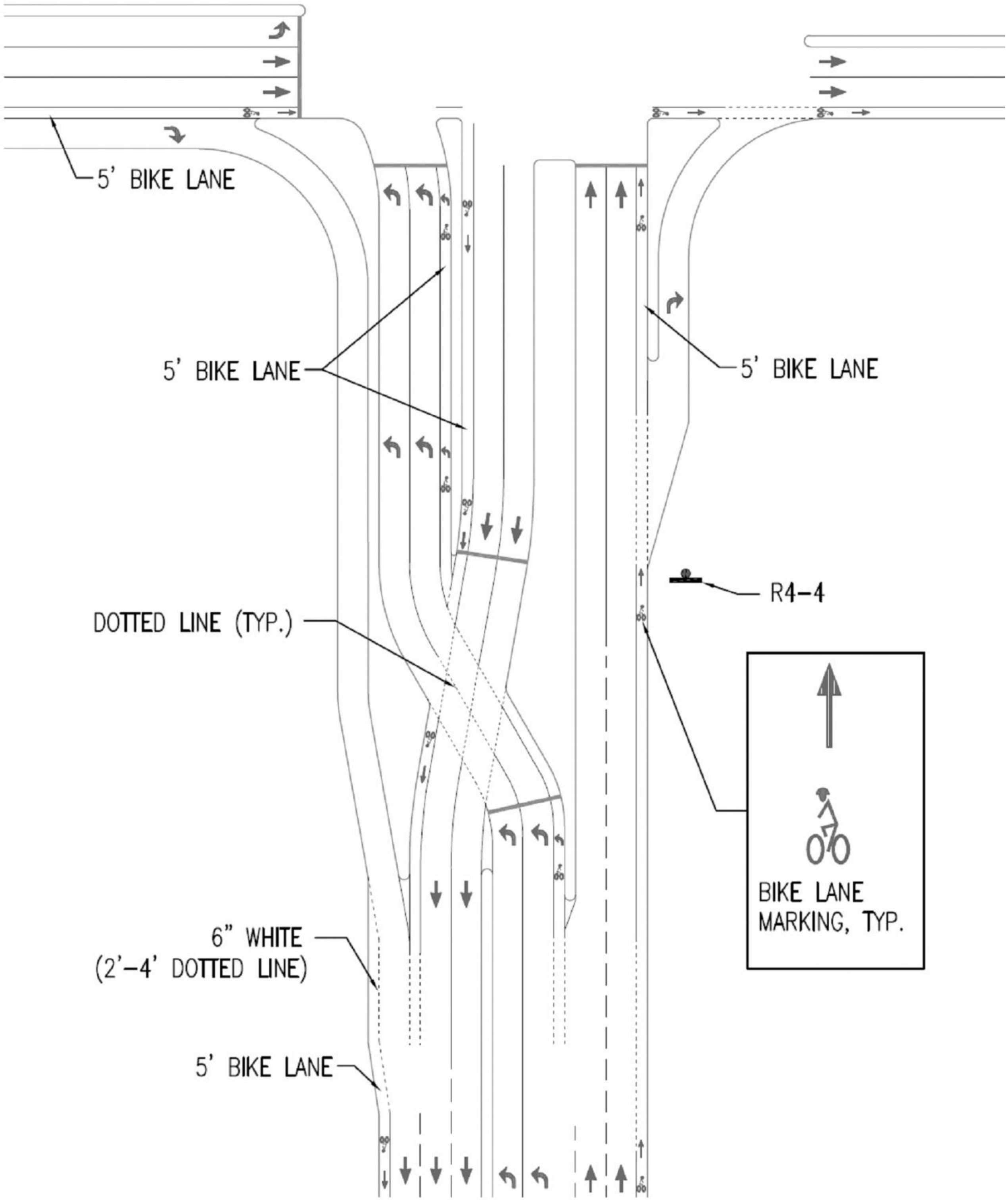


Figure 14-20 Typical Bike Lane - Continuous Flow Intersection

14.1.7 Detection of Bicycles at Signalized Intersections

Various detection technologies can be used to detect bicyclist at intersections. The most common in Colorado are video detection and loop detection. Video detection is effective if cyclists are using the travel lanes for which detection is provided. This may exclude right turn lanes but should include left turn lanes.

There is a perception among many cyclists and roadway engineers that inductive loops do not detect the presence of bicycles; this perception results from cyclists not waiting in an optimal spot for detection. Research has shown that inductive loops are highly reliable at detecting steel and aluminum bicycles when bicycles are in the proper position **(24).**

Calibrating loop sensitivity to detect bicycles is a principal challenge of signal hardware design, which has led to the development of numerous loop configuration solutions. The 6'x40' quadripole loops shown on standard drawing S-614-40 Typical Traffic Signal Installation Details should be capable of detecting bicycles.

There are two basic strategies to improve detection of bicycles: to direct bicyclists to the area of optimal loop sensitivity and alternatively to place new loops in spots where cyclists are likely to be waiting, such as in the bike lane or at the right edge of the pavement. It is recommended that these strategies for optimizing loop detection of bicyclists be employed before investigating a substantial investment of new technology; the technology already in place at many intersections is likely quite capable of detecting bicyclists.

One of the simplest ways to facilitate the detection of bicyclists at traffic signals is to mark the spot on the roadway where a given loop will detect a bicycle. The *MUTCD* provides for a symbol that may be placed on the pavement to indicate the optimum position for a bicyclist to actuate the signal **(25)**. Used in conjunction with the BICYCLE SIGNAL ACTUATION sign (R10-22) **(26)** (see Figure 14-21), this symbol can eliminate the problem of bicycle detection for any intersection movement where the loops can detect bicyclists.

New loops should be of a type that will detect bicycles.

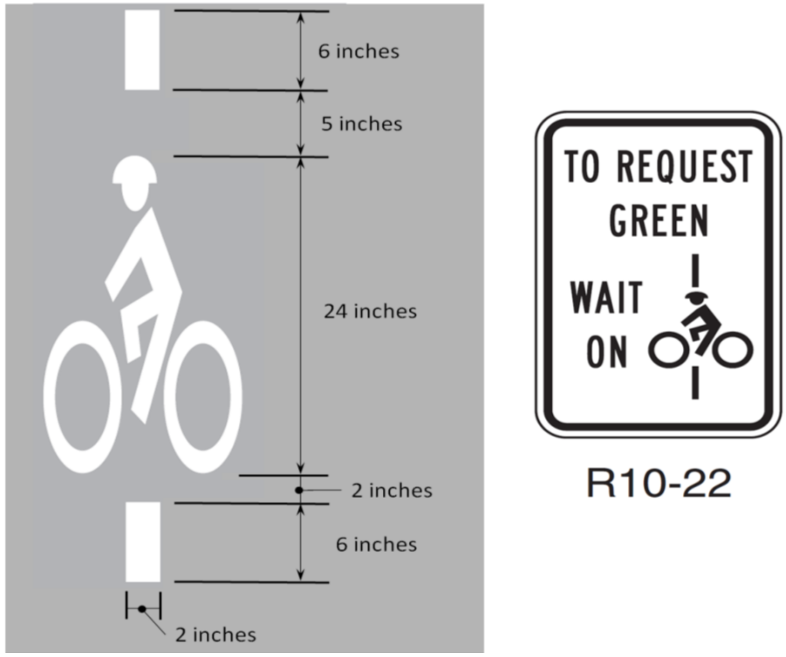


Figure 14-21 Bike Detection Symbol and Bicycle Signal Actuation Sign

14.1.7.1 Signal Detection Loops in Bike Lanes

Changing lanes at an intersection to call for a signal change is not a normal vehicular behavior, yet bicyclists are frequently required to do so. In the interest of providing consistent treatments and promoting consistent vehicular behavior, bike lane detection should still be considered at locations where signal change is unlikely without detection.

The recommended loop type for bike lanes is a quadripole loop of reduced size (2'x10'). These loops are highly sensitive to objects in the area immediately above them, but detection falls off rapidly outside of this sensitivity field; this means that cars in adjacent lanes will not be detected.

14.1.7.2 Signal Timing for Bicycles

The MUTCD requires that on bikeways signal timing and actuation be reviewed and adjusted to consider the needs of bicyclists **(27)**. Meeting the needs of bicyclists on bikeways means providing adequate minimum green times and adequate change periods.

The minimum green time allows bicyclists to start from a stopped condition, cross, and clear the intersection. For the crossing of narrow roadways, the bicyclists may not accelerate to full speed prior to clearing the intersection. On wider roads the bicyclist will accelerate to full speeds and require additional time to finish crossing and clear the intersections. The equations to calculate minimum crossing distance are as follows:

$$G_{min} = 1.0 + 1.15\sqrt{W + 6} \qquad \text{Where W} \leq 72 \text{ feet}$$

$$G_{min} = 10.8 + \frac{(W-72)}{14.7} \qquad \text{Where W} > 72 \text{ feet}$$

and

G_{min} = minimum green time, s;

W = width of intersection, ft

Typically the minimum change period is calculated using the following equation **(28):**

$$CP = \left[t + \frac{1.47v}{2(a + 32.2g)} \right] + \left[\frac{W + L_V}{1.47v} \right]$$

where:

CP = change period (yellow change plus red clearance intervals), s;

t = perception-reaction time to the onset of a yellow indication, s, assume 1 s;

v = approach speed, mph, assume 10 mph for a bicycle;

a = deceleration rate in response to the onset of a yellow indication, assume 5 fps for a bicycle;

g = grade, with uphill positive and downhill negative (percent grade / 100), ft/ft;

W = width of intersection, ft; and

L_v = length of vehicle, assume 6 feet for a bicycle.

On wide intersections, the clearance interval provided for motorists may not be long enough to adequately provide for bicyclists to clear the intersection. Advance loops in bike lanes or on shoulders can provide for an extended green time to allow bicyclists to clear the intersection prior to the conflicting traffic getting a green signal. Alternatively, a supplemental signal (see Section 14.2.16.6.3 Bicycle Signals) with a supplement plaque stating BICYCLE SIGNAL could be provided for bicyclists.

At installations where visibility-limited signal faces are used, signal faces shall be adjusted so bicyclists for whom the indications are intended can see the signal indications. If the visibility-limited signal faces cannot be aimed to serve the bicyclist, then separate signal faces shall be provided for the bicyclist.

14.1.8 Cycle Tracks

Cycle tracks are bikeways located on the street between the general travel lanes and the sidewalk. They are distinct from shared use paths in that they are bicycle only facilities. Typically they are separated from the general travel lanes by on street parking and a physical divider. Operationally, they can be very challenging particularly at their intersections with driveways and streets.

There are no national standards for cycle tracks, research is currently underway to identify best practices. However, some guidance is provided for those designers who may have cycle tracks included on their projects.

The implementation of cycle tracks may require close coordination with local businesses to coordinate their parking needs and loading zone requirements that may conflict with the cycle tracks.

Ideally, cycle tracks are one-way facilities. However where there are space constraints or wrong way riding is common, two-way facilities may be considered. Two way cycle tracks should be designed as sidepaths as described in Section 14.2.12.

The minimum width for a one-way cycle track is six feet. The minimum width for a two-way cycle track is ten feet.

The separation between the cycle track and the adjacent travel lane or on street parking should be at least four feet. This is to provide space for opening car doors when on street parking is present.

At right turn conflict points, motorists shall be required to yield to bicyclists on the cycle track. At intersections the cycle track is discontinued and the space is used as shared space for right turning motorists and through cyclists. Left turns are addressed through a pair of through movements or through an upstream weave. Space on the far side of intersecting roadways is provided for bicyclists to stage prior to making their second through movement. An example of treatments at conflict points and intersections is provided in Figure 14-22. A BEGIN RIGHT TURN LANE YIELD TO BIKES (R4-4) could be installed on the island at the beginning of the turn lane.

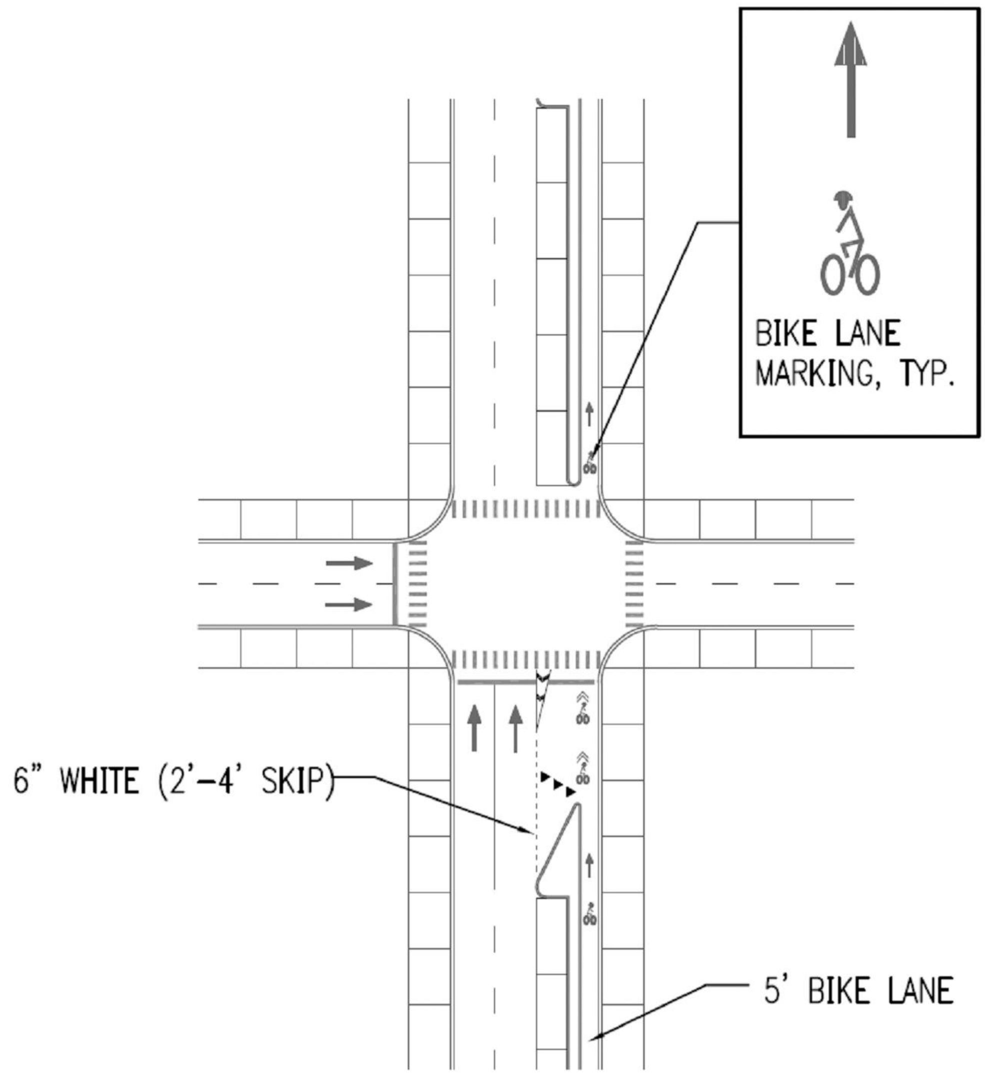


Figure 14-22 Conflict Markings on Cycle Tracks

14.1.9 Bicycle Boulevards

A bicycle boulevard is a local street or series of contiguous street segments that have been modified to provide enhanced accommodation as a through street for bicyclists while discouraging through automobile travel. Local motor vehicle access is maintained along the streets. Bicycle boulevards would not be implemented on CDOT roadways. However, they may be used to improve alternative routes (see Section 14.1.10).

Bicycle boulevards often make use of low volume, very low speed local streets. Shared lane markings may be used along bike boulevards. Often bicycle boulevards include bicycle friendly traffic calming treatments (speed pillows, mini traffic circles) to reduce speeds of motor vehicles along the roadway. Some portions of a bike boulevard may be on busier roads with bike lanes. Through motor vehicle traffic can be discouraged using traffic diverters at intersections. Bicycle boulevards can be created by connecting the ends of cul de sac roadways with bikeways. At intersections the bicycle boulevard should be given priority over side streets. Additionally, since bike boulevards typically serve as bike routes, wayfinding signage should be provided.

One potential obstacle to implementing bike boulevards is the crossing of major roadways. Improvements to signal timing and detection, or the provision of enhanced crossing treatments (activated beacons, raised medians) where no signals exist will make a bicycle boulevard more appealing to cyclists.

Another challenge related to bike boulevards is the frequent opposition voiced by local residents. Those who live along the streets being altered are commonly hesitant about the bike boulevard concept. Other motorists who travel on the street may feel the same way because of altered travel patterns for the auto mode. Designers considering the implementation of a bike boulevard should be aware of these considerations and should accordingly plan for early and sustained public outreach to the project's neighbors, communities and municipalities.

14.1.10 Alternative Routes

On some projects it may not be possible to improve the project roadway to provide for bicyclists. In these cases it may be possible to improve an adjacent street to provide an alternative route for bicyclists to access destinations that would be served by the primary project roadway. Alternative routes could potentially be improved using some of the treatments described in this chapter.

In addition to the accommodations provided along the alternative route, several other factors must be addressed when considering whether or not an alternative route provides a suitable accommodation for bicyclists:

- Geometric delay - This is the delay caused to the bicyclists by increased distance they must travel to use the alternative route. If an alternative route significantly increases the distance and time a bicyclist must travel to access a destination it will be less likely to be used.
- Control delay - This is the delay caused by increasing the number of STOP signs or red traffic signals bicyclists will encounter along a route. Often the primary corridor is a major arterial and given the majority of the green time at signals, and therefore does not often have to stop at minor street intersections. If the alternative route is a local street that must stop at every cross street and gets minimal green time at signalized intersections, bicyclists will be less likely to use it.
- Access to destinations - An alternative route must provide access to the trip ends along the primary corridor or it will not be a practical option for bicyclists.
- Safety - Any alternative route being considered for improvement should be subject to a safety assessment. This would include reviewing crashes along the route as well as identifying potential safety concerns associated with accessing the primary project corridor from the alternative route.

14.1.11 Other Roadway Considerations

14.1.11.1 Cross Slopes

Cross slopes provided for roadways will usually accommodate cyclists. Generally, maximum cross slopes of 5% or less are desirable. However, the AASHTO *Guide for the Development of Bicycle Facilities* provides for superelevation rates up to 8%.

14.1.11.2 Drainage Inlets and Utility Covers

Placement of drainage inlet grates should be avoided within an in-roadway bicycle facility regardless of whether that facility is a bike lane, shoulder, or shared lane. If this is not possible, drainage inlet grates should be bicycle-safe. Utility covers and drainage grates should be installed to be flush with the pavement. The construction of new roadway facilities should consider the use of curb inlets as opposed to gutter pan drop inlets.

Drainage inlet grates with slots or gaps parallel to the roadway can trap a bicycle's front wheel and seriously damage the bicycle and injure the cyclist. These types of grates should be replaced with bicycle-safe grates that maintain the required hydraulic capacity for the inlet. A bicycle-safe grate should have, at a minimum, bars perpendicular to the travel direction at a 4 inch center-to-center spacing.

For safety considerations, any utility cover or drainage inlet located within an in-roadway bicycle facility that has been identified to have a gap or opening parallel to the roadway, should be replaced or corrected as soon as possible. If a drop inlet with parallel slots cannot be replaced, an obstruction marking should be placed on the pavement prior to the inlet (Figure 14-23).

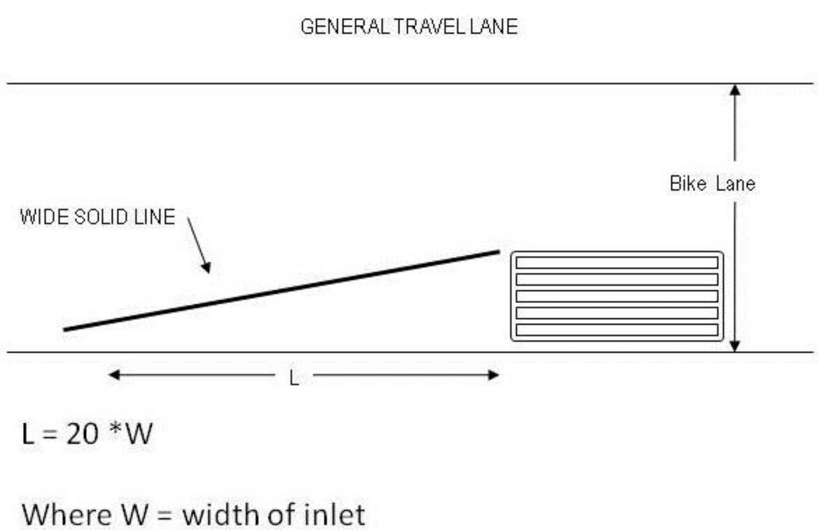


Figure 14-23 Bicycle Obstruction Marking in Advance of a Drop Inlet

14.1.11.3 Railroad Crossings

Ideally travelways should cross rail lines at right angles. The more the railroad crossing deviates from a right angle, the greater the potential for a cyclist's front wheel to be trapped in the tracks, causing the loss of steering control and a crash. SKEWED CROSSING warning signs (W10-12) should be considered for the approach to the crossing.

A special treatment should be considered for railroad crossings with angles less than 45 degrees. It is recommended a special path be provided for cyclists to cross the tracks at a right angle. The simplest approach to treatment would be pavement widening at the crossing. Figure 14-24 shows two scenarios of potential skewed crossing treatments. Additionally, pavement markings can be provided to direct bicyclists to the preferred path of travel.

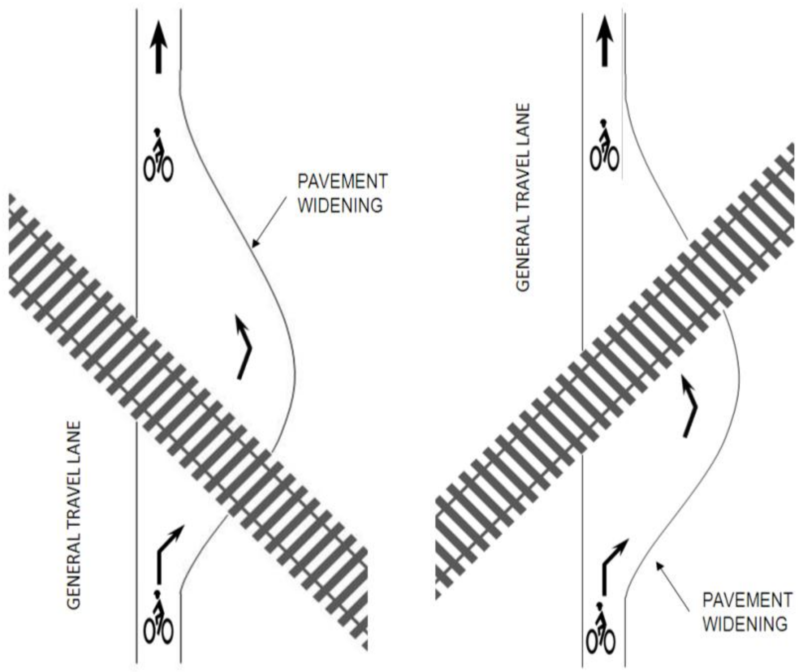


Figure 14-24 Potential Treatments at a Skewed Railroad Crossing

14.1.11.4 Bridges and Tunnels

The FHWA Design Guidance and Policy Statement **(29)** states: "A bridge that is likely to remain in place for 50 years should be built with sufficient width for safe bicycle and pedestrian use (sidewalks and shoulders) in anticipation that facilities will be available at either end of the bridge even if that is not currently the case. Design bridges with sidewalks and shoulders or bike lanes on both sides of the structure." Tunnels should also be designed to accommodate bicyclists and pedestrians.

14.2 SHARED USE PATHS

Shared use paths are bikeways that are physically separated from motorized vehicular traffic by either a physical barrier or clear space. They are often on their own alignments but may be located within the right-of-way of an adjacent roadway.

Since shared use paths are intended for use by others (such as pedestrians, persons with disabilities, etc.) they must be made ADA compliant to the maximum extent feasible (see Section 14.3).

14.2.1 Surface Treatments

14.2.1.1 Paved Shared Use Path

Most CDOT shared use path projects will be paved. Asphalt and Portland cement concrete are the two most common surfaces for shared use paths. For rigid pavement design information, refer to the CDOT *Pavement Design Manual.* The Materials Engineer should be consulted for flexible pavement design information.

Where paved shared use paths cross unpaved roadways or driveways the road or drive should be paved 20 feet on each side of the shared use path to help minimize debris accumulation on the path.

14.2.1.2 Unpaved Shared Use Paths

In areas where path use is expected to be primarily recreational, unpaved surfaces may be acceptable for shared use paths. Materials should be chosen to ensure the ADA requirements for a firm, stable, slip resistant surface are met. Even when meeting ADA criteria, some users such as in-line skaters, kick scooters, and skateboarders, may be unable to use unpaved shared use paths.

On unpaved shared use paths, grades of greater than 3 percent may result in erosion problems and bicycle handling problems for some bicyclists. Additionally, snow plowing may be impractical on unpaved shared use paths.

14.2.2 Design Speed

As with roadways, the design speed selected for shared use paths dictates other design criteria (sight distance, curve alignments). Consequently, the selection of an appropriate design speed is important to maximize flexibility of design when developing a shared use path.

Design speeds range from 12 to 30 mph. Two mph increments of design speed should be used for less than 20 mph, and 5 mph increments should be used above 20 mph.

An 18 mph design speed is generally sufficient for most paths in relatively flat areas (generally less than 2 percent grades). If it is expected that there will be significant use by recumbent bicyclists, the minimum design speed should be to 18 mph **(7).**

Design speeds lower than 18 mph may be used in areas where the expected riding population is anticipated to be made up of lower speed users such as school children. A design speed of less than 14 mph should be used only in unusual circumstances. Justification based upon environmental context and user types should be provided when using a design speed less than 14 mph.

Lower design speeds may be used on the approach to roadway crossing points or hazards. Lower design speeds may also be desirable on paths where user types include primarily younger children. Traffic control and geometric features should be used together to reduce speeds in these locations (see Section 14.2.10.6).

Where sustained grades exceeding 4 percent in excess of 300 feet in length are required, an increased design speed should be used. They should be based upon the anticipated travel speeds of cyclists traveling downhill. Thirty mph should be the maximum design speed used in all but the most unusual cases.

14.2.3 Sight Distance

As stated in Chapter 3 of this *Roadway Design Guide*, a critical element in assuring safe and efficient operation of a vehicle on a highway - or in the case of this chapter a bicyclist on a shared use path - is the ability to see ahead. Sight distance is the distance along a roadway or path throughout which an object of specified height is continuously visible to the bicyclists. In a vertical plane, this distance is dependent on the height of the bicyclist's eye above the road or path surface; the specified object height above the road surface; and the height and lateral position of sight obstructions such as cut slopes, guardrail, and retaining walls within the bicyclists' line of sight. Horizontal alignment, including the routing of paths around visual screens can also impact sight distance and should therefore be considered. Sight distance of sufficient length must be provided to allow a bicyclist to avoid striking unexpected objects in the traveled way.

14.2.3.1 Stopping Sight Distance

Stopping sight distance is the sum of two distances:

- The distance a bicycle travels from the instant the cyclist sights an object necessitating a stop to the instant the brakes are applied (brake reaction distance), and
- The distance required to stop the bicycle from the instant brake application begins (braking distance).

Stopping sight distance is measured from the bicyclist's eyes, which are assumed to be 4.5 feet above the pavement, to an object flush with the surface of the shared use path. If during the project development, it is found that a significant number of recumbent cyclists are represented in the local cycling population, an eye height of 2.8 feet should be used **(7)**. Distances greater than the minimum stopping sight distance provide an additional measure of safety and should be considered where practical.

The equation for stopping sight distance, assuming a 2.5 second reaction time, is

$$S = 3.67V + \frac{V^2}{30(f + G)}$$

Where,

S = stopping sight distance

V = design speed in mph

f = friction factor (assume 0.16 for a typical bicycle)

G = grade in ft/ft

Table 14-2 of this Roadway Design Guide shows sight distances for level roadways and roadways with grade for various design speeds. See also Chapter 3 for adjustments for grades.

Design Speed (mph)	Stopping Sight Distance (Design Values)						
	No grade adjustment	% Down Grade			% Up Grade		
		3	6	9	3	6	9
8	43	46	51	60	41	40	38
10	58	63	71	85	55	52	51
12	75	81	93	113	70	66	64
14	93	102	117	145	86	82	78
16	113	125	145	181	104	98	93
18	134	150	175	221	123	116	110
20	157	176	207	264	144	135	127
25	222	253	301	390	202	187	176
30	298	341	411	539	268	247	231

Table 14-2 Stopping Sight Distance

14.2.3.2 Sight Distance on Horizontal curves

Sight distance on horizontal curves on shared use paths may be obtained with the aid of Figures 14-25 and 14-26 and Table 14-1 of this *Roadway Design Guide.* The line of sight is assumed to intercept the obstruction at the midpoint of the sight line and at the surface of the center of the inside lane. The middle horizontal sightline offset (HSO) is obtained from Figure 14-26.

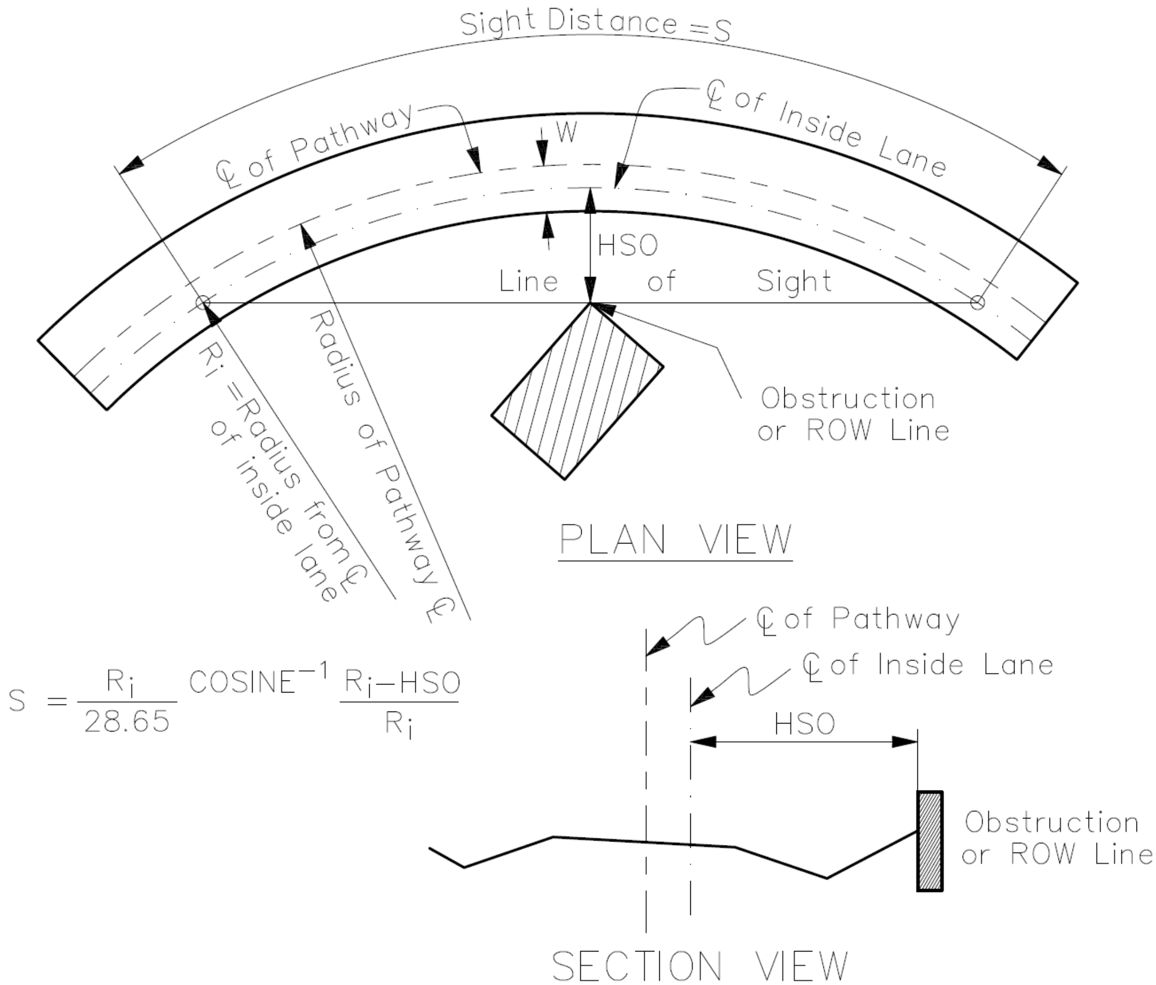


Figure 14-25 Stopping Sight Distance on a Shared Use Path Horizontal Curves

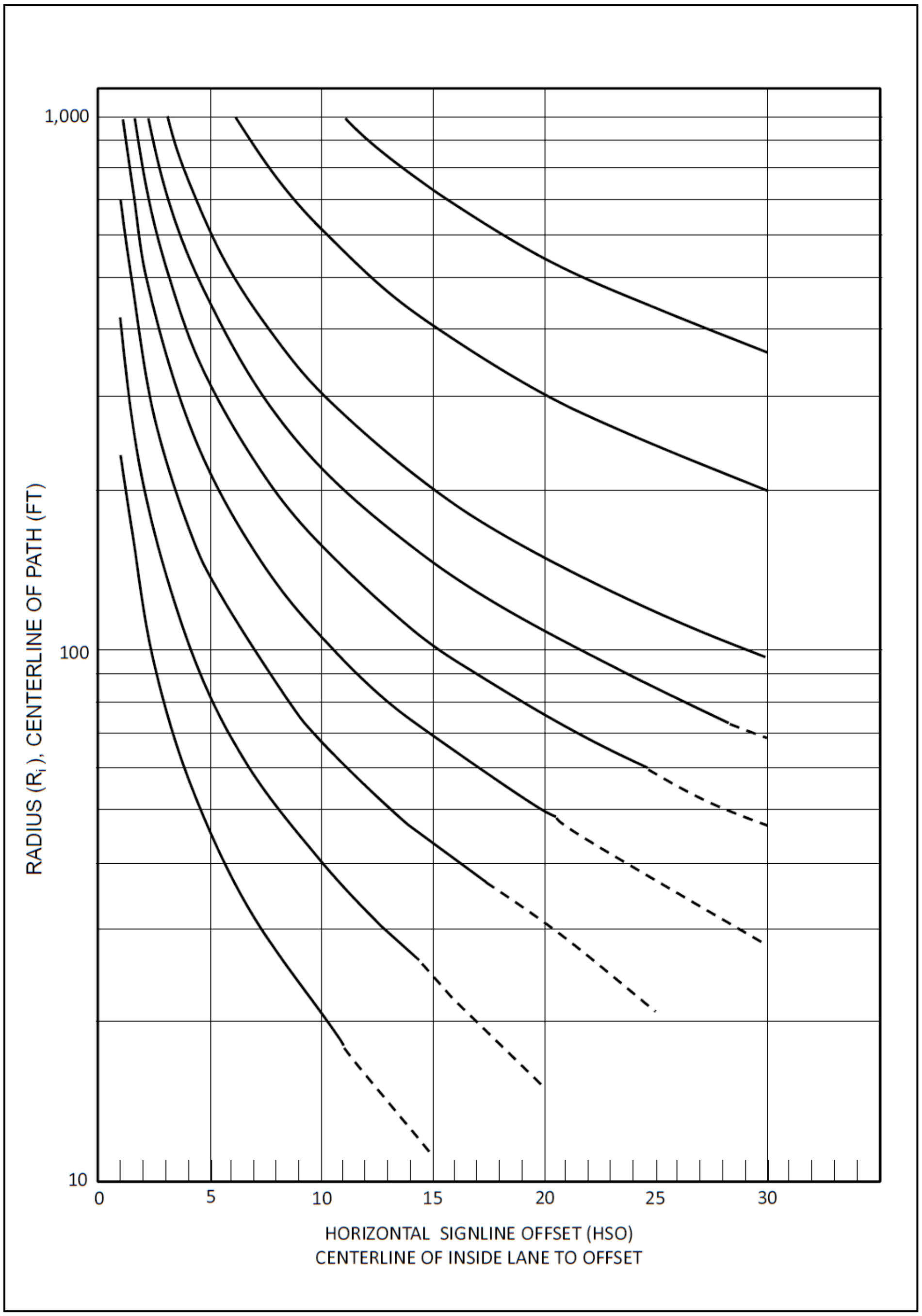


Figure 14-26 Design Controls for

Stopping Sight Distance on Horizontal Curves

Note: this figure does not consider the effects of grade.

The minimum radii for horizontal curves are addressed in Section 14.2.7

14.2.3.3 Sight Distance on Vertical curves

Sight distance on vertical curves is required to allow bicyclists to see objects on the path over the crest of vertical curves, or obstacles that are located beyond overhanging visual obstructions on sag vertical curves. Stopping sight distance is measured when the height of eye and the height of object are 4.5 feet (for a typical bicycle rider) and 0 feet (flush with the pavement surface) respectively.

When S is less than L,

$$S = 30\sqrt{\frac{L}{A}}$$

When S is greater than L,

$$S = \frac{L}{2} + \frac{2025}{A}$$

Where,

S = stopping sight distance, in feet

L = length of crest vertical curve, in feet

A = algebraic difference in grades, in percent

Table 14-3 is used to select the minimum length of vertical curve necessary to provide minimum stopping sight distance at various speeds on crest vertical curves. Note that this table is for regular bicycles. For recumbent bicycles the values would need to be recalculated using equations 3-14 and 3-42 in the *PGDSH* **(1)**.

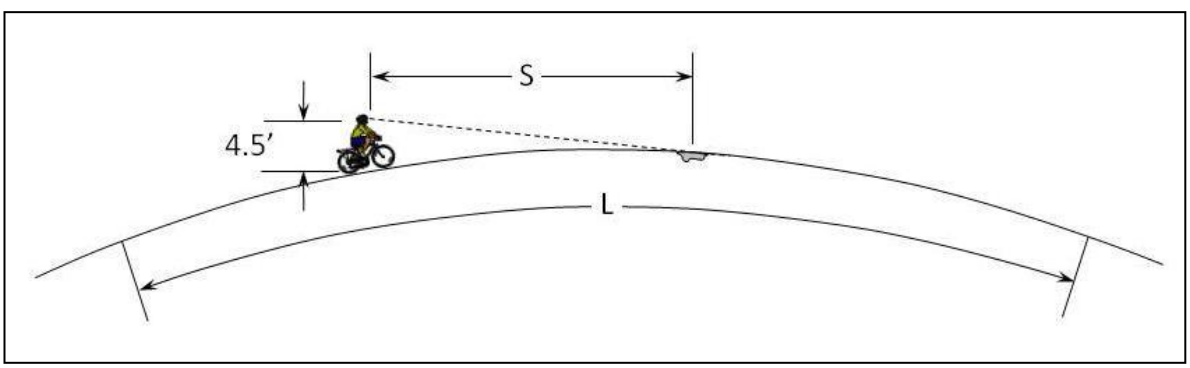


Figure 14-27 Sight Distance on Crest Vertical Curves

A (%)	S = Stopping Sight Distance (ft)														
	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300
2												30	70	110	150
3								20	60	100	140	180	220	260	300
4						15	55	95	135	175	215	256	300	348	400
5					20	60	100	140	180	222	269	320	376	436	500
6				10	50	90	130	171	216	267	323	384	451	523	600
7				31	71	111	152	199	252	311	376	448	526	610	700
8			8	48	88	128	174	228	288	356	430	512	601	697	800
9			20	60	100	144	196	256	324	400	484	576	676	784	900
10			30	70	111	160	218	284	360	444	538	640	751	871	1000
11			38	78	122	176	240	313	396	489	592	704	826	958	1100
12		5	45	85	133	192	261	341	432	533	645	768	901	1045	1200
13		11	51	92	144	208	283	370	468	578	699	832	976	1132	1300
14		16	56	100	156	224	305	398	504	622	753	896	1052	1220	1400
15		20	60	107	167	240	327	427	540	667	807	960	1127	1307	1500
16		24	64	114	178	256	348	455	576	711	860	1024	1202	1394	1600
17		27	68	121	189	272	370	484	612	756	914	1088	1277	1481	1700
18		30	72	128	200	288	392	512	648	800	968	1152	1352	1568	1800
19		33	76	135	211	304	414	540	684	844	1022	1216	1427	1655	1900
20		35	80	142	222	320	436	569	720	889	1076	1280	1502	1742	2000
21		37	84	149	233	336	457	597	756	933	1129	1344	1577	1829	2100
22		39	88	156	244	352	479	626	792	978	1183	1408	1652	1916	2200
23		41	92	164	256	368	501	654	828	1022	1237	1472	1728	2004	2300
24	3	43	96	171	267	384	523	683	864	1067	1291	1536	1803	2091	2400
25	4	44	100	178	278	400	544	711	900	1111	1344	1600	1878	2178	2500

Table 14-3 Minimum Length of Crest Vertical Curve Based on Stopping Sight Distance

The primary control for designing sag vertical curves for roadways is the limitations of headlamp lighting at night. This control is reasonable for cars because they are required to have operating headlamps and headlamps are typically adjusted with a reasonable degree of consistency. While bicyclists who are riding between sunset and sunrise are required to have a headlamp, the purpose of the headlamp is to make the bicyclists visible **(30)**. There are a wide variety of headlamp designs and the light they provide for bicyclists to see the path in front of them is widely variable. Consequently, using headlamp limitations for a design control is not practical for shared use paths.

A sag curve on a shared use path must be designed so that it provides the minimum stopping sight distance described for in Section 14.2.3.1. In most cases meeting these criteria will not be problematic. One common exception is when a path is depressed through an undercrossing, in which case the sight distances should be checked to ensure that any overhanging structure does not limit the stopping sight distance to less than that which is required.

14.2.3.4 Sight Distance at Intersections

The discussion on intersection sight distance provided in Chapter 9 of this *Roadway Design Guide*, is also applicable to shared use paths. Also applicable are the procedures to determine sight distances at intersections presented in Chapter 9 of the *PGDHS* **(1)**, using the appropriate design speed for the shared use path approaches to the intersection, for each of the Cases below:

Case A --Intersections with no control (not typically used on shared use paths)

Case B -- Intersections with stop control on the minor road

Case B3 – Crossing maneuver from the minor road

Case C – Intersections with yield control on the minor road

Case C1 – Crossing maneuver from the minor road

Case D – Intersections with traffic signal control

Checking the sight distances for vehicles turning onto or off of the shared use path is typically not necessary. The minor roadway may be either the shared use path or the roadway.

14.2.4 Shared Use Path Width

The minimum width of pavement for a two-directional shared use path is 10 feet.

Additional width may be appropriate depending on the volume of users and mix of users on the shared use path. FHWA has developed a level of service document and shared use path calculator which may be helpful for determining the appropriate width of users **(31, 32)**. Pathways of wider than10 feet up to 14 feet are recommended in locations that are anticipated to have high volumes (greater than 300 users in the peak hour) with a high percentage (greater than 30 percent) of pedestrians. Eleven-foot shared use paths allow for a bicyclist to pass another traveling in the same direction at the same time a user is approaching from the opposite direction **(31)**. Wider paths should also be considered where there is expected significant use by in-line skaters, hand cyclists, or adult tricyclists **(7)**; on steep grades; and through curves.

A reduced width, to as little as 8 feet, may be used only under short sections of constrained conditions and where the following conditions apply:

- bicycle traffic is expected to be low, even on peak days or during peak hours,
- pedestrian use of the facility is not expected to be more than occasional,
- horizontal and vertical alignments provide safe and frequent passing opportunities, and
- the path will not be regularly subjected to maintenance vehicle loading conditions that would cause pavement edge damage.

In most cases it is not necessary to designate separate space for different users on shared use paths. Slower path users tend to keep right while higher speed users pass on the left. If additional encouragement is necessary to encourage this behavior, signs may be installed to remind users of this required behavior (see Figure 14-28) **(33)**.

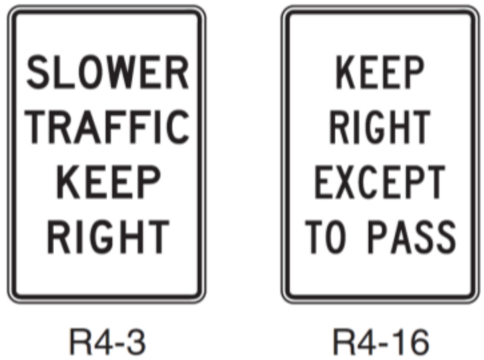


Figure 14-28 Path User Position Signs

In cases where there are high path volumes it may be appropriate to separate directions on the path with a yellow centerline stripe. On areas with adequate sight distance a broken line (3-foot segment with a 9-foot gap) may be provided.

On the approach to conflict points, substandard curves, locations where sight distances cannot be maintained, or other potential hazards, a single solid yellow centerline stripe and an appropriate sign should be installed. The solid stripe should extend a distance at least equal to the Stopping Sight Distance in advance of the conflict point or hazard.

Where users are separated onto separate paths, sometimes referred to as *wheels and heels*, mode specific guide signs can be used in conjunction to denote the preferred path for each user type (see Figure 14-29). SELECTIVE EXCLUSION signs **(33)** can be used to indicate where various users are not permitted (see Figure 14-30).

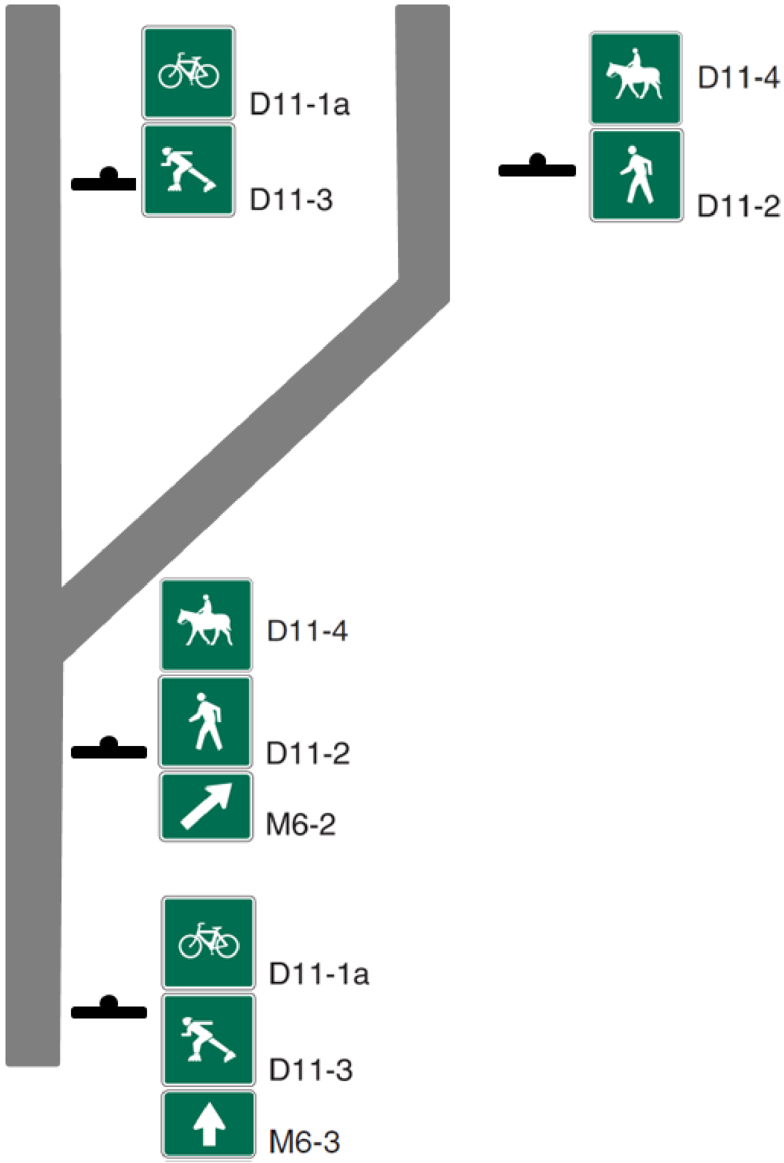


Figure 14-29 Mode Specific Guide Signs

Figure 14-30 Selective Exclusion Signs

14.2.5 Cross Slope

The cross slope of a shared use path must be designed so that rain and snow melt will drain from the pavement surface. Consequently, a minimum cross slope of 1 percent should be maintained on shared use paths. Shared use paths typically are not crowned; a uniform cross slope is maintained across the path.

Because shared use paths are intended to be used by pedestrians and persons with disabilities, they must comply with the cross slope requirements of the ADA. Therefore, the maximum cross slope for a shared use path is 2 percent.

14.2.6 Clearances

Just as minimum clear recovery “Z” slope areas and clear zones to obstructions are provided for roadways, horizontal clearance is required to signs, poles, drop-offs and other path-side obstructions and hazards.

Where practical, a graded shoulder free of obstructions at least 3 feet wide with a maximum cross slope of 6:1 should be maintained on each side of the shared use path pavement. Under constrained conditions, minimum clear space of 2 feet should be provided to vertical obstructions. If a smooth protective railing is provided, this clearance may be reduced to 1 foot. In addition, where minimum clearance cannot be provided to obstructions, path users should be warned of the obstruction. Warnings for lateral obstructions can include warning signs, edge line striping, reflectorization, or a combination thereof. Because the barrier, railing or fence is itself a vertical obstruction, the barrier should be flared on the approach end of an obstruction so that the end of the barrier is at least 3 feet from the edge of the path.

Embankments and sheer drop-offs are particularly hazardous to shared use path users. If possible a 5-foot separation should be provided to embankments with slopes greater than 4:1 and drop-offs. Where this separation cannot be maintained, a suitable barrier such as a railing or fence should be provided at the top to the slope. Specifically, barriers should be placed to separate shared use paths from embankments and drop-offs under the following conditions (see Figure 14-30):

- Slopes 3:1 or steeper, with a drop of 6 feet or greater
- Slopes 2:1 or steeper, with a drop of 4 feet or greater
- Slopes 1:1 or steeper, with a drop of 1 foot or greater
- Slopes 3:1 or steeper, adjacent to a parallel water hazard, roadway, or other obvious hazard

When used barriers used next to a shared use path shall be a minimum of 42 inches high.

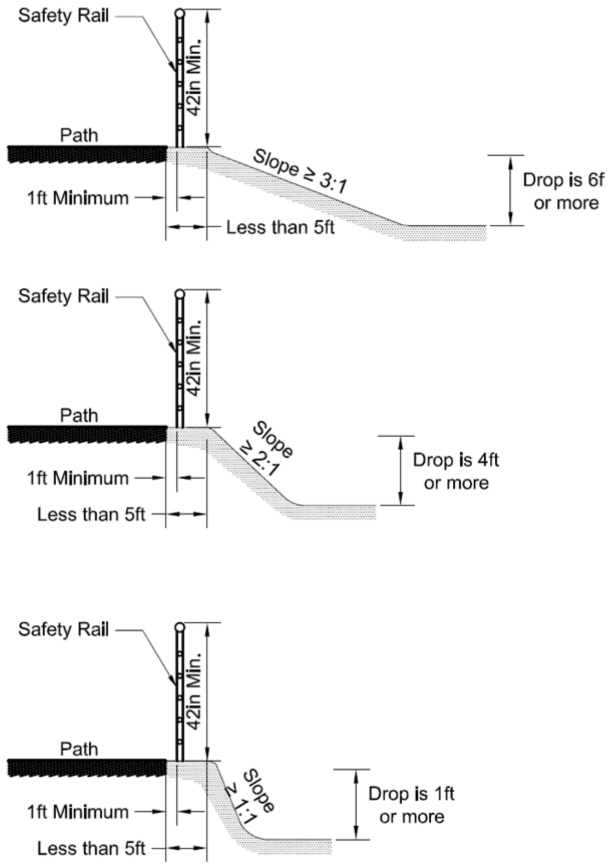


Figure 14-30 Conditions where Barriers to Embankments are Recommended

Openings between horizontal or vertical members on railings should be small enough that a 4-inch sphere cannot pass through them in the lower 27 inches. For the portion of railing that is higher than 27 inches, openings may be spaced such that an 8-inch sphere cannot pass through them. This specification is to prevent children from falling through the openings.

Some Colorado jurisdictions require a rub rail at a height where a bicyclist's handlebar may come into contact with a railing or barrier. A rub rail is a smooth surface 36 inches to 44 inches installed to reduce the likelihood bicyclists' handlebars will be caught by the railing. Local requirements should be consulted.

The minimum vertical clearance to obstructions is 10 feet.

14.2.7 Horizontal Alignment of Shared Use Paths

The discussion of horizontal alignment provided in Chapter 3 is also applicable to shared use paths.

Typically, simple horizontal curves should be used on shared use paths. The simple horizontal curves discussion in Chapter 3 of this *Roadway Design Guide* are also pertinent to shared use paths.

Because a shared use path is also a pedestrian facility, paths must be designed to be compliant with the applicable sections of the ADA. Consequently, the maximum superelevation on a shared use path is 2 percent. If separate pathways for pedestrians and bicyclists are provided the superelevation for the bicycle path may be increased up to 8 percent.

The minimum radius recommended for shared use paths is provided in Table 14-4.

e	R (feet) for Design Speed (mph)								
(%)	8	10	12	14	16	18	20	25	30
-2.0	14	22	33	47	64	85	109	192	316
-1.5	14	22	33	46	63	83	107	188	308
0.0	13	21	31	44	60	79	101	176	286
1.5	12	20	30	42	57	74	96	165	267
2.0	12	20	29	41	56	73	94	162	261
2.2	12	20	29	41	55	73	93	161	259
2.4	12	19	29	41	55	72	93	160	256
2.6	12	19	29	40	55	72	92	158	254
2.8	12	19	29	40	54	71	91	157	252
3.0	12	19	28	40	54	71	91	156	250
3.2	12	19	28	40	54	70	90	155	248
3.4	12	19	28	40	53	70	89	154	246
3.6	12	19	28	39	53	69	89	153	244
3.8	12	19	28	39	53	69	88	151	242
4.0	12	19	28	39	52	69	88	150	240
4.2	11	19	27	39	52	68	87	149	238
4.4	11	18	27	38	52	68	87	148	236
4.6	11	18	27	38	51	67	86	147	234
4.8	11	18	27	38	51	67	85	146	233
5.0	11	18	27	38	51	66	85	145	231
5.2	11	18	27	37	51	66	84	144	229
5.4	11	18	27	37	50	66	84	143	227
5.6	11	18	26	37	50	65	83	142	226
5.8	11	18	26	37	50	65	83	141	224
6.0	11	18	26	37	49	64	82	140	222
f = Friction Factor	0.33	0.32	0.31	0.30	0.29	0.28	0.26	0.24	0.21

Table 14-4 Minimum Radii and Superelevation for Shared Use Paths

If the minimum curve radius cannot be met, a centerline stripe and TURN or CURVE WARNING sign (W1 series) shall be installed.

14.2.8 Vertical Alignment of Shared Use Paths

Where technically feasible, the maximum continuous grade on a shared use path should be limited to 5 percent. Where right-of-way and geometric constraints make the provision of a continuous grade less than 5 percent impractical, grades should be minimized.

Where potential grades exceed 5 percent, intermittent level resting intervals should be considered. Where provided, resting intervals shall be full width of the shared use path and 60 inches long.

Alternatively, a 36-inch wide resting interval may be located adjacent to the shared use path. Recommended maximum distance between resting areas is 200 feet.

Shared use paths located along roadways may follow the grade of the road. Where grades exceed 5 percent, resting intervals should be provided.

Where sustained grades exceeding 4 percent in excess of 300 feet in length are required, an increased design speed should be used. Additionally, consider providing the following mitigating measures:

- HILL WARNING signs (W7-5) (Figure 14-31);
- Wider clear recovery areas adjacent to the shared use path; and
- An additional six feet of width to allow some users to dismount and walk their bicycles.

Figure 14-31 Bicycle HILL WARNING Sign

Alternatively, consider installing a series of switchbacks to reduce the longitudinal grade.

Except for ramps on structures, transitions between grades with more than 2 percent algebraic difference should be made with vertical curves. The minimum length for a vertical curve on a shared use path is 3 feet.

On unpaved shared use paths, grades greater than 3 percent are not recommended. Grades exceeding 3 percent can create maintenance (erosion) problems and cause bicycle handling problems for some cyclists.

In flat terrain, the grade of the shared use path may be controlled by drainage considerations.

14.2.9 Intersections with Shared Use Paths

The background information provided in Chapter 9 of this *Roadway Design Guide,* is also applicable to intersections of shared use paths with roadways and with other shared use paths.

The fundamental design of intersections requires that users be able to

- perceive the intersection and the potential conflicts
- understand their obligations to yield
- fulfill the obligation to yield

The design criteria in this section and its subsections are intended to support these three fundamental concepts.

When designing intersections with shared use paths, the sight distance criteria provided in Section 14.2.3.4 (Sight Distance at Intersections), and Chapter 9 of the *Roadway Design Guide*, are applicable. Only the design speeds of the intersecting approach legs of the intersection - using the bicycle as a design vehicle for pathway approaches - are necessarily adjusted when applying these criteria to shared use path intersections.

At shared use path intersections with roadways or with other shared use paths, one facility should be given priority over the other. Four-way stop control should not be used at intersections of shared use paths.

According to the MUTCD **(36)**,

> *When placement of STOP or YIELD signs is considered, priority at a shared use path/roadway intersection should be assigned with consideration of the following:*
>
> > *A. Relative speeds of shared use path and roadway users;*
> >
> > *B. Relative volumes of shared use path and roadway traffic; and*
> >
> > *C. Relative importance of shared use path and roadway.*
>
> *Speed should not be the sole factor used to determine priority, as it is sometimes appropriate to give priority to a high-volume shared-use path crossing a low-volume street, or to a regional shared-use path crossing a minor collector street.*
>
> *When priority is assigned, the least restrictive control that is appropriate should be placed on the lower priority approaches. STOP signs should not be used where YIELD signs would be acceptable.*

The primary consideration in the assignment of traffic control type (STOP as opposed to YIELD signs) at intersections is the availability of adequate sight distance for approaching users. If sight triangles cannot be maintained to provide for yield control, STOP signs must be used. A detailed discussion of sight triangles is provided in Section 14.2.9.1.

Because a shared use path is intended for use by pedestrians and because bicycles are vehicles in Colorado, the intersection of a shared use path creates a location where a pedestrian path crosses a vehicular way. Where a shared use path crosses a roadway, detectable warnings shall be installed. Where two shared use paths intersect, the approach that is required to yield the right of way should have detectable warnings installed.

Roundabouts can also be used at the intersection of two shared use paths. A path width of 8 feet should be maintained around the circulating pathway. Splitter islands and central islands on roundabouts for shared use paths should be curbed.

Traffic control for shared use path approaches to intersections is provided in Section 14.2.9.2.

Intersections of shared use paths with roadways should be located outside of the functional area of the intersection of two roadways (Figure 14-32). If a shared use path crosses a roadway within the functional area of an intersection, the path should either be diverted to outside the functional area of the intersection or moved to the intersection and treated as a sidepath crossing (see Section 14.2.13.1).

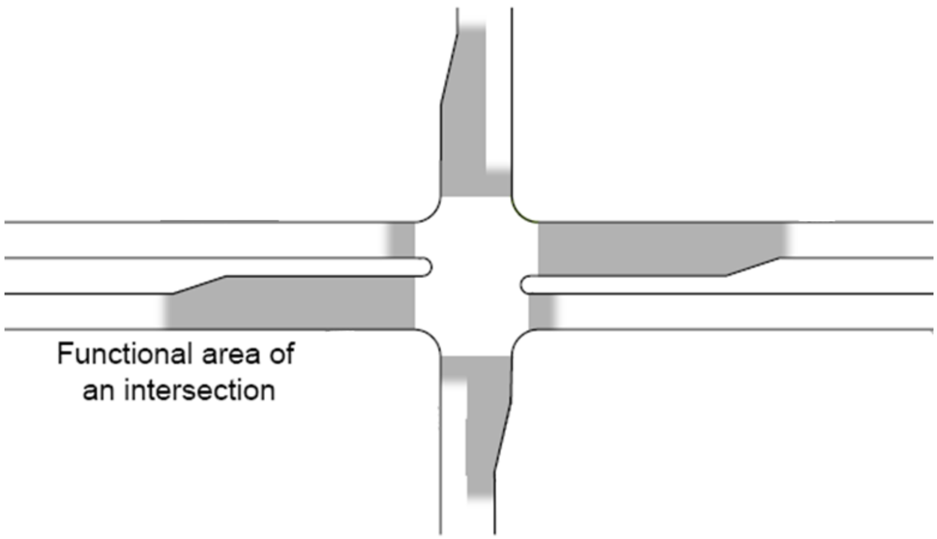


Figure 14-32 Functional Area of an Intersection

Traffic signals can be warranted at shared use path crossings of roadways, based on any of the nine warrants described in the MUTCD **(36)**. For the School Crossing and Pedestrian Volume warrants, all path users may be counted as pedestrians. For the Eight-Hour Vehicular Volume, Four-Hour Vehicular Volume, and Peak Hour warrants only bicycles are counted as vehicles on the path approaches.

Where signals are installed for shared use paths, signal timing shall accommodate the needs of bicyclists and pedestrians.

14.2.9.1 Required Sight Triangles at Shared Use Path Intersections

The decision to use a STOP sign as opposed to a YIELD sign will be primarily determined by the available sight distance required for bicyclist at the intersection.

The procedures to determine sight distances at intersections presented in Chapter 9 of the *PGDHS* **(1)** apply to bicycle facilities as well as to roadways. In this section the requirements for each of the following cases is discussed for both stop and yield control:

Case B3 – Stop Controlled crossing maneuver from the minor road

Case C1 – Yield Controlled crossing maneuver from the minor road

For Case B3 where the path is under stop control, the required sight distance at the intersection is a function of the time it takes the slowest design user to cross the street or cross to a refuge island in the middle of a divided roadway. In most cases the slowest design user is the pedestrian. However, since shared use path crossings of roadways are nearly always marked with crosswalks, the sight distance must allow for a motorist to observe and yield to a pedestrian approaching and crossing at the shared use path-roadway intersection. To calculate the required sight triangle, it should be assumed the pedestrian is standing behind the shared use path yield or stop line.

For Case B3 where the road is under stop control, the sight distance should be calculated as provided in the *PGDSH* **(1)** using the shared use path design speed as the speed on the major road. By applying equation 9-1 from the *PGDSH*

$$ISD = 1.47V_{path}t_g$$

Where

ISD = intersection sight distance

V_{path} = design speed of path

t_g = time gap for minor road vehicle to enter and cross path

The *PGDSH* provides a time gap, t_g, of 6.5 seconds for passenger cars, 8.5 seconds for single unit trucks, and 10.5 seconds for a combination truck to cross a two-lane roadway based upon observational studies. Consequently, they are conservative for crossing of most shared use paths. However, on multilane roadways where advance STOP or YIELD lines are used, additional time should be allowed: 1.3 seconds additional for a 30-foot advance line and 1.8 seconds for a 50-foot advance line for passenger cars (2.1 seconds and 2.9 seconds for trucks respectively). Additionally, where approach grades exceed 3 percent, add 0.1 second for each percent grade.

The clear sight triangle is that space which should be kept free of obstructions that might block an approaching driver's view of any potentially conflicting path users. Figure 14-33 illustrates the needed dimensions for calculating the sight triangle for case B3 where motorists are required to stop. Table 14-5 provides the values for those dimensions.

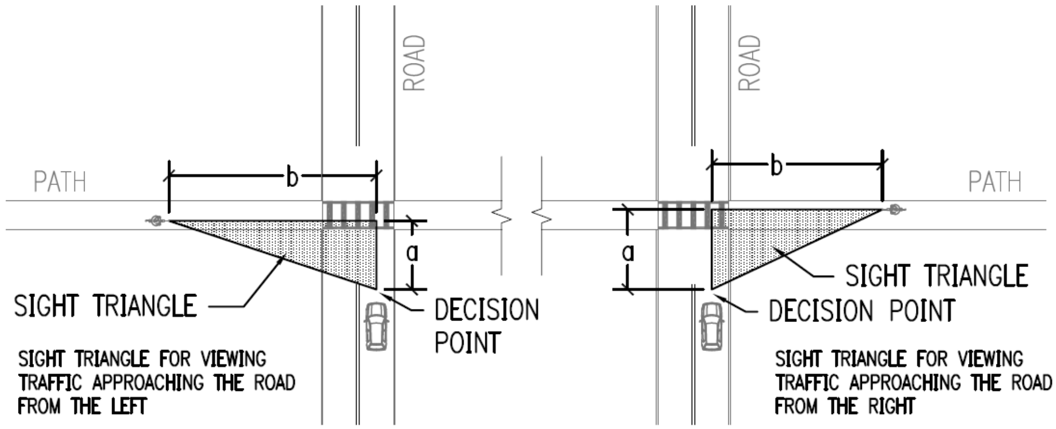


Figure 14-33 Illustration of Intersection Sight Triangle Dimensions

Case B3, Motorist Required to Stop

Where,

a = assumed distance to driver's eye

b = intersection sight distance

Design Speed of Path (mph)	Intersection Sight Distance for Passenger Cars (distance *b*) Distance to Stop Bar		
	4 feet	30 feet	50 feet
8	80	95	100
10	100	115	125
12	115	140	150
14	135	165	175
16	155	185	200
18	175	210	220
20	195	230	245
25	240	290	310
30	290	345	370
Asumed distance to driver's eye (distance a)	14.5 feet	40.5 feet	50.5 feet

Table 14-5 Intersection Sight Distance

For Case C3 where the path is under yield control, sight triangles are calculated assuming that the yielding approaches will decelerate to 60 percent of the design speed on the approach to the intersection and that the approaches with priority will not decelerate. Sight distances are calculated based upon the time taken for the vehicle on the minor road to cross the intersection. The travel time to reach and clear the major road from the decision point on the minor approach is calculated using the following equations:

$$t_g = t_a + \frac{w + L_a}{0.88V_{minor}}$$

where

$$t_a = \frac{1.47(V_{minor} - V_r)}{a_m}$$

and

t_g = time gap for minor road vehicle to reach and clear the major road

t_a = travel time for minor road vehicle to reach the major road while decelerating

w = width of intersection to be crossed

L_a = length of design vehicle

V_{minor} = design speed of minor facility

V_r = reduced speed of minor approach (60 percent design speed)

a_m = acceleration rate assumed for minor approach (assume 5 fpsps)

The length of the sight triangle along the major approach is calculated using the equation

$$b = 1.47V_{major}t_g$$

where

b = sight distance required along major approach

V_{major} = design speed of major facility

The sight distance required along the minor approach, *a*, can be obtained from Table 14-6

Design Speed	Minor Leg
12	62
14	71
16	80
18	90
20	100
25	130
30	160
35	195
40	235
45	275
50	320
55	370

Table 14-6 Required Sight Distance for Minor Leg of Yield Control

Figure 14-34 illustrates the dimensions for yield control intersections. Users are not shown on the graphic because either approach (major or minor) could be the shared use path.

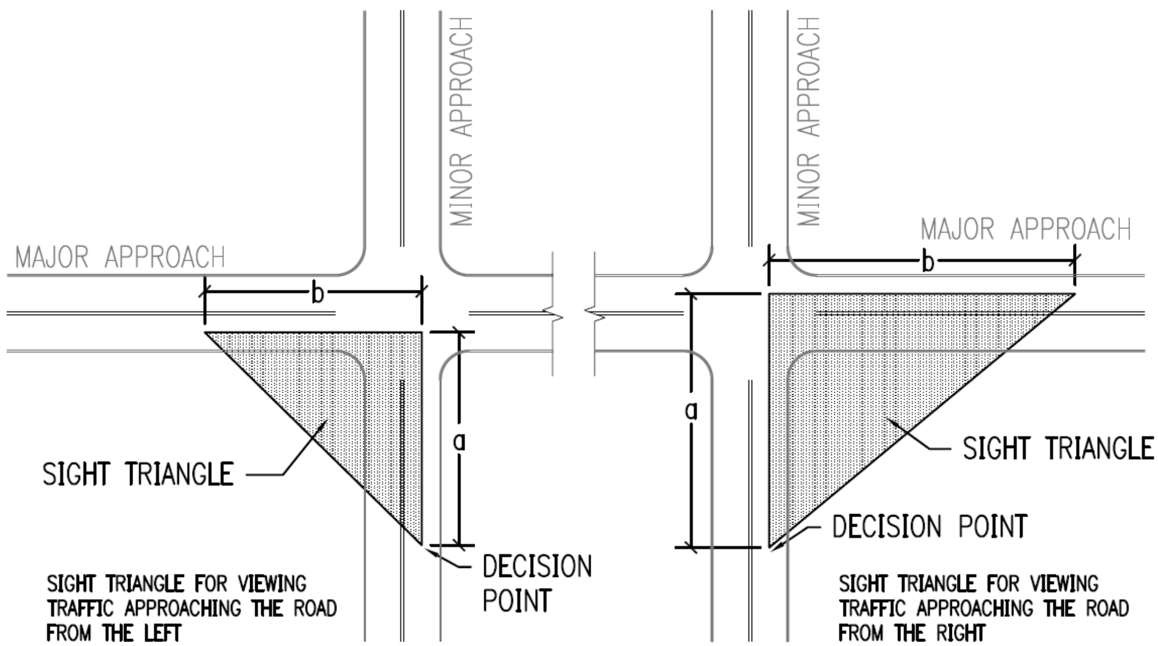


Figure 14-34 Illustration of Intersection Sight Triangle Dimensions

Case C3, Yield Condition

Where a shared use path approaches a walkway and the shared use path is required to stop, the legs of the sight triangle should extend 25 feet back from the edge of the sidewalk along the shared use path, and 15 feet back from the edge of the shared use path along the sidewalk (Figure 14-35).

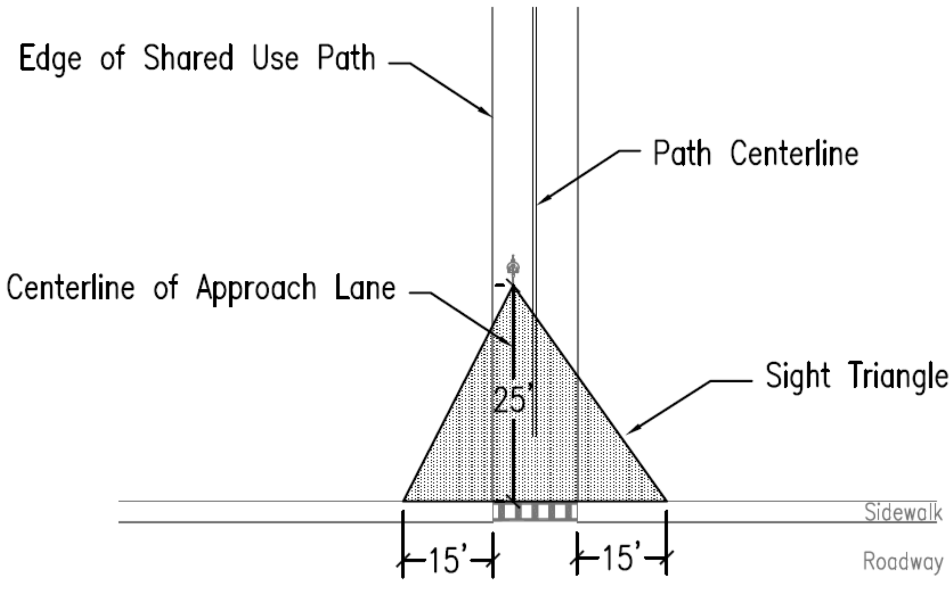


Figure 14-35 Illustration of Intersection Sight Triangle Dimensions

Path Approaching Sidewalk

14.2.9.2 Traffic Control at Intersections with Shared Use Paths

The traffic control provided on shared use paths at intersections with other paths or with roadways is similar to that provided at the intersection of two roadways.

STREET NAME signs (D1-3) should be included for shared use path users.

On the approach to any intersection, a solid yellow centerline should be striped on the approach to the intersection for a distance equal to the Stopping Sight Distance of the shared use path.

An INTERSECTION WARNING (W2 series) or ADVANCE TRAFFIC CONTROL (W3 series) sign may be used on a roadway, street, or shared-use path in advance of an intersection to indicate the presence of an intersection and the possibility of turning or entering traffic. However, these signs are not required unless the engineering judgment determines that the visibility of the intersection is limited on the shared-use path approach to the intersection. When deciding whether or not to install advance signs, the designer should consider that intersections and intersection traffic control should be visible from at the least Stopping Sight Distance in advance of the intersection. Figure 14-36 shows W2 and W3 series signs.

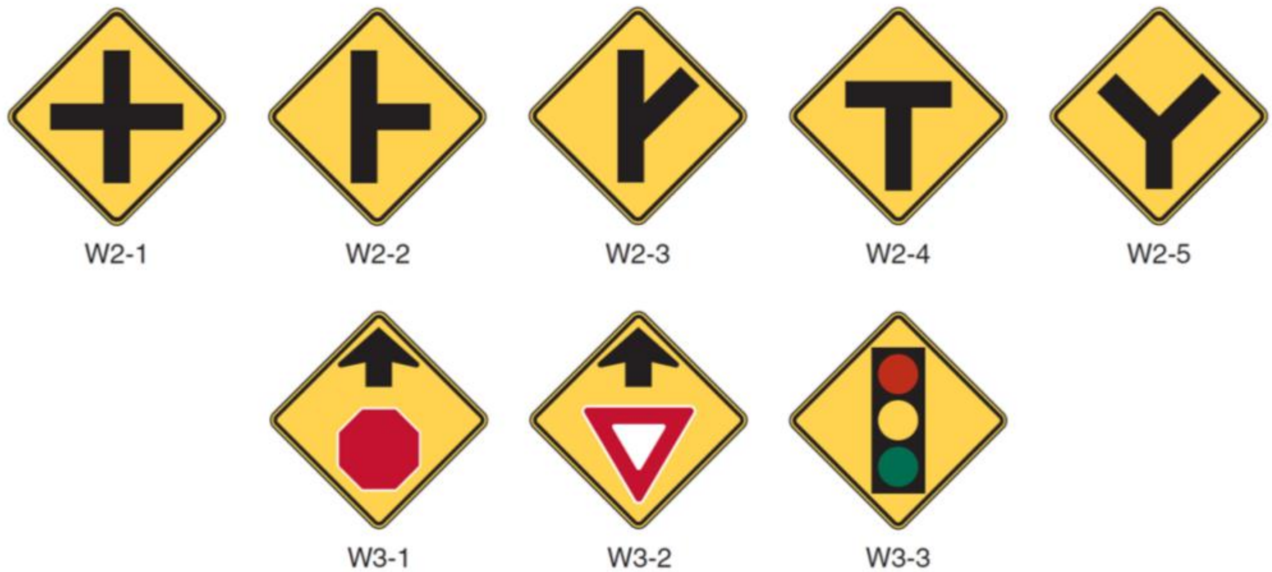


Figure 14-36 INTERSECTION WARNING (W2 Series) and ADVANCE TRAFFIC CONTROL (W3 Series) Signs

Where the shared use path is to yield or stop (with either a STOP sign or a signal) at the intersection, YIELD signs and YIELD lines or STOP signs and STOP lines shall be installed on the path approach to the intersection. YIELD or STOP lines shall be placed four feet in advance of the intersecting travel way or sidewalk.

For signal control intersections, detector loops in the pavement, as well as push buttons for pedestrians should be installed on the path approaches.

On the motor vehicle approach, signing and striping will vary with respect to which facility is given priority at the intersection. If the path is given priority at the intersection, then the roadway approaches should be signed and marked as they would be on the approach to any intersection with a roadway with similar control (YIELD, STOP, or signal control). If the roadway is given priority at the intersection, traffic control for motorists appropriate at a midblock pedestrian crossing must still be installed (see Sections 14.3.8 and 14.3.9). At trail crossings, however, the TRAIL CROSSING (W11-15 and W11-15p) sign assembly (Figure 14-37) should be used instead of the PEDESTRIAN CROSSING sign (W11-2).

Figure 14-37 TRAIL CROSSING Assembly

14.2.9.3 Reducing Speeds on the Approach to Intersections

As stated in Section 14.2.8, users of intersections must be able to perceive conflicts at intersections, understand their obligations to yield or stop, and be able to fulfill their obligations to yield. Slowing drivers and path users down on the approach to intersections can provide more time for users to perceive and understand their obligations. With the exception of raised crossings, roadway traffic calming features are beyond the scope of this chapter. However, slowing the path user on the approach to the intersection will also support these fundamental concepts.

Horizontal deflection, either through a series of low design speed curves or a chicane, on the approach to an intersection is an effective technique in reducing bicycle speeds on the approach to intersections. Examples of these geometric design techniques are provided in Figure 14-38, a detail of the chicane treatment is shown in Figure 14-39.

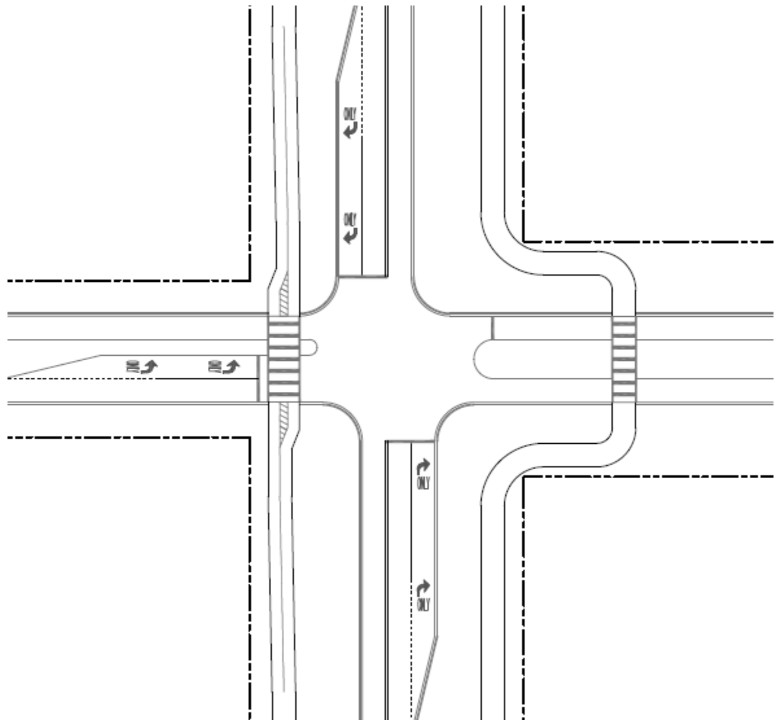


Figure 14-38 Geometric Design to Slow Bicyclists on Intersection Approaches

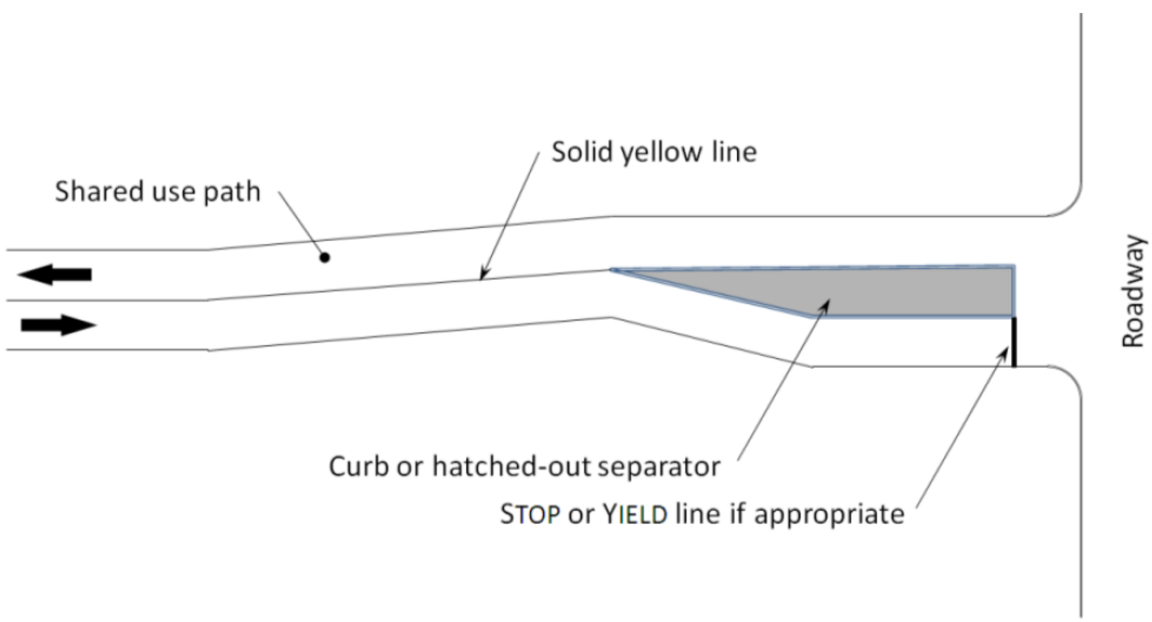


Figure 14-39 Chicane on Approach to Intersection

14.2.9.4 Curb Ramps

Where a shared use path crosses a roadway it represents a pedestrian crossing location. ADA compliant curb ramps (if curbs are present) must be installed. The width of the ramp, not inclusive of the flares or curb returns on the side of the ramp, must be full width of the approach path. Refer to section 14.3.1.4 of this chapter.

Detectable warnings must be placed at the base of the curb ramps across the entire width of the ramps or across the entire width of the path on the approach to crossings where no curbs are present.

14.2.9.5 Prevention of Motor Vehicle Encroachment onto Shared Use Paths

On some shared use paths, encroachment by motor vehicles may be a concern. If the primary cause of encroachment is a lack of understanding on the part of motorists of the non-motorized nature of the facility, consider the installation of NO MOTOR VEHICLES (R5-3) (see Figure 14-40) signs at path access points.

Figure 14-40 NO MOTOR VEHICLES Sign (R5-3)

Physical barriers to motor vehicles are often ineffective in prohibiting access to motor vehicles. Motorists, and more frequently all terrain vehicles, often go around or damage objects intended to limit motor vehicle access. Barriers can, however, present obstructions to shared use path users. Consequently, their use should be limited.

One method of discouraging access to motorists is the use of a low, central, dividing island on the path approach to intersections. Combined with tight curb radii, this method can be quite effective. The island should be designed so that emergency and maintenance vehicles can access the path by straddling the island. The width of the path on either side of the island should be at least 6 feet wide; in constrained conditions the path may be narrowed to 5 feet wide on either side of the dividing island. Where divisional islands are provided, solid yellow lines are to be provided in advance of and on either side of the island.

Tight curb radii, such as 2 feet, at path-roadway intersections can reinforce the non-motorized nature of shared use paths. See Figure 14-41.

If bollards are used to restrict motor vehicle access at intersections of roadways with paths, a six foot clear space is to be provided between bollards. If more than one bollard is used, then an odd number of bollards shall be used so that one bollard is in the center of the path. Obstruction striping shall be installed around bollards. Around the *central* bollard the obstruction striping shall be yellow to denote opposing directions of travel on either side of the bollard. Additional bollards shall have white obstruction markings. See Figure 14-42. Solid lines on the approach to the bollards should extend a distance equal to the stopping sight distance in advance of the bollards.

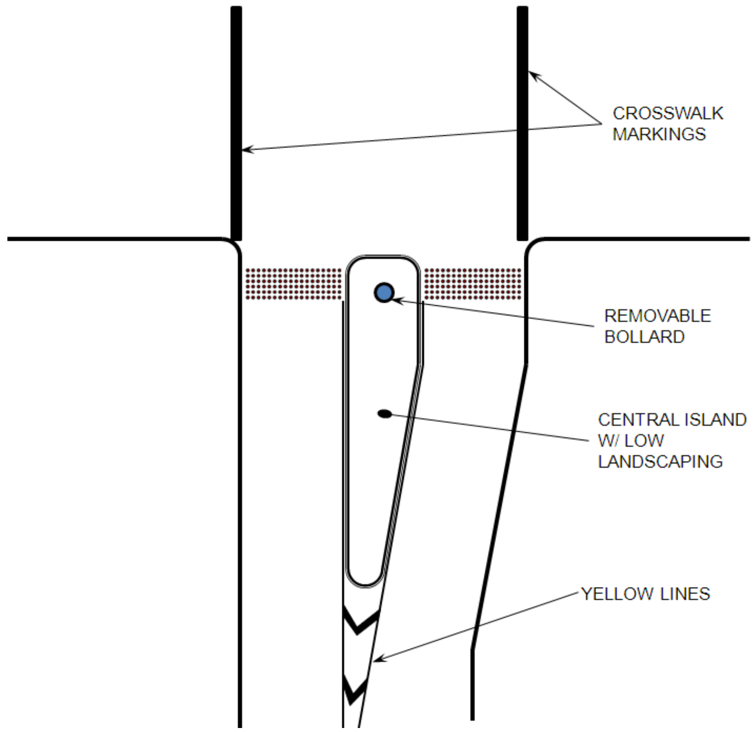


Figure 14-41 Example Schematic Path Entry

Directional arrows may be placed on the approach to the paths between bollards to prevent confusion of path users. Where used, bollards shall be marked with retroreflective material on both sides or the appropriate object marker as shown in the *MUTCD* (37). In addition, bollards should be

- visible from a distance equal to or greater than the stopping sight distance;
- at least 40 inches high;
- have a minimum diameter of 4 inches; and
- set back 30 feet from the through lanes on the adjacent roadway.

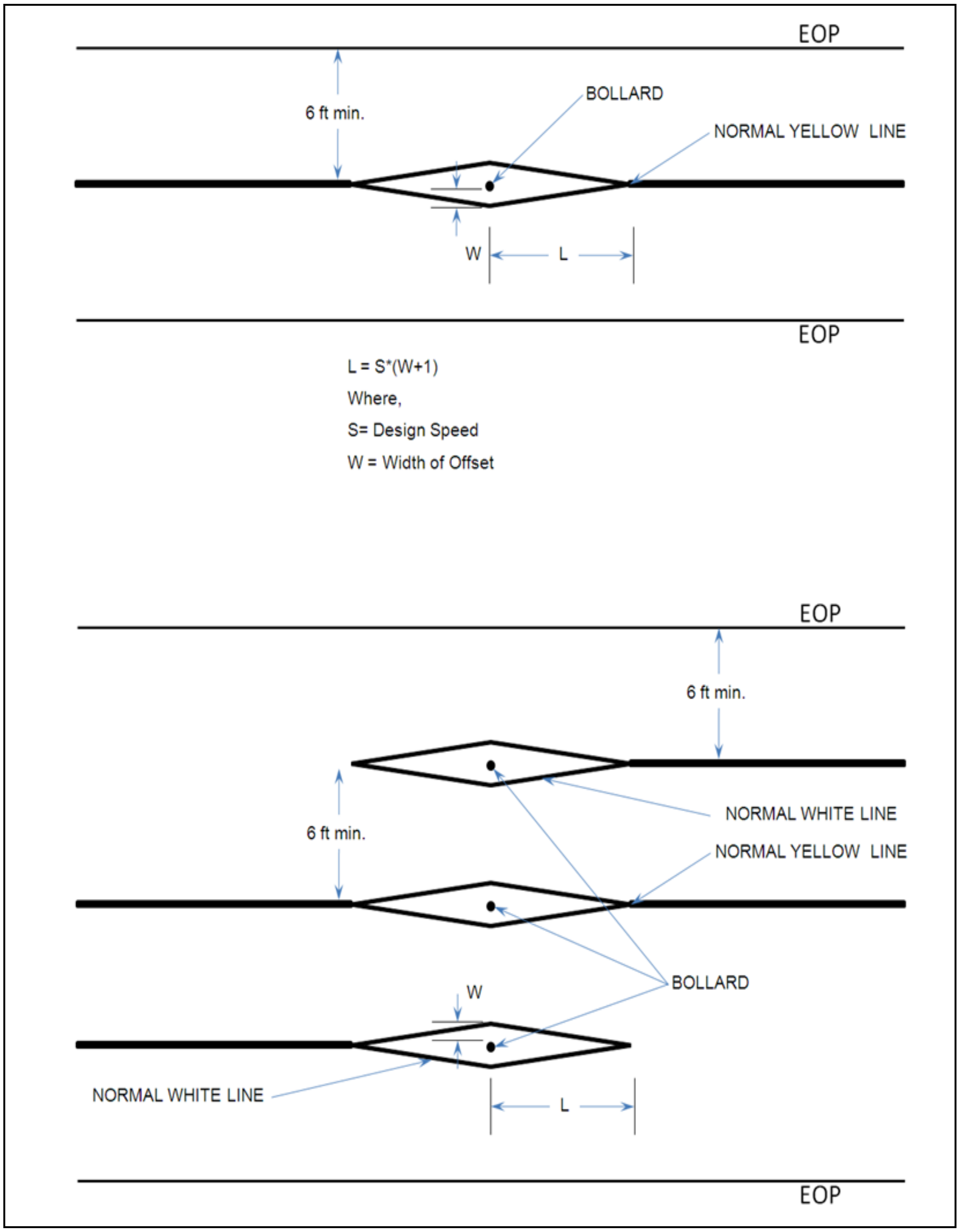


Figure 14-42 Obstruction Striping around Bollards on Shared Use Paths

If used, bollards shall be placed where motorized vehicles cannot easily bypass them.

Bollards may be installed in such a manner as to be removable by emergency or maintenance personnel. Any hardware used to secure the bollard should be flush with the surface of the bollard or ground so as not to create an additional obstruction.

14.2.10 Underpass and Overpass Structures

To maintain continuity of a shared use path facility or system, some structures will be required.

On some projects, the designer may have a choice between a tunnel and an overpass. From a user standpoint an overpass is often preferable. Overpasses have security advantages. Additionally, lighting is often a requirement for tunnels and may not be necessary for an overpass. The need to climb onto the overpass (ride uphill) may result in lower speeds on a constrained facility. Drainage may also be easier to accommodate on overpasses. Underpasses are often more difficult to construct because of utility conflicts or phasing issues. However, overpasses have significantly greater vertical clearance requirements, 17 feet 6 inches over the roadway as opposed to 10 feet over the path surface. Underpasses provide the ridability advantage of providing momentum for bicyclists, riding downhill before riding uphill.

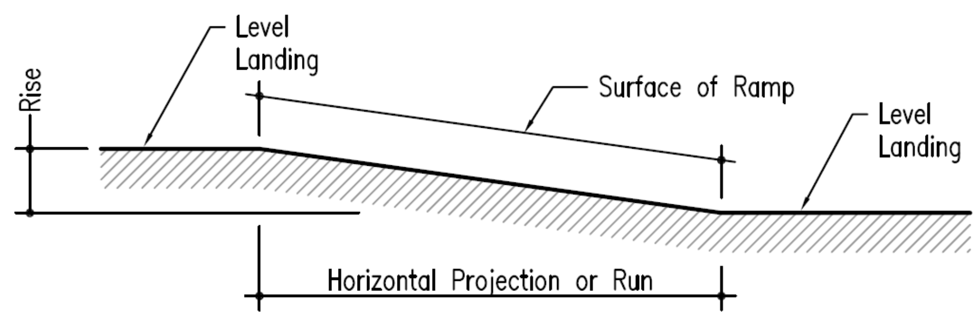
14.2.10.1 Width and Clearance for Structures Serving Shared Use Paths

All bridges and tunnels serving shared used paths should provide a clear width equal to at least the width of the approach path and shoulders. Full path width and striped shoulders should be carried across the structure. If the full path width and shoulders cannot be carried across a structure, railings with proper end flares should be provided as for an obstruction (see Section 14.2.6).

Minimum vertical clearances for enclosed structures, tunnels or caged bridges, is 10 feet.

14.2.10.2 Grades on Structures Serving Shared Use Paths

All structures serving shared use paths must be ADA compliant. Cross slopes shall not exceed 2 percent. If approach grades exceed 5 percent they shall be designed as ramps. Resting intervals measuring 60 inches in the direction of travel along the path and full width of the structure shall be provided a maximum of every 30 inches of rise. See Figure 14-43.



Slope	% Grade	Maximum Rise In.	Maximum Horizontal Projection Ft.
1:12 to < 1:16	8.33% to < 6.25%	30	30
1:16 to < 1:20	6.25% to < 5.00%	30	40

Components of a Single Ramp Run and Sample Ramp Dimensions

Figure 14-43 Maximum Spacing of Resting Intervals on Shared Use Path Structure Ramps

14.2.10.3 Railings on Structures Serving Shared Use Paths

Railings on shared use path structures shall be designed to comply with Section 14.2.6 of this chapter.

14.2.10.4 Railroad crossings

Where possible, shared use paths should be aligned to cross railroad tracks at near right angles. Where this cannot be accomplished and the crossing angle is less than 45°, SKEWED CROSSING signs (W10-12) shall be placed on the path approaches to the rail crossing.

A railroad-path crossing, like a railroad-highway crossing, involves either a separation of grades or a crossing at-grade. The horizontal and vertical geometrics of a path approaching an at-grade railroad crossing should be constructed in a manner that does not divert a path user's attention from path surface conditions.

The same types of crossing treatments used for roadway crossings of railroads, ranging from the required CROSSBUCK sign (R15-1) to full signals and gates, can be used on shared use paths.

Where active traffic control devices are not used, a CROSSBUCK ASSEMBLY shall be installed on each approach to a pathway grade crossing except the CROSSBUCK ASSEMBLY may be omitted at station crossings and on the approaches to a pathway grade crossing that is located within 25 feet of the traveled way at a highway-rail or highway-LRT grade crossing. Pathway grade crossing traffic control devices shall be located a minimum of 12 feet from the center of the nearest track.

If used at a pathway grade crossing, an active traffic control system shall include flashing-light signals for each direction of the pathway. A bell or other audible warning device shall also be provided.

Advance pavement markings and signs shall be used on the approach to railroad crossings. See Figure14-44. The minimum sizes of pathway grade crossing signs shall be as shown in the shared-use path column in Table 9B-1 of the *MUTCD*.

If used, swing gates shall be designed to open away from the tracks so that pathway users can quickly push the gate open when moving away from the tracks. If used, swing gates shall be designed to automatically return to the closed position after each use.

To meet the requirements of the draft Public Right of Ways Accessibility Guideline (PROWAG), path surfaces shall be flush with the tops of rails ***(48).*** Openings for wheel flanges at path crossings of freight rail track shall be 3 inches maximum. Openings for wheel flanges at path crossings of non-freight rail track shall be 2.5 inches maximum.

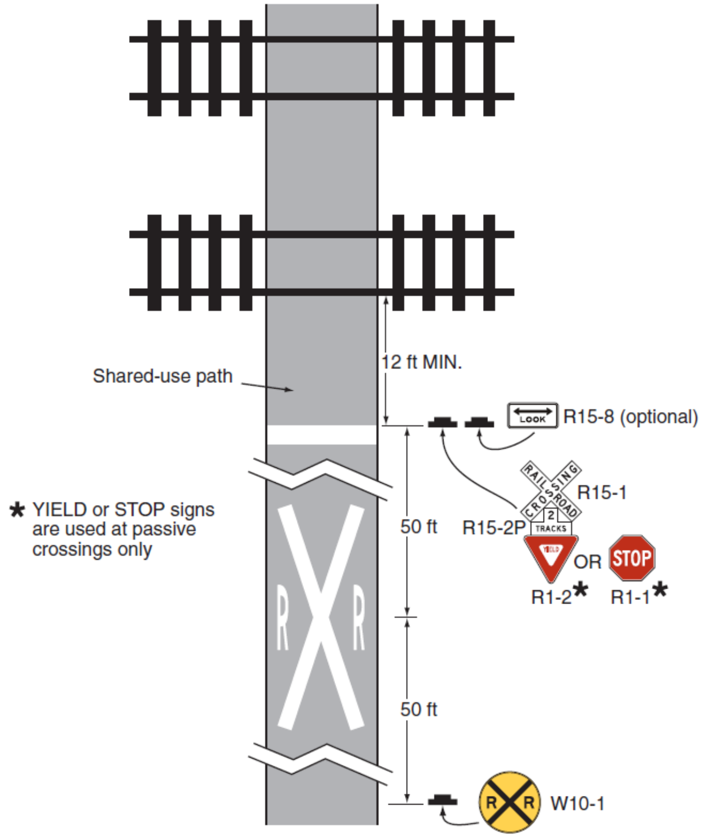


Figure 14-44 Example Signage and Markings at a Shared Use Path Crossing of a Rail Road (49)

Coordinate early and often with the Railroads to determine the appropriate design elements.

14.2.10.5 Utilities

Just as discussed in Section 14.1.2.10.1 drainage structures and utility lids should not be placed in shared use paths. Where it is unavoidable, drainage grates shall be of a bike friendly design and utility covers shall be flush with the surface of the path.

Utilities that project from the ground, such as backflow preventers or valves, shall be treated as vertical obstructions and addressed as discussed in Section 14.2.6 (Clearances).

14.2.10.6 Traffic Calming on Shared Use Paths

In some situations, such as in areas with frequent crossing conflicts with motor vehicles, it may be desirable to limit the speed traveled by the path user (see section 14.2.2 Design Speed). Signage is not an effective method for reducing speeds for two reasons: (1) because bicyclists, like motorists, ride at a speed they feel comfortable with on a facility, and (2) because most bicyclists do not have speedometers installed on their bicycle. Consequently, the use of design features is recommended to reduce speeds on shared use paths.

Vertical traffic calming treatments (speed humps, tables or pillows) are not recommended on shared use paths as they can adversely impact the handling of wheeled operators.

Horizontal alignment is the recommended method of reducing speeds on shared use paths. A series of low design speed curves or a chicane along a path, much like those described in Section 14.2.9.4 (Reducing Speeds on the Approach to Intersections), can also be used to reduce speeds at non intersection areas. Advance striping and signage should supplement the trail calming features, either appropriate CURVE WARNING signs or a general text sign indicating that the section of trail is a reduced speed zone.

14.2.11 Wayfinding on Shared Use Paths

The bicycle wayfinding signs described in 14.1.2.1 Bike Routes may be used on shared use paths.

Additional wayfinding signage on shared use paths is often appropriate. On independent alignment paths, information such as the distance between trail heads, or to the next water fountain or restroom facilities are important to path users. Much as Motorists Service signs provide expressway users information on what amenities are available at interchanges, signs may be appropriate to inform path users of the proximity of dining establishments, bike shops, or other destinations of particular interest to path users.

14.2.12 Shared Use Paths Adjacent to the Roadway (Sidepaths)

The term *sidepath* refers to a shared use path located immediately adjacent and parallel to a roadway.

Ideally, shared use paths will be constructed in their own rights-of-way. However, in some cases a shared use path may be designed adjacent to a roadway. Such cases might include

- where the public desires a low stress facility to ride on adjacent to a busy or high-speed roadway,
- as a temporary facility where a roadway cannot be modified to include bike facilities, and
- as a connecting facility along a longer shared use path.

It is likely the last condition will be the one that most designers are requested to address. As discussed below in Section 14.2.13 the perception of a sidepath as a low stress facility does not necessarily equate to it being a safer facility. For reasons of safety or convenience, a sidepath may not be used by more traffic savvy bicyclists. A sidepath should not be considered a permanent alternative to an in-street facility; rather it should be considered either temporary, or a supplemental facility to serve a specific class of user.

All design criteria associated with shared use paths apply to sidepaths.

14.2.13 Safety Considerations of Sidepaths

According to the AASHTO Bike Guide

1. *When two-way shared use paths are located immediately adjacent to a roadway, some operational problems are likely to occur… Some problems with paths located immediately adjacent to roadways are as follows:*
2. *Unless separated, they require one direction of bicycle traffic to ride against motor vehicle traffic, contrary to normal rules of the road.*
3. *When the path ends, bicyclists going against traffic will tend to continue to travel on the wrong side of the street. Likewise, bicyclists approaching a shared use path often travel on the wrong side of the street in getting to the path. Wrong-way travel by bicyclists is a major cause of bicycle/automobile crashes and should be discouraged at every opportunity.*
4. *At intersections, motorists entering or crossing the roadway often will not notice bicyclists approaching from their right, as they are not expecting contra-flow vehicles. Motorists turning to exit the roadway may likewise fail to notice the bicyclist. Even bicyclists coming from the left often go unnoticed, especially when sight distances are limited.*
5. *Signs posted for roadway users are backwards for contra-flow bike traffic; therefore these cyclists are unable to read the information without stopping and turning around.*
6. *When the available right-of-way is too narrow to accommodate all highway and shared use path features, it may be prudent to consider a reduction of the existing or proposed widths of the various highway (and bikeway) cross-sectional elements (i.e., lane and shoulder widths, etc.). However, any reduction to less than AASHTO Green Book 1 (or other applicable) design criteria must be supported by a documented engineering analysis.*
7. *Many bicyclists will use the roadway instead of the shared use path because they have found the roadway to be more convenient, better maintained, or safer. Bicyclists using the roadway may be harassed by some motorists who feel that in all cases bicyclists should be on the adjacent path.*
8. *Although the shared use path should be given the same priority through intersections as the parallel highway, motorists falsely expect bicyclists to stop or yield at all cross-streets and driveways. Efforts to require or encourage bicyclists to yield or stop at each cross-street and driveway are inappropriate and frequently ignored by bicyclists.*
9. *Stopped cross-street motor vehicle traffic or vehicles exiting side streets or driveways may block the path crossing.*
10. *Because of the proximity of motor vehicle traffic to opposing bicycle traffic, barriers are often necessary to keep motor vehicles out of shared use paths and bicyclists out of traffic lanes. These barriers can represent an obstruction to bicyclists and motorists.*

Additional potential operational and design problems associated with sidepaths include the following:

- Because utilities are often located in the right of way, it can be difficult to meet clearance and radii requirements within the available space.
- In addition to travelling in a direction not expected by motorists exiting driveways or side streets, bicyclists riding on sidepaths are also traveling at speeds significantly greater than

those of pedestrians. This makes them less likely to be seen by motorists exiting the side street who may be looking immediately to their right for pedestrians.

- If a sidepath is created in a location where there would otherwise be a sidewalk (i.e., a residential neighborhood or an urban commercial district), higher volumes of pedestrians are likely and thus conflicts with pedestrians are likely to increase. While this concern could be mitigated by widening the path, this may increase bicyclists' speeds in off peak periods, exacerbating the problem of higher speed cyclists approaching conflict points.
- Most roadways have destinations on both sides of the roadway. Since a sidepath serves only one side of the road, this requires sidepath user to cross the roadway midblock to access their destinations or to cross at intersections and ride on a sidewalk (if available) on the opposite side of the road. The former, while not difficult on low volume, low speed streets can be difficult on higher volume, higher speed roadways where sidepaths are likely to be built. The latter may not be legal in some locations.
- The proximity of sidepaths to the roadway may result in cyclists riding at night being subject to glare from approaching car headlamps. This can make it difficult for the bicyclist to see hazards on the trail surface.

Those potential operational problems associated with the visibility of the path user by motorists are most likely to be more significant on higher speed, higher volume, multi-lane roadways where motorists are focused on the motor vehicle traffic in the travel lanes **(20)**.

14.2.13.1 Potential Mitigation Measures to the Operational Challenges of Sidepaths

Despite the safety, operational, and design challenges with sidepath design, there are times when they are unavoidable. They are often the preferred facility of the public. It may not be possible to improve the roadway to provide an adopted target level of bicycle accommodation. Alternatively, they may be the only way to complete a bicycle network or close a gap in an otherwise continuous facility. Consequently, when sidepaths are designed, their design must include measures to help minimize the operational challenges described in Section 14.2.13. Some of these measures are described below. These geometric measures are the ones most likely to improve the operations and safety at sidepath conflict points.

- Divert the shared use path away from the adjacent roadway at conflict points. Ideally, the path should be moved far enough away to function as a midblock crossing and be provided with the associated traffic control. At a minimum enough space should be provided for one vehicle (25 feet) to queue between the roadway ant the parallel path.
- Reduce the speeds of shared use path users on the sidepath. This can be done through horizontal alignment as described in Section 14.2.9.4.
- Reduce motor vehicle speeds at conflicts points. This can be accomplished by designing for the smallest design vehicle likely to commonly turn at the drive or intersection ***(1)*** and using the minimum radii provided for in Chapter 9 of this *Roadway Design Guide.*
- If feasible, reduce the operating speeds on the adjacent roadway.

- Where possible, eliminate conflicts with motor vehicles. Access management techniques such as reducing the number of driveways or installing raised medians reduces the potential conflict locations.
- Keep sight lines clear to ensure that motorists approaching the conflict can clearly see the path users and so that path users can see approaching motorists. This requires limiting parking and landscaping around the conflict points. Sight distances are to be calculated for stopping sight distance.
- Where conflicts cannot be separated from the parallel roadway by at least a car length, the crossing should be designed to be close to the adjacent road.
- At signalized intersections, consider installing blank-out signs, to be activated by path users (i.e., push buttons or loops) to alert motorists of their presence. NO RIGHT ON RED blank-out signs would be appropriate for the near side street approach. YIELD TO PEDS IN CROSSWALK would be appropriate for the adjacent right-turn, through-right, and opposing left-turn movements.

Individually, the above measures may not be sufficient to ensure the safety of sidepath users. It is likely a combination of treatments will be required **(20)**.

An additional measure that should be taken is to provide signage to warn motorists of the adjacent path (see Figure 14-45).

Unless they are moved to a midblock location, intersections of sidepaths with side streets and driveways are to be given the same priority as the parallel roadway. Installing STOP or YIELD signs at these locations is not an effective method of slowing or stopping path users at side streets and driveways. If path users perceive the signs as overly restrictive, they will not comply with them. Furthermore, motorists may yield to path users and wave them through in conflict with the sign priority at the intersection. The overuse of these signs may decrease their effectiveness at locations where compliance with STOP or YIELD signs is critical to the path users' safety.

Figure 14-45 Example ADJACENT PATH Sign

14.2.14 Sidepath Clearance to the Adjacent Roadway

The minimum midblock separation between a roadway and sidepath is 5 feet from the back of curb or from the edge of pavement if no curb is present.

If 5 feet of separation cannot be provided, a suitable barrier should be provided. If place, the barrier should be consistent with the requirements of Section 14.2.6. The location of the barrier shall not impair sight distance at intersections.

On low speed roadways (45 mph or less), it is not necessary for the barrier to be designed to redirect errant motorists toward the roadway unless other conditions require a crashworthy barrier. If the railing cannot be designed so as to not be a hazard to motorists, it shall be protected by a guardrail or barrier wall.

It is not acceptable to mount a railing on top of a guardrail unless it has been appropriately crash tested.

On higher speed roadways, barriers between roadway and sidepaths shall be crashworthy.

At some locations where the pathway is located more than 5 feet from a roadway, a guardrail may be placed between the roadway and the sidepath to protect motorists from an object in the clear zone. When a guardrail is located within 3 feet of the shared use path the back of the guardrail should be considered a vertical obstruction next to the path.

Snow storage should be considered when designing sidepaths. A separation distance of 18 feet is desirable to accommodate snow storage. Where space is limited, overall road cross-section design must consider the likely amount of removed snow, the space needed to store it, and how snow will be managed. When snow is stored in the separation area between the road and shared-use path, at least three-fourths of the path should remain usable. The placement of barrier between the roadway and the shared use path must consider the needs of snow removal and drainage.

14.2.15 Equestrian Facilities

Equestrian facilities may be included on some shared use path projects. Shared bicycle, pedestrian and equestrian use is relatively common across the country. However, care must be taken when designing these facilities to minimize the potential conflicts between equestrians and other users as horses can startle, compromising safety for their riders and other users. Where possible, separate trails or bridle paths, should be provided for equestrian use.

For a complete discussion of equestrian planning and design, the designer should refer to the USDA document *Equestrian Design Guidebook for Trails, Trailheads, and Campgrounds* ***(38)***. The criteria contained within this section assumes an equestrian path in the same right-of-way as an adjacent shared use path.

The word *trail* in this section refers to an unpaved facility. *Tread* refers to the width intended to be used by equestrians exclusive of the shoulder or clear area adjacent to this space.

14.2.15.1 Geometric Design of Equestrian Facilities

Ideally separate paths should be provided for equestrian users. As the frequency of path users increases, so does the demand for a separate equestrian trail. The equestrian tread should be separated from the shared use path by at least a 6 -foot wide buffer.

The recommended minimum tread widths for equestrian trails are provided in Table 14-7.

Number of Tracks	Low Development Area	Moderate Development Area	High Development Area
Single-track Tread	1.5 to 2 feet	3 to 4 feet	6 to 8 feet
Double-track Tread	Usually is a converted vehicle trail	5 to 6 feet	8 to 12 feet

Table 14-7 Suggested tread width on shared use horse trails

The tread surface should provide relatively good traction and be conducive to safe cantering. Fine aggregate or dry woodchips provide acceptable surfaces for trails. The depth of surface material must be adequate to ensure a stable surface given the base surface and drainage requirements. Tread obstacles, such as tree roots, waterbars, holes, and protruding objects present tripping hazards and should be removed.

The minimum recommended turn radii are presented in Table 14-8.

Low Development Area	Moderate Development Area	High Development Area
5 to 6 feet	6 to 8 feet	8 to 10 feet

Table 14-8 Suggested minimum turn radii for horse trails

The maximum recommended cross slopes (also known as outslopes) for equestrian trails are presented in Table 14-9.

Low Development Area	Moderate Development Area	High Development Area
5% to 10%	5%	2% to 5%

Table 14-9 Suggested maximum cross slope for horse trails

Three-foot graded shoulder should be maintained on both sides of the equestrian trail.

The recommended overhead clearance for an equestrian trail is 12 feet. The minimum overhead clearance for an equestrian trail is 10 feet.

A sight distance of 100 feet should be maintained along equestrian trails. The equestrian's eye height is assumed to be eight feet.

14.2.15.2 Signage of Equestrian Facilities

While compliance with the *MUTCD* is not required on equestrian facilities, appropriate highway signs may be used on equestrian trails.

Where conflicts are likely to occur between equestrians and other path users TRAIL COURTESY sign (not a standard *MUTCD* sign) should be installed (Figure 14-46).

Figure 14-46 TRAIL COURTESY sign

14.2.16 Other Considerations on Bicycle Facilities

14.2.16.1 Retrofit Projects

The dimensions provided within this chapter should be applied on all projects, including Resurfacing, Restoration, Rehabilitation (3R) projects.

For existing sections without bicycle facilities where no widening is planned, consideration shall be given to reducing lane widths to provide bicycle lanes or paved shoulders. Bike lanes shall meet the criteria on Section 14.1.2.5. Paved shoulders should meet the criteria on Section 14.1.2.4. Existing through lane widths on urban multi-lane roadways and two-lane curb and gutter roadways shall not be reduced to less than 11 feet for design speeds ≥ 50 mph, and to no less than 10 feet for design speeds ≤ 45 mph. Coordinate with the CDOT Transit and Rail Division and local transit agency when considering the reduction of lane widths on roadways where public transit routes are present. Any recommendation to reduce lane widths should be accompanied by a safety assessment.

14.2.16.2 Shared Use Path Lighting

Where shared use paths are used at night, lighting should be provided at shared use path intersections with roadways. If implemented, this lighting should be consistent with requirements for roadway intersections contained in Section 5.0 of the *CDOT Lighting Design Guide,* or as necessary, the AASHTO *Roadway Lighting Design Guide.* The *CDOT Lighting Design Guide* is based upon the AASHTO *Guide* and the IESNA *(Illuminating Engineering Society of North America)* recommended practices.

Even where paths are not open at night it may be advisable to light roadway crossings.

In-street bicycle lanes shall be lit to the same level as the adjacent roadway.

14.2.16.3 Maintenance of Traffic

Neither portable nor permanent sign supports should be located on bicycle facilities, or areas designated for bicycle traffic. If the bottom of a secondary sign that is mounted below another sign is mounted lower than 7 feet above a pathway, the secondary sign should not project more than 4 inches into the pathway facility ***(47).***

Bicyclists should not be exposed to unprotected excavations, open utility access, overhanging equipment, or other such conditions. Except for short duration and mobile operations, when a highway shoulder is occupied, a SHOULDER WORK sign (W21-5) should be placed in advance of the activity area. When work is performed on a paved shoulder 8 feet or more in width, channelizing devices should be placed on a taper having a length that conforms to the *MUTCD* requirements of a shoulder taper.

If a designated bicycle route is closed because of the work being done, a signed alternate route should be provided. The *MUTCD* includes approved detour signs for bicycle facilities (Figure 14-47) Bicyclists should not be directed onto a sidewalk or exclusive pedestrian path.

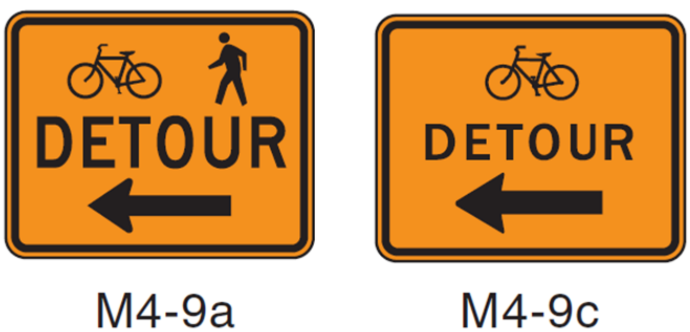


Figure 14-47 Bicycle Facility DETOUR Signs

To maintain the systematic use of the fluorescent yellow-green background for pedestrian, bicycle, and school warning signs in a jurisdiction, the fluorescent yellow-green background for pedestrian, bicycle, and school warning signs may be used in Temporary Traffic Control zones.

14.2.16.4 Integration of Bicycles with Transit

Integration of bicycling with transit can increase the utility and extend the range of both modes. Bicyclists sometimes cite trip length, steep grades, and weather as reasons they do not use bicycling as a mode of transportation. By integrating bicycling and transit services, these barriers (real or perceived) can be overcome.

Bicycle racks on, or bicycle space within, transit vehicles can help integrate bicycling and transit. Providing short and long term bicycle parking **(40)** is a key aspect in making this integration.

Where a change in level occurs at a transit station, some modifications may be considered to make the station accessible to bicyclists. Retrofitting a bicycle channel onto an existing staircase is one technique to improve bicycle access (Figure 14-48).

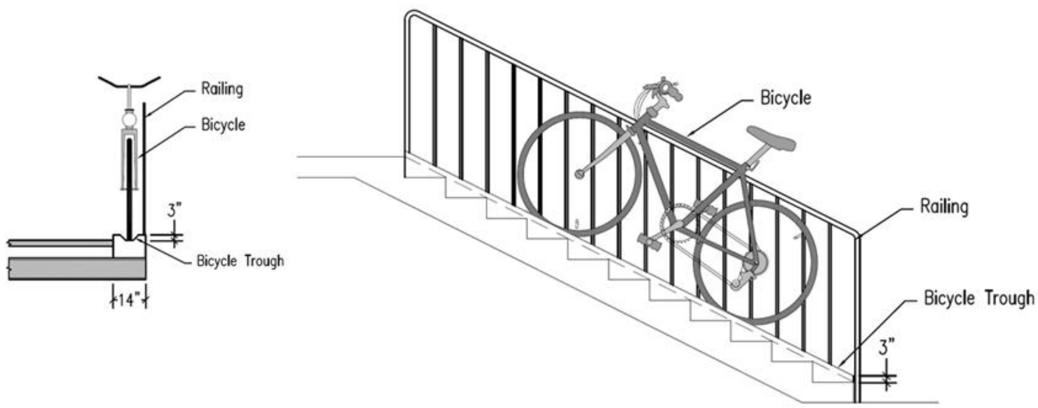


Figure 14-48 Bicycle Channel (41)

Another potential integration of bicycles and transit is use of shared facilities. These are discussed in the following sub-sections.

14.2.16.4.1 Shared Bicycle Facilities with Bus Transit

Shared bicycle facilities with transit can take multiple forms.

Ideally, a bus facility - exclusive busway or bus only lanes - would be constructed with separate bicycle facilities. On an exclusive busway this would entail the provision of a shared use path adjacent the busway (Section 14.2 SHARED USE PATHS). Bicycle lanes could be installed adjacent to and to the left of a dedicated bus lane (assuming a right side bus lane).

Alternative facilities include shared bike-bus lanes. A bike-bus lane can be created by using signage to allow bicycles to use a designated bus lane.

Another option is to design a shared bus-buffered bike lane (Figure 14-49). This facility provides added separation of bicycles from adjacent motor vehicle traffic.

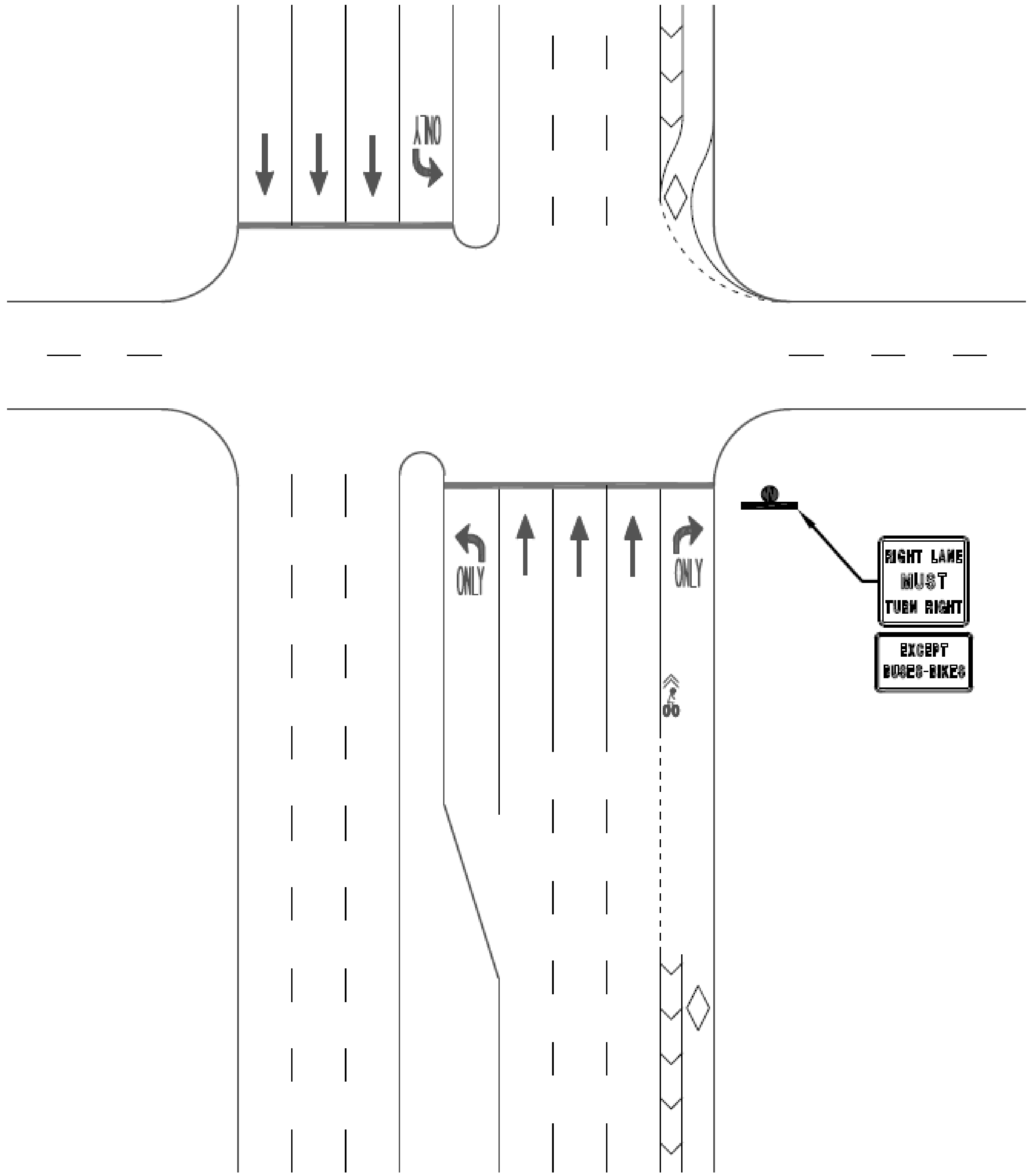


Figure 14-49 Shared Bus-Buffered Bike Lane

14.2.16.4.2 Shared Bicycle Facilities with Light Rail

Shared use paths adjacent to rail lines have been implemented around the country.

If shared use paths are constructed adjacent to light rail, special consideration must be given to pedestrian crossings near rail stops. Treatments to slow bicyclists should be installed in advance of these crossings.

Shared use paths adjacent to light rail should be located at least 5-feet clear of the dynamic envelope of the Light Rail Transit vehicle. This will result in the shared use path being at least 11-feet clear of the rail line.

Barriers, as described in Section 14.2.6 (Clearances) should be provided between the light rail facility and the path where practical.

14.2.16.5 Innovative Signage and Markings

There are currently numerous design treatments and traffic control devices being used or tested to determine their effectiveness in promoting bicycling and improving bicycle safety. Several of these are discussed in this section.

The decision to use any of these treatments should be based upon discussions with local jurisdictions to ensure consistent application. Additionally, a justification for using the treatment shall be included in the project file including any research supporting the use of the treatment. Use of non-standard treatments will require approval of the Resident Engineer. The headquarters Bicycle and Pedestrian Coordinator shall be consulted on the use of these treatments.

14.2.16.5.1 Colored Bike Lanes

Colored bike lanes are generally proposed to increase motorist's awareness of bicyclists at intersections. Evaluation results have been mixed. The most extensive study, performed in Portland, Oregon, found that motorists were more likely to yield to bicyclists in bike lanes that had been painted blue through conflict areas. However, the researchers noted the colored bike lane installations resulted in fewer bicyclists scanning over their shoulders to look for potentially conflicting motorists. Until additional research is documented that is conclusive on the safety of colored conflict areas, this treatment should be avoided.

Additional research is being conducted in other communities. Blue has been removed from consideration for most communities testing colored bike lanes as blue is reserved for disable parking markings. Green is the color most commonly being tested.

This treatment has obtained an Interim Approval from the FHWA for application. The interim approval assumes that the green coloring will supplement bike lane striping and marking either at conflict areas or continuously along a bike lane. Specifications for the color have been developed by FHWA.

14.2.16.5.2 Bike Boxes

A bike box is a colored area (green) at a signalized intersection that allows bicyclists to pull in front of waiting traffic. Designed to be used only at red lights, the box is intended to reduce car-bike conflicts, increase cyclist visibility and provide bicyclists with a head start when the light turns green.

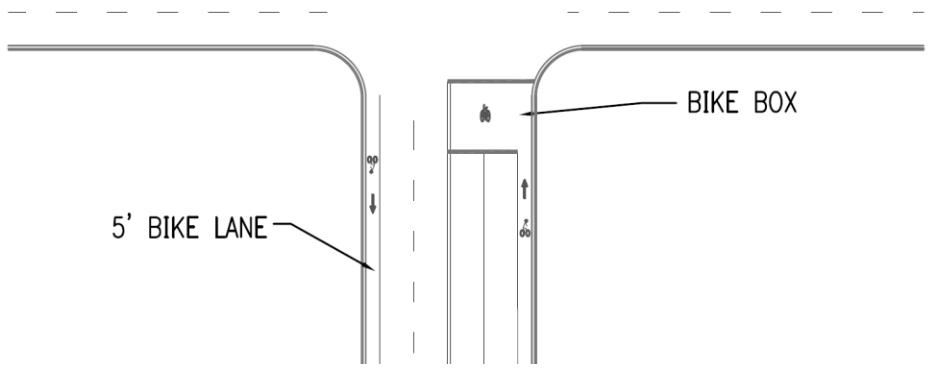


Figure 14-50 Example Striping and Marking for a Bike Box

One concern about the use of bike boxes is how conflicts are addressed when the bicyclist arrives at the intersection just as the traffic signal is turning green for motorists. The motorists are not likely to be expecting a cyclist to move left from the bike lane at the moment the light turns green. In Europe, where this treatment originates, motorists are given a yellow signal prior to the traffic signal turning green; this would serve as a warning to the approaching bicyclist. Often exclusive bicycle signals are provided for bicyclists using the bike box treatments.

Another operational consideration is that if right turning motorists approach the intersection from as close to the right hand edge of the roadway as is practicable, as is required by law, they will be blocking the bike lane and thus the bicyclists' access to the bike box. (It is noteworthy that a bike lane in Oregon, where this treatment is most often cited as having been implemented, the bike lane is defined as being adjacent to the roadway, thus eliminating this requirement for right turning motorists to move into the bike lane prior to turning right at an intersection).

A request to experiment must be submitted to FHWA prior to implementing this treatment.

A variation of the bike box is a space provided in front of a Stop line to assist bicyclists making a left turn via two through movements. An example of this treatment is shown in Figure 14-20 continuous flow intersections.

14.2.16.5.3 Bicycle Signals

The *MUTCD* allows for the use of standard signal heads to control exclusive bicycle traffic movements. The use of bike specific signal heads requires the use of directional signal heads, so that bicyclists and motorists are not confused as to which signal is meant for whom.

Bicycle signals are being proposed that would allow the use of a BIKE SIGNAL sign or a signal display in the shape of a bicycle. These signals could be used to provide a leading bicycle interval at a traffic signal, an exclusive left turn phase for bicycles on sidepaths, or as a signal for shared use paths.

A request to experiment must be submitted to FHWA prior to implementing this treatment.

14.2.16.6 Maintenance of Bicycle Facilities

Maintenance of pavement surfaces is critical to safe and comfortable bicycling. While regular maintenance activities will be required, some design treatments will help minimize maintenance needs:

- Place public utilities such as manhole covers and drainage grates outside of bikeways.
- Ensure that drainage grates, if located on or near a bikeway, have narrow openings and that the grate openings are placed perpendicular to the riding surface.
- Design of appropriate cross slopes should help to keep the riding surface clear of debris and water.

14.2.16.6.1 Vegetation Maintenance

Vegetation encroaching into bikeways is both a nuisance and a problem. Many vegetative maintenance problems can be mitigated during the design and construction of the facility. The following are examples of vegetation control methods that may be done before or during construction.

- Place a tightly woven geotextile or landscape fabric under the asphalt pavement. This method may be chosen in sensitive areas where a nonselective herbicide is undesirable. Several brands of geotextiles are available. Many provide additional structural support for the asphalt paving as well, and may allow reduced pavement thickness.
- Control undesirable “volunteer” vegetation and noxious weeds during construction.
- Use root barriers where they are beneficial to prevent root intrusion to the path surface. Suckering plants are the ones most likely to come through the path surface.
- Place a non-selective herbicide under asphalt paving. All applications must be done according to label directions. This herbicide will prevent vegetative growth from penetrating the asphalt paving for a number of years. Caution is needed in applying non-selective herbicides. They may injure nearby trees if their root systems grow into the treated area.

14.2.16.6.2 Snow and Ice Control

In designing roadways, roads should be designed to allow for snow storage. The roadside should have adequate space to place plowed snow so that it does not block a shared use path that may be adjacent to the roadway. Separation between road and path allows for snow storage.

14.3 PEDESTRIAN FACILITIES

Pedestrians and their interactions with vehicular traffic are major considerations for highway planning and design ***(1)***. While more rare in rural areas, pedestrians are part of every roadway environment and they should be considered in all roadway designs. According to the *Policy on the Geometric Design of Streets and Highways (PGDSH):*

> *Because of the demands of vehicular traffic in congested urban areas, it is often very difficult to make adequate provisions for pedestrians. Yet provisions should be made,*

because pedestrians are the lifeblood of our urban areas, especially the downtown and other retail areas.

Consequently, all design projects on CDOT facilities, except for those for roadways where pedestrians are prohibited, shall include accommodations for pedestrians.

14.3.1 General Pedestrian Considerations

Pedestrian accommodations can take any of a number of forms. On CDOT projects in urban areas pedestrian accommodations will most often be represented by sidewalks. Separated shared used paths, as discussed in Section 14.2 (Shared Use Paths**),** are another class of facility which may be provided for pedestrians. In more rural areas, where pedestrian traffic is expected to be light, paved shoulders may accommodate pedestrians.

The degree of pedestrian accommodation provided will be influenced by the land use patterns surrounding the project, or by the planned land use patterns.

14.3.1.1 Accommodating Pedestrians in the Right-of-Way

The level of accommodation for pedestrians can be measured by a number of methods ranging from subjective to objective.

Often, as part of downtown redevelopment projects or Safe Route to School projects, a walking audit which includes subjective and objective analyses will have been performed. A walking audit documents recommended improvements to the roadway and pedestrian facilities to improve pedestrian accommodation. Any such local plans should be reviewed and the recommendations addressed in the design plans to the maximum extent feasible.

The 2010 *Highway Capacity Manual (HCM)* **(6)** establishes an objective method for determining the level of pedestrian accommodation based upon the geometric and operational characteristics of the roadway being analyzed. This method is based upon numerous research projects which quantified what factors influence how pedestrians perceive a roadway and sidewalk safety and comfort. This method is often used by agencies to set minimum target levels of accommodation for pedestrian facilities. The model for links (roadway segments between intersections) includes the following factors:

- presence and width of a sidewalk,
- width of the outside lane,
- presence and width of a paved shoulder or bike lane,
- presence and width of a parking lane,
- percent of parking occupied by parked cars,
- presence of trees or a barrier between the sidewalk and the roadway,
- operating speeds on the roadway, and
- traffic volume on the roadway.

The primary geometric conditions that are influenced by design are the presence of a sidewalk, width, and the separation of the sidewalk from the outside lane. This *HCM* methodology is a useful tool for designing cross sectional geometry to meet a target level of pedestrian accommodation.

The *Highway Capacity Manual* also provides a method for determining the Level of Service based upon sidewalk congestion. This methodology should also be employed also to ensure adequate sidewalk width where high volumes of pedestrians are expected.

As stated above in 14.3.1 General Pedestrian Considerations, on new CDOT construction projects, it is likely that sidewalks will be the facility of choice for accommodating pedestrians. However, in some cases, particularly in rural areas where traffic volumes are low and pedestrian traffic is expected to be only occasional, a paved shoulder, though not an actual pedestrian facility, may be the only accommodation needed for pedestrians.

When sidewalks are included in projects, they should be continued to logical termini. For example, if a roadway project ends just prior to an intersection, pedestrian improvements should continue to the intersection.

14.3.1.2 Operating Characteristics of Pedestrians

There is no single type of design pedestrian. Pedestrians come in all sizes, and with varying degrees of physical and cognitive abilities. It is important to recognize the diversity and wide spectrum of pedestrians' abilities during facilities design.

Typical pedestrian walking speeds range from approximately 2.5 feet per second to 6.0 feet per second. The *MUTCD* states that a speed of 3.5 feet per second should be used for calculating pedestrian clearance intervals at pedestrian signals **(44)**. Such seasonal factors as ice and snow can reduce travel speeds below normal.

The space taken up by a single stationary person can be approximated by an ellipse 1.5 feet x 2 feet, with a total area of 3square feet. In evaluating a pedestrian facility, the HCM assumes an area of 8 square feet including a buffer zone for each pedestrian **(45)**. Two pedestrians walking side by side require at least 4.7 feet of width. Two people in wheelchairs passing each other will need at least 5 feet of width, and if each has an assistive animal, 8 feet of width will be required.

According to the AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities **(3)**,

> *In 1994, an estimated 7.4 million persons in the United States used assistive technology devices for mobility impairments, 4.6 million for orthopedic impairments, 4.5 million for hearing impairments, and 0.5 million for vision impairments. These numbers are expected to increase because there is a positive correlation between an increase in age and an increase in the prevalence rate of device usage. For example, persons who are 65 years and over use mobility, hearing, and vision assistive devices at a rate four times greater than the total population* ***(46)****.*

These pedestrians must be considered in the design of pedestrian facilities.

14.3.1.3 Americans with Disabilities Act Requirements

The Americans with Disabilities Act (ADA) mandates the accommodation of persons with disabilities in pedestrian facility design through the provision of *pedestrian access routes*.

A *pedestrian access route* is a continuous and unobstructed walkway within a pedestrian circulation path that provides accessibility.

The standards for accessible routes are set by the U.S. Access Board in the *Americans with Disabilities Act Architectural Guidelines for Buildings and Facilities* (*ADAAG*) **(47)**. The ADA standards for public rights-of-way, the *Public Rights-of-Way Accessibility Guidelines* (*PROWAG*) are currently in draft form **(48)**. The criteria contained within this *Roadway Design Guide* will comply with the draft *PROWAG;* notations will be made when these vary from the *ADAAG* ***(47).***

All newly designed and newly constructed pedestrian facilities located in the public right-of-way shall comply with these requirements. All altered portions of existing transportation facilities located in the public right-of-way shall comply with these requirements to the maximum extent feasible.

If it is technically infeasible to comply with the requirements of the ADA, documentation shall be made to the file to fully justify any non-compliant features of a design. It is not anticipated that right-of-way will be purchased for the sole purpose of complying with the ADA.

14.3.1.4 Curb Ramps and Blended Transitions

Curb ramps shall be installed where a pedestrian access route crosses a raised curb that vertically separates pedestrians from vehicles. Where sidewalks are not separated from the roadway with curb, such as on roadways with open shoulders, the at grade connection between the sidewalk and roadway is referred to as a blended transition.

Curb ramps shall have a maximum longitudinal slope of 8.33 percent, except that the maximum required length of a curb ramp is 15 feet.

The maximum cross slope of a curb ramp is 2 percent.

A landing a minimum of 4.0 feet by 4.0 feet shall be provided at the top of the ramp run and shall be permitted to overlap other landings and clear floor or ground space. Running slope and cross slopes of landings at intersections shall be 2 percent maximum. Running and cross slope at midblock crossings shall be permitted to meet street or highway grade.

Flared sides with a slope of 10 percent maximum, measured parallel to the curb line, shall be provided where a pedestrian circulation path crosses the curb ramp. Where a curb ramp does not occupy the entire width of a sidewalk, drop-offs at diverging segments shall be protected.

The clear width of landings, blended transitions, and curb ramps, excluding flares, shall be a minimum of 4.0 feet.

Detectable warning surfaces complying with the ADAAG shall be provided where a curb ramp, landing, or blended transition connects to a street ***(47).***

Grade breaks at the top and bottom of curb ramps shall be perpendicular to the direction of the ramp run. At least one end of the bottom grade break shall be at the back of curb. Surface slopes that meet at grade breaks shall be flush.

The counter slope of the gutter or street at the foot of a curb ramp, landing, or blended transition shall be 5 percent maximum.

On a diagonal ramp, where the pedestrian is required to change direction upon entering the crosswalk, a clear space of at least 4.0 feet by 4.0 feet minimum beyond the crosswalk shall be provided within the width of the crosswalk and wholly outside the parallel vehicle travel lane.

14.3.1.5 Vertical Changes in Grade

The maximum instantaneous elevation change on a pedestrian access route without a treatment is one-quarter inch. Changes in level from one quarter to one half inch shall be beveled at a slope of no greater than 2:1. Changes in elevation greater than one half inch shall be designed with a maximum slope of 5 percent.

14.3.2 Sidewalks

Sidewalks shall be provided on all projects on CDOT facilities on which the design year land use is urban. Where feasible, sidewalks should be provided on both sides of CDOT roadways on these projects.

Sidewalk surfaces shall be firm, stable, and slip resistantConcrete sidewalks shall have a broom finish to increase skid resistance.

The pedestrian access route along a sidewalk should be designed to maximize straight through movements by pedestrians without the need to divert around utilities, street furniture, or driveways.

Adopted pedestrian plans shall be consulted to determine if a project roadway has been identified for the inclusion of pedestrian facilities. CDOT projects should implement relevant pedestrian plan facility recommendations to the maximum extent possible.

Sidewalks should also be provided on those projects where other factors indicate a need.

14.3.2.1 Separation from Roadway

The separation of a sidewalk from a roadway is an important factor in the perceived safety and comfort of a pedestrian facility ***(6)***. The greater the separation from the roadway the more pleasant the facility and consequently the more likely it is to be used by pedestrians.

Separation from the roadway, provides benefits beyond the perceived safety and comfort of the pedestrian. Safety is improved by increasing separation from the roadway, particularly on roadways without curb and gutter. A buffer area provides a place to construct curb ramps and driveways outside of the sidewalk area, making it easier to comply with ADA. Buffer areas can also be used for snow storage. Utility poles, parking meters, and signs can be placed in a sufficiently wide buffer, thus ensuring the complete sidewalk width is available for pedestrians.

14.3.2.1.1 Separation from Roadway with Curb and Gutter

If a project roadway is included in an adopted pedestrian plan, the provided separation should comply with target values presented in the plan. Target values may be in the form of adopted minimum separations distances (or buffer, See Figure 14-51) or in target Level of Service values. For minimum level of service values, the separation will need to be calculated based upon roadway and traffic characteristics.

The minimum setback of a sidewalk from the back of curb to accommodate the construction of a perpendicular curb ramp outside of the sidewalk is 7.9 feet. Where possible this separation should be provided between the back of curb and sidewalk on curb and gutter projects.

The minimum width of setback to a sidewalk on an arterial roadway with curb and gutter is 6 feet. Under constrained conditions, this may be reduced to 5 feet. The minimum width of setback to a sidewalk on a local or collector roadway with curb and gutter is 4 feet. Under constrained conditions, this may be reduced to 2 feet.

Minimum separation to the sidewalk may be dictated by requirements for snow storage. Regional snow storage requirements should be considered when determining the minimum setback.

Where local jurisdictions are required to maintain the buffer and sidewalk area, maintenance agreements should be obtained during pre-construction.

14.3.2.1.2 Separation from Roadway without Curb and Gutter

If a project roadway is included in an adopted pedestrian plan, the provided separation should comply with target values presented in the plan.

Sidewalks on roadways without curb and gutter should be placed as far from the roadway as practical in the following sequence of desirability **(50)**:

1. As near the right of way line as possible.
2. Outside of the clear zone.
3. Five feet from the shoulder point
4. As far from edge of traffic lane as practical.

14.3.2.2 Sidewalk Width

The minimum width for sidewalks on CDOT projects is 5 feet exclusive of the width of the curb.

Under constrained conditions the minimum width may be reduced to 4 feet exclusive of the width of the curb. This is the minimum pedestrian access route width allowed by the draft *PROWAG* ***(48)*****.** The *ADAAG* allows for a minimum accessible route of 3 feet in width **(47)**. Where less than 5 feet continuous width is provided, passing spaces shall be provided at intervals of 200 feet maximum. Passing spaces shall be a minimum of 5 feet wide for a distance of 5 feet along the sidewalk.

14.3.2.3 Protruding Objects

Protruding objects, including pedestrian amenities such as street furniture, water fountains, and informational kiosks, shall not reduce the width of the sidewalk to less than 4 feet.

Objects with leading edges more than 27 inches and not more than 80 inches above the sidewalk shall not protrude more than 4 inches into the clear pedestrian path. See Figure 14-51. Objects protruding more than 4 inches into the pedestrian path at more than 27 inches above the sidewalk may not be detectable by cane. Maintaining at least 80 inches clear to overhangs provides clear space to walk under protrusions for most pedestrians.

Objects mounted on free-standing posts or pylons, 27 inches minimum and 80 inches maximum above the sidewalk, shall not overhang into the clear pedestrian path more than 4 inches beyond the post or pylon base measured 6 inches above the sidewalk. Where a sign or other obstruction is mounted between posts or pylons and the clear distance between the posts or pylons is greater than 12 inches, the lowest edge of such sign or obstruction shall not be more than 27 inches or less than 80 inches above the sidewalk.

Where the vertical clearance to an obstruction is less than 80 inches, guardrails or other barriers shall be provided. The leading edge of such guardrail or barrier shall be located not more than 27 inches above the sidewalk.

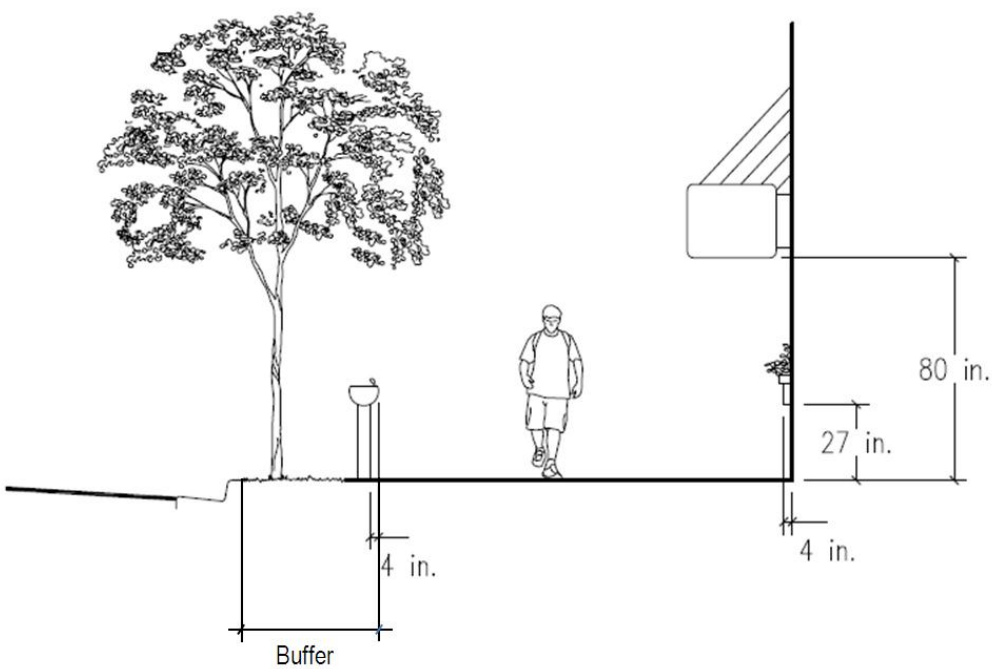


Figure 14-51 Protruding Objects

14.3.3 Grade and Cross Slopes

The grade of a sidewalk should not exceed the general grade established for the adjacent street or highway.

On structures, and constructed approaches thereto, with grades exceeding 5 percent, ramps with a maximum slope of 8.33 percent and a maximum rise of 30 inches between resting intervals shall be provided. Resting intervals shall be a minimum of 5 feet measured longitudinally along the sidewalk.

The maximum cross slope for a sidewalk is 2 percent. Care must be taken so that the cross slope and longitudinal grade provide for the drainage of rain and snowmelt from the sidewalk.

14.3.4 Driveways

Where a driveway crosses a sidewalk, path of the pedestrian across the driveway must comply with the width and cross slope requirements of Section 14.3.2.2 (Sidewalk Width) and Section 14.3.3 (Grade and Cross Slopes).

14.3.5 Sidewalk Lighting

Sidewalk alignments must be considered when designing the roadway lighting pattern. Sidewalks along roadways should be lit to the same level as the adjacent roadway. This is important as pedestrians coming from the side of the road to cross must be adequately lit for motorists to see them.

Roadway lighting designed to light just the travel lanes to design levels may not provide adequate illumination for sidewalks. In these cases, supplemental lighting should be provided.

This lighting shall be consistent with requirements for walkways contained in Section 5.11 of the *CDOT Lighting Design Guide,* or as necessary, the AASHTO *Roadway Lighting Design Guide.*

14.3.6 Transit Stops

Where possible, transit waiting areas should be located outside of the sidewalk. Transit pads shall be connected to the sidewalk.

Bus stop boarding and alighting areas shall provide a clear length of 8.0 feet minimum, measured perpendicular to the curb or roadway edge, and a clear width of 5.0 feet minimum, measured parallel to the roadway.

14.3.7 Pedestrian Crossings of Roadways

Careful design of roadway crossings is critical to pedestrians' mobility and safety. Pedestrian crossings should be designed so that they are convenient for users or pedestrians will choose to cross at other locations, outside the protection of a crosswalk.

ADA compliant curb ramps or blended transitions shall be installed wherever a pedestrian access route crosses a roadway.

14.3.8 Pedestrian Crossings at Intersections

Motorists approaching intersections are primarily concerned with conflicts with other motorists. Consequently, it is important to ensure pedestrians waiting at intersections and approaching motorists are clearly visible to each other.

In urban areas, the minimum curb radii allowed for the design vehicle as found in Chapter 9 of this *Roadway Design Guide* should be used. This will reduce vehicle speeds and pedestrian crossing distances. Curb extensions should be considered to reduce crossing distances at intersections of streets with on-street parking.

14.3.8.1 Pedestrian Crossings at Uncontrolled Approaches to Intersections

Designated pedestrian crossings of uncontrolled approaches to intersections should be designed as midblock crossings. Guidance on these crossings can be found in Section 14.3.9 (Pedestrian Crossings at Midblock Locations).

14.3.8.2 Pedestrian Crossings at Stop and Yield Control Intersections

In urbanized areas, marked crosswalks should be provided wherever a sidewalk crosses a street under stop or yield control. STOP or YIELD lines shall be placed a minimum of 4 feet in advance of the crosswalks.

On multilane roadways under yield control, YIELD lines should be placed 30 feet in advance of the near edge of the intersecting roadway. This advance placement is to improve the visibility of crossing pedestrians to motorists.

14.3.8.3 Pedestrian Crossings at Signal Control Intersections

If an intersection under signal control has sidewalks, then marked crosswalks should be provided. In urbanized areas pedestrian signals are recommended at all intersections where sidewalks are provided on the approaches to a signalized intersection. STOP lines shall be placed a minimum of 4 feet in advance of the crosswalks. Consideration may be given to providing advance right turn STOP lines to improve the visibility of pedestrians coming from the motorist's left.

Pedestrian push buttons shall be accessible to pedestrians via an accessible pedestrian route in compliance with the ADA.

The draft PROWAG requires that whenever pedestrian signals are installed, accessible pedestrian push buttons be installed ***(48).***

At intersections with high volumes of right turning traffic, raised right turn channelization islands should be provided to allow pedestrians to cross the right turning traffic independently of the rest of the intersection. Single right turn channelization islands should be under yield control and have YIELD lines a minimum of 4 feet in advance of the crosswalk. Pedestrian crossings, crosswalks and W11-2 (Pedestrian crossing sign) should be placed on the approach end of the channelization island to maximize visibility to motorists. Space should be provided beyond the crosswalk for a single motor vehicle to store. Pedestrian signal heads for crossing of the through lanes shall be placed on the concrete channelization island.

Painted channelization islands do not provide the pedestrian advantages of raised channelization islands. Signal poles cannot be placed in painted islands. Consequently the pedestrian signal necessarily applies to the entire crossing, not just the through lanes. This precludes the use of yield control on the slip lane and the right turn must be signalized.

At multilane right turn channelization islands, the draft PROWAG requires the use of accessible pedestrian signals across the turn lanes ***(48).*** See the *MUTCD* Section 4.E.

At intersections with high volumes of pedestrians, consideration should be given to restricting the right turn on red movement. NO RIGHT ON RED blank-out signs may be used to restrict right turns only when pedestrians have pushed the pedestrian push button. This minimizes the delay to motorists due to the right turn restriction.

Additionally, YIELD TO PEDS IN CROSSWALK blank-out signs can be used to remind right-on-green and permissive left-turn movements of their obligation to yield to pedestrians in the crosswalk.

Another method to reduce pedestrian conflicts with turning motorists is through the use of a leading pedestrian interval. Where leading pedestrian intervals are used, Accessible Pedestrian Signals should be considered.

14.3.8.4 Pedestrian Crossings at Roundabouts

Research suggests that properly designed single-lane roundabouts have fewer pedestrian conflicts and crashes than typical signalized intersections **(51)**. To accommodate pedestrians, roundabouts should be designed to reduce speeds of approaching vehicles. Design speeds through single-lane roundabouts of 12 to 22 mph are typical.

Crosswalks at roundabouts shall be placed a minimum of 20 feet back from the circulating roadway. See Figure 14-56.

In areas prone to snow where the crosswalks may not be visible in winter, the W11-2 (PEDESTRIAN CROSSING) sign assembly should be installed the crosswalks.

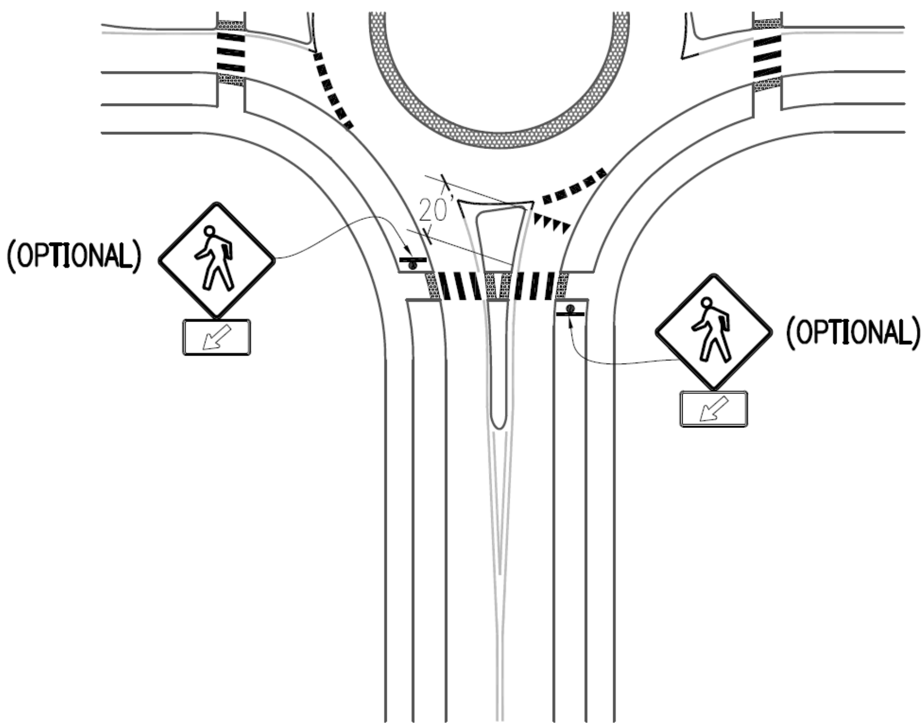


Figure 14-52 Locations of Pedestrian Crossings at Roundabouts (52)

The Draft PROWAG requires crosswalks across multi-lane approaches to roundabouts to be provided with accessible pedestrian signals ***(48).***

14.3.9 Pedestrian Crossings at Midblock Locations

When pedestrian crossing volumes meet the warrants for signalized pedestrian crossings, the installation of traffic signals for pedestrians should be considered.

The minimum clear width between crosswalk lines is 6 feet.

The *MUTCD* provides information on what type of traffic control devices may be used at midblock crossings. However, other than requiring crosswalk markings and PEDESTRIAN WARNING (W11-2) signs, it provides no clear guidance about the conditions in which any particular traffic control devices are recommended to be used to ensure motorists' yielding. The following section provides guidance in this regard. The tables provided should not be taken as requirement, rather as guidance for determining appropriate levels of traffic control at midblock crossings.

White, retroreflective crosswalk pavement markings shall be installed at all midblock crossings.

Raised median pedestrian refuge islands should be installed at all midblock crossing locations where the pedestrian must cross four or more lanes of traffic. The minimum raised separation width between travel lanes for a pedestrian refuge island is 6 feet. For shared use path crossings the desirable minimum width of a refuge island is 10 feet. Where crossings are cut through median refuge islands detectable warnings shall be installed: two feet of detectable warnings, two feet flat surface minimum, and two feet of detectable warnings. See Figure 14-53.

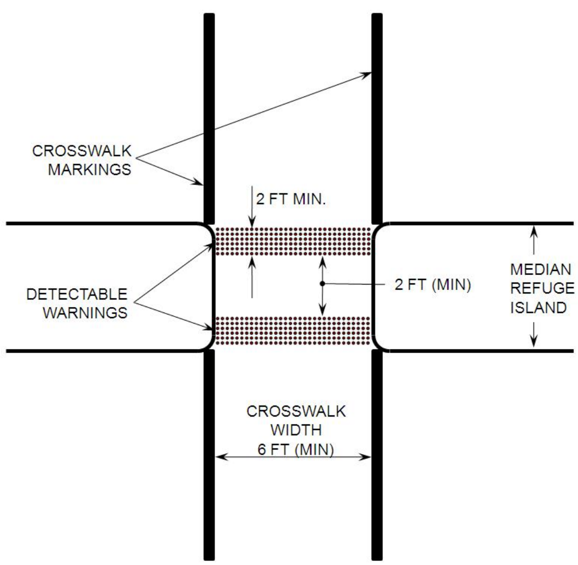


Figure 14-53 Detectable Warning Placement in Median Refuge Islands

Ideally, raised islands should extend along the roadway in advance of the crossing to the STOP or YIELD line.

An angled cut through of the median provides additional space for pedestrians to stage as well as encouraging them to look toward oncoming traffic. See Figure 14-54.

Advance STOP or YIELD lines shall be installed at all midblock crossing locations where the pedestrian must cross four or more lanes of traffic.

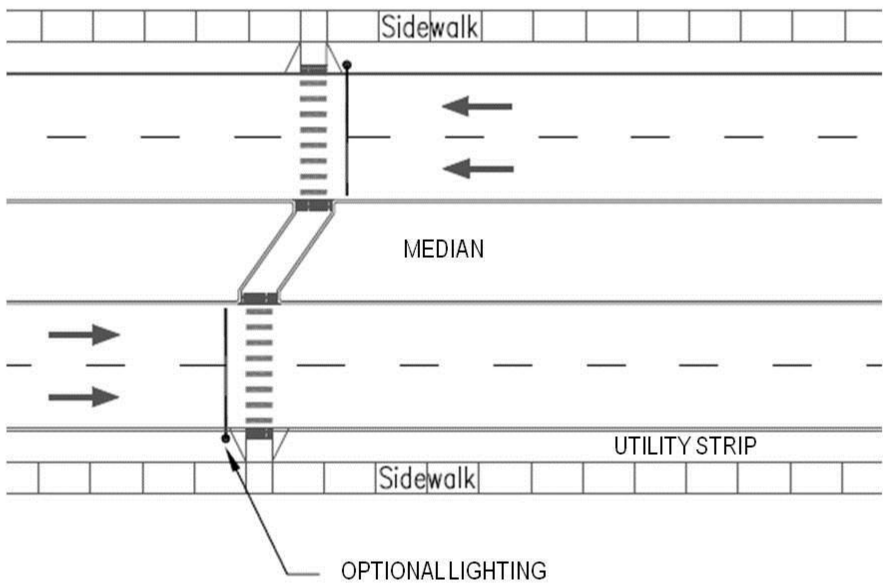


Figure 14-54 Angle Cut through a Median

14.3.9.1 Rapid Rectangular Flashing Beacons

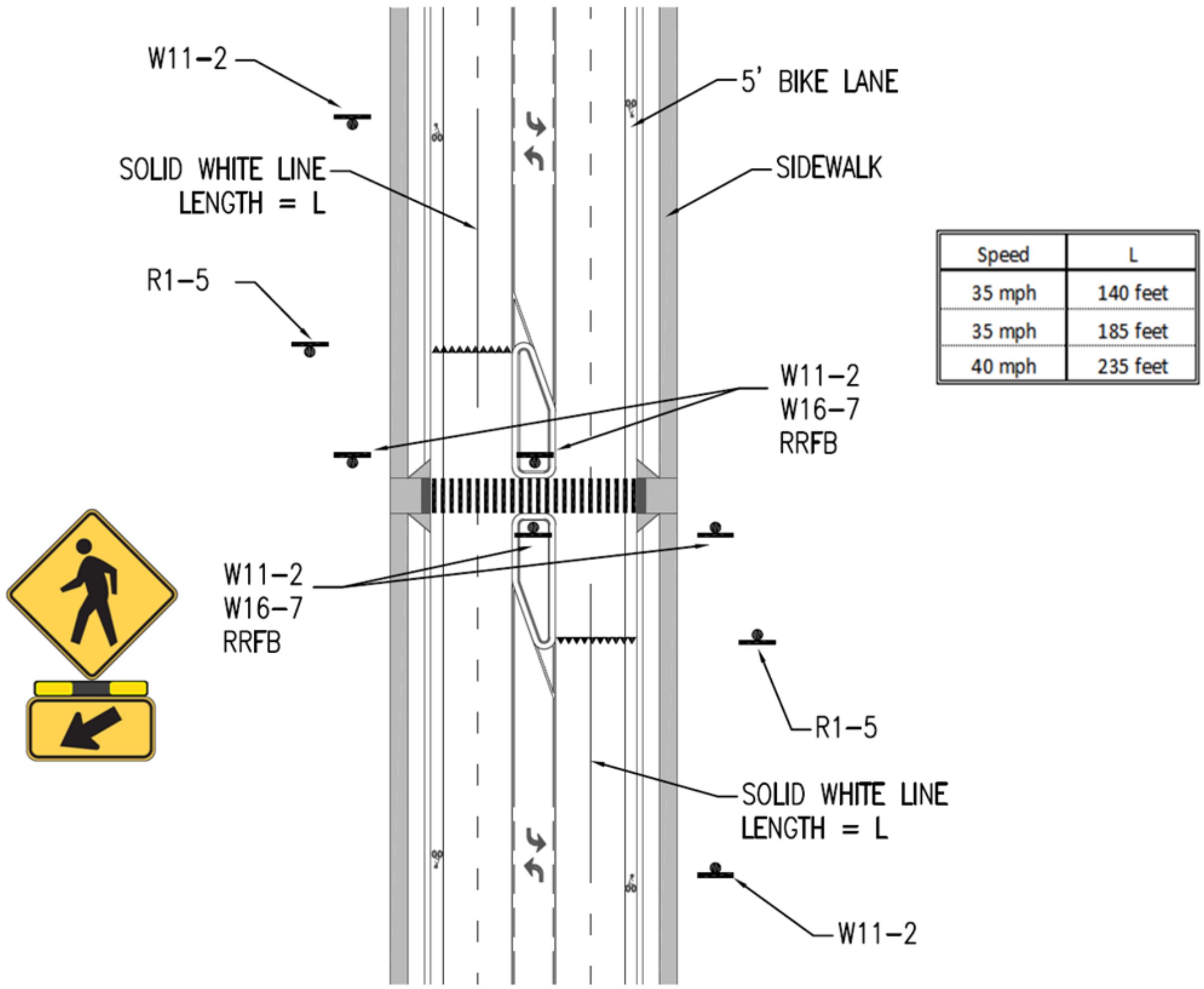
While not yet included in the MUTCD, RAPID RECTANGULAR FLASHING BEACONS (RRFB) have been shown to improve motorist yielding at midblock crossings. Research suggests motorist yield rates are ranging from 80 to 97 percent six months after deployment. To date this appears to be the most effective combination of traffic control devices that do not actually require the motorist to stop. This treatment has obtained an Interim Approval from the FHWA for application.

The RRFB treatment is a combination of signage markings and pedestrian activated strobe and feedback devices. Signage for the RRFB typically includes advance PEDESTRIAN WARNING signs (W11-2) with AHEAD supplemental plaques (W16-9p), and PEDESTRIAN WARNING signs (W11-2) with down arrow supplemental plaques (W16-7p). Pavement markings include yield markings and solid white lane lines (on divided multi-lane roads); the length of these lines is dependent upon the design stopping sight distance for the roadway. The pedestrian activated treatments would be the W11-2 signs with built in rectangular strobe flashers. Additionally, pedestrian visible strobes and a recorded message inform pedestrians when the crossing is activated and instruct them to wait for motorists to yield.

The RRFB should not be used on roadways with more than 4 through lanes. Raised medians should be provided at crossings using the RRFB to provide a space for left hand signs to be installed.

The R1-5 (YIELD HERE TO PEDS IN CROSSWALK) shall be placed so that it does not restrict motorists' visibility of the RRFB at the crosswalk.

High visibility crosswalks are to be used with the RRFB crossing treatment, as seen in Figure 14-55.



Speed	L
35 mph	140 feet
35 mph	185 feet
40 mph	235 feet

Figure 14-55 Rapid Rectangular Flashing Beacon

14.3.9.2 Pedestrian Hybrid Signals

PEDESTRIAN HYBRID SIGNALS are pedestrian activated beacons to warn motorists that pedestrians are crossing the street and that require the motorists to stop for pedestrians **(53)**. They do not require the satisfaction of traffic signal warrants. Chapter 4F of the MUTCD does provide some guidance regarding the volume of pedestrians crossing a roadway that would merit the consideration of a PEDESTRIAN HYBRID SIGNAL **(52)**.

PEDESTRIAN HYBRID SIGNALS are required for use on unsignalized designated crossings of roadways with six or more lanes.

The signal sequence for a pedestrian hybrid signal is shown in Figure 14-56.

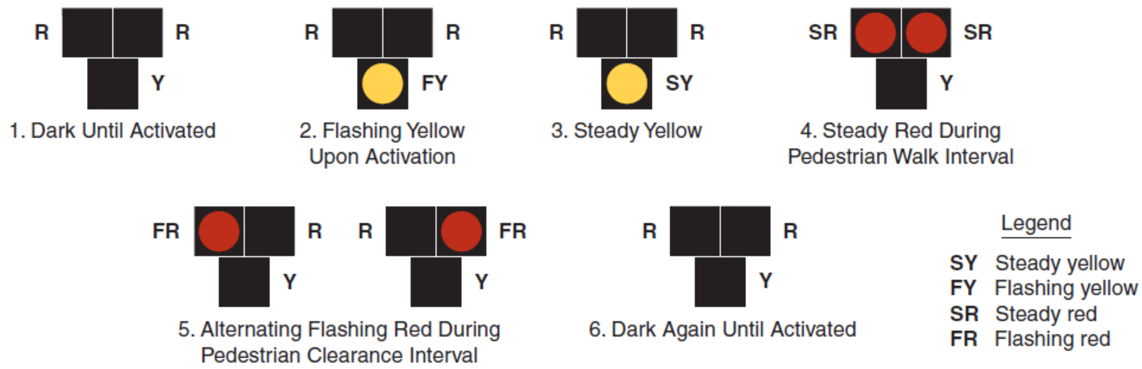


Figure 14-56 Pedestrian Hybrid Signal Sequence (53)

14.3.9.3 Guidance for Traffic Control Selection at Midblock Crossings

For these guidelines, roadways were stratified into low-, medium-, and high-volume. The threshold volume for low- to medium-volume is determined using the amount of time a pedestrian can expect to wait for an adequate gap in traffic to cross the street. The medium- to high-volume threshold is based upon a midblock crossing safety study prepared by the University of North Carolina's Highway Safety Research Center **(54)**. Depending on whether the street being crossed is low, medium or high volume, the corresponding value listed in Table 14-10, would be referenced to determine the recommended traffic control devices for the crossing.

Traffic Volume in	Recommended
< 6,700 vpd	Table 14-11
6,700 – 12,000 vpd	Table 14-12
>12,000 vpd	Table 14-13

vpd = vehicles per day

Table 14-10 Referral Table for Midblock Crossing Treatments

The following general notes should be considered when using Tables 14-11, 14-12, and 14-13.

General notes for applying the Crossing Treatment Guidelines Matrices:

Each column in the table represents a package of traffic control devices recommended for the specific crossing condition.

The designation of "YES" for the median assumes there is potential for installing a raised median at the crossing location and that one will be installed. Raised medians that can be used as pedestrian refuges (6 feet wide or wider in the direction of the roadway cross-section) will allow for less restrictive motor vehicle traffic controls to be used in conjunction with the midblock crossings. Wider refuge islands, 10 feet or more, should be considered to accommodate bicycle with trailers and recumbent bicycles.

1. On multi-lane roadways with medians on the approach, crossing signage for motorists should be placed in the medians as well as on the side of the roadway.
2. The use of angled cuts through the median (sometimes referred to as Danish offsets) should be considered at all crossings with raised medians for two reasons. First, the offset through the median directs the path users' attention toward the traffic about to be crossed. Secondly, of particular importance when using these tables for shared use path intersections, by providing an angled cut through the median, longer users (tandems, bicycles with trailers) may be better accommodated than in a narrower median.
3. When advance yield lines are used on the approach roadways they should be used in conjunction with solid lane lines. The lane lines should extend a distance equal to the stopping sight distance back from the yield lines. This is to enable law enforcement officers to determine when a motorist fails to yield when he could have done so.
4. On six-lane, undivided roadways, strong consideration should be given to providing a signalized crossing of the roadway for pedestrians. Until such time as this can be achieved, aggressive channelization should be used to divert pathway users to the nearest safe crossing.
5. This guidance assumes that lighting will be provided for crossings to be used at night.

Lanes	2 – lanes						4 - lanes					
Median	No			Yes			No			Yes		
Speed	≤ 30 mph	35–40 mph	≥ 45 mph	≤ 30 mph	35–40 mph	≥ 45 mph	≤ 30 mph	35–40 mph	≥ 45 mph	≤ 30 mph	35–40 mph	≥ 45 mph
Marked Crosswalks	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pedestrian Crossing Sign (W11-2) w/ Arrow (W16-7p)[2] 	✓		✓	✓	✓			✓	✓			✓
Advance Ped Xing Sign[2] (W1-2)	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Yield Here to Ped Signs (R1-5)[3] 		✓	✓			✓			✓	✓	✓	✓
Advance yield lines[4]		✓	✓			✓	✓	✓	✓	✓	✓	✓
Rapid Rectangular Flashing Beacon			✓					✓	✓			✓

[1] Assumes a K factor of 0.097
[2] *The Combined Bicycle/Pedestrian Crossing warning sign may be used at shared use path crossings of roadways. Strong Yellow Green may be used for this sign.*
[3] *MUTCD* 2B.11
[4] Placed 20 -50 feet in advance of the crosswalk (Section 3B.16)

Table 14-11 Roadway Volume less than 650 Vehicles per hour, vph (6,700 vehicles per day [1], vpd)

Lanes	2 - lanes						4 - lanes						6 - lanes
Median	No			Yes			No			Yes			No or Yes
Speed	≤ 30 mph	35–40 mph	≥ 45 mph	≤ 30 mph	35–40 mph	≥ 45 mph	≤ 30 mph	35–40 mph	≥ 45 mph	≤ 30 mph	35–40 mph	≥ 45 mph	All
Marked Crosswalks	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PEDESTRIAN CROSSING Sign (W11-2) w/ Arrow (W16-7p)[2] 	✓			✓		✓	✓	✓			✓		
Ped Xing Sign (advance)[2]	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Yield Here to Ped Signs (R1-5)[3] 		✓			✓	✓	✓	✓		✓	✓		
Advance Yield lines[4]		✓			✓	✓	✓	✓		✓	✓		
Stop Lines			✓						✓			✓	✓
Rapid Rectangular Flashing Beacon						✓	✓	✓			✓		
Pedestrian Hybrid Signals[5]			✓						✓			✓	✓

[1] Assumes a K factor of 0.097
[2] *The COMBINED BICYCLE/PEDESTRIAN CROSSING warning sign may be used at shared use path crossings of roadways. Strong Yellow Green may be used for this sign.*
[3] *MUTCD* 2B.11
[4] Placed 20 -50 feet in advance of the crosswalk (Section 3B.16)
[5] *MUTCD* Chapter 4.F

Table 14-12 Roadway Volume greater than 650 vph[1] (6,700 vpd) and less than 1,150 (12,000 vpd)

Lanes	2 - lanes						4 - lanes						6 - lanes
Median	No			Yes			No			Yes			No or Yes
Speed	≤ 30 mph	35–40 mph	≥ 45 mph	≤ 30 mph	35–40 mph	≥ 45 mph	≤ 30 mph	35–40 mph	≥ 45 mph	≤ 30 mph	35–40 mph	≥ 45 mph	All
Marked Crosswalks	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
/PEDESTRIAN CROSSING Sign (W11-15) w/ Arrow (W16-7p)[2] 	✓			✓	✓			✓	✓	✓	✓		
Ped Xing Sign (advance)[2]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Yield Here to Ped Signs (R1-5)[3] 		✓			✓	✓	✓			✓	✓		
Advance yield Lines[4]		✓			✓	✓	✓			✓	✓		
Stop Lines[5]			✓					✓	✓			✓	✓
Rapid Rectangular Flashing Beacon						✓	✓			✓	✓		
Pedestrian Hybrid Signal[5]			✓					✓	✓			✓	✓

[1] Assumes a K factor of 0.097
[2] *The COMBINED BICYCLE/PEDESTRIAN CROSSING warning sign may be used at shared use path crossings of roadways. Strong Yellow Green may be used for this sign.*
[3] *MUTCD* 2B.11
[4] Placed 20 -50 feet in advance of the crosswalk (Section 3B.16)
[5] *MUTCD* Chapter 4.F

Table 14-13 Roadway Volume Greater than 1,150[1] vph (12,000 vpd)

14.3.9.4 Signalized Pedestrian Crossings

Where signal warrants for pedestrian crossings are met, the installation of traffic signals should be considered. At midblock locations accessible pedestrian signals shall be provided.

Where accessible pedestrian signals are to be installed, they shall comply with all the requirements of the *MUTCD*.

14.3.9.5 Grade Separated Pedestrian Crossings

In some locations a grade separated crossing will be the only practical method of getting pedestrians across a roadway. Common examples include crossings of expressways and where children must cross major arterials. When appropriately designed, grade separated pedestrian crossings improve the mobility and safety of pedestrians. Attributes of such a pedestrian crossing include the following ***(3):***

- The facility must be located where it is needed and will actually be used.

- Crossing structures must be built with adequate widths based on perceptions of safety as well as pedestrian volumes.
- The design must be accessible for all users.
- Barriers and railings must be provided to add an increased sense of safety to the pedestrian.
- The facility must be lit to provide an increased level of security to the pedestrian.

Where grade separated crossings are installed, approaches must meet grade criteria provided in Section 14.3.3 Grade and Cross Slopes.

Where the designer has a choice between a tunnel and an overpass, an overpass is often preferable. Overpasses have security advantages. Additionally, lighting is often a requirement for tunnels and may not be necessary for an overpass. Drainage may also be easier to accommodate on overpasses. Underpasses are often more difficult to construct because of utility conflicts or phasing issues. Additionally, pedestrians are more likely to use an overpass than an underpass. However, overpasses have significantly greater vertical clearance requirements, 17 feet 6 inches over the roadway as opposed to 10 feet over the path surface.

When considering a grade separated pedestrian crossing a feasibility study shall be conducted. This study shall quantify current and future pedestrian use, as well as alternatives for at-grade crossings.

14.3.9.6 Additional Treatments at Midblock Crossings

On roadways with on street parking, mid-block curb extensions should be considered to reduce pedestrian crossing distances. Curb extensions also improve pedestrian and motorist sight lines. Drainage must be addressed when designing curb extensions.

On lower speed and volume arterials and collector streets raised crosswalks may be considered. Raised crosswalks decrease motorist speeds, resulting in greater yielding rates. Snow plow operators have reported problems plowing over raised crosswalks; the use of short vertical curves instead of grade break lines may address this operational problem. Drainage must be addressed when designing raised crosswalks.

The approach slopes for raised crosswalks shall be marked in accordance with the *MUTCD* required markings for raised pedestrian **(54)** crossings as shown in Figure 14-57.

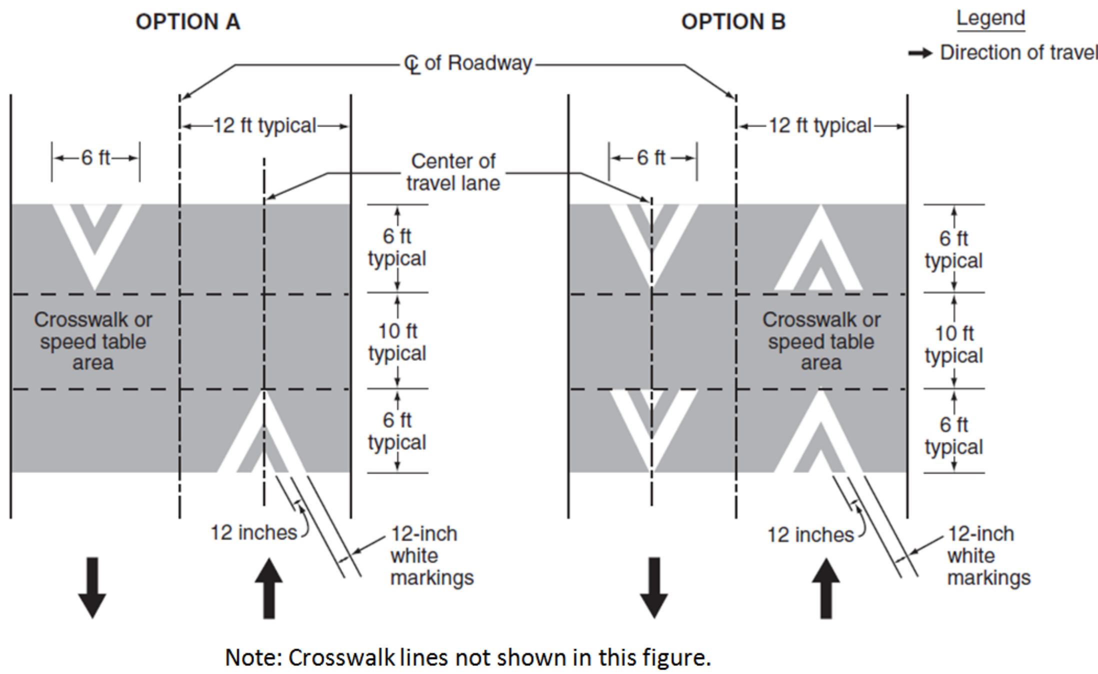


Figure 14-57 Approach Slope Markings for Raised Pedestrian Crossings (55)

Contrasting crosswalk coloring is often requested in downtown areas. The use of contrasting coloring does not eliminate the requirement to mark crosswalks with white, retroreflective pavement markings.

14.3.9.7 Sidewalk Crossings of Rail Lines

Where sidewalks cross rail road tracks, appropriate crossing treatments shall be provided.

Of particular importance to individuals with mobility impairments is the interface between the rails and the sidewalk. Sidewalk surfaces shall be flush with the tops of rails. Openings for wheel flanges at pedestrian crossings of freight rail track shall be 3 inches maximum. Openings for wheel flanges at pedestrian crossings of non-freight rail track shall be 2.5 inches maximum.

Detectable warnings shall be placed on the approaches to all rail crossings unless the rail crossing is included within a roadway crossing. The detectable warning surface shall be located so that the edge nearest the rail crossing is 6 feet minimum and 15 feet maximum from the centerline of the nearest rail. The rows of truncated domes in a detectable warning surface shall be aligned to be parallel with the direction of wheelchair travel.

When used at Light Rail Transit (LRT) crossings, pedestrian signal heads shall comply with the provisions of the *MUTCD* **(56)**.

Where a sidewalk crosses a light rail transit line, Flashing-light signals (see Figure 14-58) with a CROSSBUCK (R15-1) sign and an audible device should be installed at pedestrian crossings where an engineering study has determined that the sight distance is not sufficient for pedestrians and bicyclists to complete their crossing prior to the arrival of the LRT traffic at the crossing, or where LRT speeds exceed 35 mph.

If an engineering study shows that flashing-light signals with a CROSSBUCK sign and an audible device would not provide sufficient notice of approaching light rail transit traffic, the LOOK (R15-8) sign, pedestrian gates, or both, should be considered.

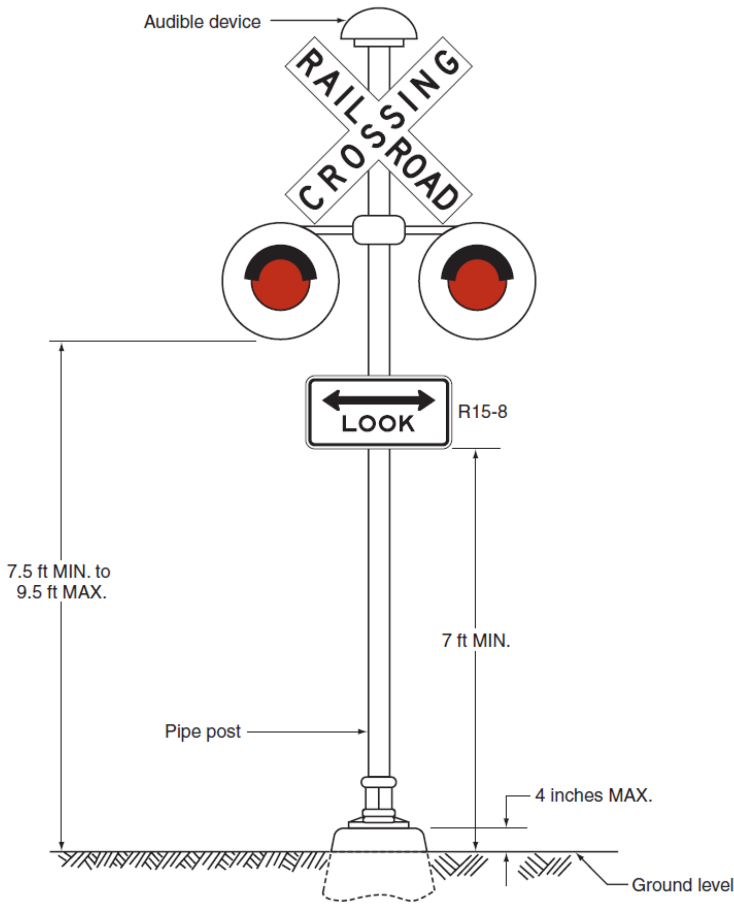


Figure 14-58 Example of Flashing-Light Signal Assembly for Pedestrian Crossings *(56)*

14.3.10 Other Pedestrian Considerations

14.3.10.1 Traffic Calming

The Institute of Transportation Engineers (ITE) defines traffic calming as follows:

> *Traffic calming is the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior and improve conditions for non-motorized street users. **(57)***

Traffic calming differs from the application of traffic control devices in that they use roadway geometrics rather than enforcement to compel people to drive more slowly. Vertical and horizontal alignment are used to physically restrict the speeds motorists are comfortable driving. Thus, traffic calming is self-enforcing.

Traffic calming is often used in combination with other treatments such as landscaping and lighting. While these additional treatments do not compel drivers to slow down, they may provide a visual signal to drive more slowly.

Traffic calming is popular in many communities because it is effective when applied properly. By reducing speeds, the number of traffic crashes is reduced and those crashes that do occur are often less severe than on uncalmed streets. By reducing speeds, pedestrians' perceptions of safety and comfort are improved as well.

ITE and FHWA have produced the document *Traffic Calming: State of the Practice* **(58)** for informational purposes. While it does not include recommendations on the best course of action or the preferred application of the data, it does provide an excellent resource for those considering the application of traffic calming treatments.

14.3.10.2 Pedestrian Amenities

Pedestrian amenities can provide a more pleasant walking environment and thus encourage more pedestrian activity. Pedestrian amenities can include aesthetic paving treatments, street furniture, shade trees, enhanced lighting, landscaping, informational signing, and public art. Because transit users begin and end their trips as pedestrians, amenities - particularly street furniture and informational signage - can encourage greater transit use. Prior to installing pedestrian amenities, a maintenance agreement should be in place to ensure local jurisdictions the amenities will be maintained.

If aesthetic paving treatments are used they shall be firm, stable, and slip resistant. Cobbles or other treatments that create a vibratory surface for wheelchair users shall not be used within the pedestrian walkway; they may be used in border areas.

Pedestrian amenities shall be designed so that they do not reduce the pedestrian access route to less than 4 feet and shall meet all the criteria of Section 14.3.2.3 Protruding Objects.

Shade trees and landscaping shall be designed so as not to restrict intersection sight distances, or to restrict pedestrian or motorists sight distances at midblock crossings.

14.3.10.3 Pedestrian Wayfinding Signage

Pedestrian wayfinding signage is important to provide information on walk routes to destinations and attractions for pedestrians. Pedestrian wayfinding can encourage pedestrian activity and transit use.

Specific pedestrian routes can be developed. The development of pedestrian routes should include the participation of local agencies and walking interest groups.

The *MUTCD* does not provide specific signage to be used for pedestrian wayfinding. Local jurisdictions may be consulted concerning the design or visual theme of pedestrian signage. However, standard alphabets with a minimum text height of 2 inches shall be used for pedestrian signs to ensure legibility.

14.3.10.4 On-street Parking

The presence of on-street parking significantly impacts the pedestrian environment. On-street parking provides an additional buffer between the travel lanes and the sidewalk; thus, it improves pedestrians' perceptions of safety and comfort. On-street parking often results in reduced motor vehicle travel speeds, further improving the pedestrian environment. By its very nature, on-street parking encourages pedestrian activity, walking along the road and increasing the number of pedestrians crossing the street.

Where on-street parking exists, curb extensions should be considered to restrict parking near intersections and midblock crossing locations. Drainage patterns will need to be considered during the design of curb extensions.

14.3.11 School Areas

School zones represent a particular challenge to pedestrian design. Children are the most unpredictable, least traffic savvy of pedestrians.

Special consideration should be given to designing pedestrian facilities near schools. Sidewalks should be located as far from the roadway as possible. In some locations, it may be advisable to channelize school children with fences or other barriers; such barriers should be designed so that they do not create sight distance limitations.

If midblock crossings are installed for school crossings, enhanced treatments shall be considered. Roadway volume thresholds for Tables 14-11, 14-12, 14-13 should be reduced by 20 percent. School children shall not be required to cross more than two lanes without a traffic signal. On roadways with raised pedestrian refuge islands, a four-lane divided roadway is the maximum width crossing without a traffic signal that may be provided specifically for school children.

Reduced speed zones may be considered in school zones. When using the SCHOOL SPEED LIMIT ASSEMBLY, the use of timed flashers is recommended (Figure 14-59). The use of the WHEN CHILDREN PRESENT (S4-3) plaque is not recommended.

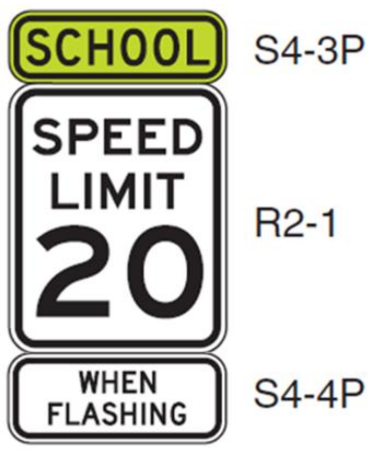


Figure 14-59 SCHOOL SPEED LIMIT Assembly

Consideration should be given to restricting right turn on red during periods when students are walking to and from school. Again, use of the WHEN CHILDREN PRESENT (S4-3) plaque is not recommended. Consideration should be given to using designated times for the no right on red or using blank-out signs pre-timed to school walking periods.

Pedestrian staging areas at intersections and midblock crossings should be designed to accommodate the expected volume of students who will be waiting to cross.

Student drop-off and pickup areas should be contained within the school site. If this is not possible and street-side drop-off and pickup is allowed, it shall not require students to make an unsupervised crossing of a roadway.

14.3.12 Maintenance of Traffic *(58)*

The following section is taken from the *MUTCD*. It includes the guidance and standard sections form the *MUTCD*. For support text, see section 6D of the *MUTCD*.

14.3.12.1 Pedestrian Considerations in Temporary Traffic Control Zones

Advance notification of sidewalk closures shall be provided by the maintaining agency or contractor.

If the temporary traffic control (TTC) zone affects the movement of pedestrians, adequate pedestrian access and walkways shall be provided. If the TTC zone affects an accessible and detectable pedestrian facility, the accessibility and detectability shall be maintained along the alternate pedestrian route.

The following three items should be considered when planning for pedestrians in TTC zones:

1. Pedestrians should not be led into conflicts with vehicles, equipment, and operations.
2. Pedestrians should not be led into conflicts with vehicles moving through or around the worksite.
3. Pedestrians should be provided with a convenient and accessible path that replicates as nearly as practical the most desirable characteristics of the existing sidewalks or footpaths.

A pedestrian route should not be severed or moved for non-construction activities such as parking for vehicles and equipment.

To accommodate the needs of pedestrians, including those with disabilities, the following considerations should be addressed when temporary pedestrian pathways in TTC zones are designed or modified:

1. Provisions for continuity of accessible paths for pedestrians should be incorporated into the TTC plan.
2. Access to transit stops should be maintained.

3. A smooth, continuous hard surface should be provided throughout the entire length of the temporary pedestrian facility. There should be no curbs or abrupt changes in grade or terrain that could cause tripping or be a barrier to wheelchair use. The geometry and alignment of the facility should meet the applicable requirements of the "Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)" ***(48).***
4. The width of the existing pedestrian facility should be provided for the temporary facility if practical.
5. Traffic control devices and other construction materials and features should not intrude into the usable width of the sidewalk, temporary pathway, or other pedestrian facility. When it is not possible to maintain a minimum width of 60 inches throughout the entire length of the pedestrian pathway, a 60 x 60-inch passing space should be provided at least every 200 feet to allow individuals in wheelchairs to pass.
6. Blocked routes, alternate crossings, and sign and signal information should be communicated to pedestrians with visual disabilities by providing devices such as audible information devices, accessible pedestrian signals, or barriers and channelizing devices that are detectable to the pedestrians traveling with the aid of a long cane or who have low vision. Where pedestrian traffic is detoured to a TTC signal, engineering judgment should be used to determine if pedestrian signals or accessible pedestrian signals should be considered for crossings along an alternate route.
7. When channelization is used to delineate a pedestrian pathway, a continuous detectable edging should be provided throughout the length of the facility such that pedestrians using a long cane can follow it. These detectable edgings should comply with the provisions of the *MUTCD*.
8. Signs and other devices mounted lower than 7 feet above the temporary pedestrian pathway should not project more than 4 inches into accessible pedestrian facilities.

Fencing should not create sight distance restrictions for road users. Fences should not be constructed of materials that would be hazardous if impacted by vehicles. Wooden railing, fencing, and similar systems placed immediately adjacent to motor vehicle traffic should not be used as substitutes for crashworthy temporary traffic barriers.

Ballast for TTC devices should be kept to the minimum amount needed and should be mounted low to prevent penetration of the vehicle windshield.

Movement by work vehicles and equipment across designated pedestrian paths should be minimized and, when necessary, should be controlled by flaggers or TTC. Staging or stopping of work vehicles or equipment along the side of pedestrian paths should be avoided, since it encourages movement of workers, equipment, and materials across the pedestrian path.

Access to the work space by workers and equipment across pedestrian walkways should be minimized because the access often creates unacceptable changes in grade, and rough or muddy terrain, and pedestrians will tend to avoid these areas by attempting non-intersection crossings where no curb ramps are available.

A canopied walkway may be used to protect pedestrians from falling debris, and to provide a covered passage for pedestrians. Covered walkways should be sound construction and adequately lighted for nighttime use.

When pedestrian and vehicle paths are rerouted to a closer proximity to each other, consideration should be given to separating them by a temporary traffic barrier. If a temporary traffic barrier is used to shield pedestrians, it should be designed to accommodate the specific site conditions. Guidance for locating and designing temporary traffic barriers can be found in Chapter 9 of AASHTO's "Roadside Design Guide".

Short intermittent segments of temporary traffic barrier shall not be used because they nullify the containment and redirective capabilities of the temporary traffic barrier, increase the potential for serious injury both to vehicle occupants and pedestrians, and encourage the presence of blunt, leading ends. All upstream leading ends that are present shall be appropriately flared or protected with properly installed and maintained crashworthy cushions. Adjacent temporary traffic barrier segments shall be properly connected in order to provide the overall strength required for the temporary traffic barrier to perform properly.

Normal vertical curbing shall not be used as a substitute for temporary traffic barriers when temporary traffic barriers are needed.

If a significant potential exists for vehicle incursions into the pedestrian path, pedestrians should be rerouted (see Figure 14-60) or temporary traffic barriers should be installed.

Tape, rope, or plastic chain strung between devices are not detectable, do not comply with the design standards in the "Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)", and should not be used as a control for pedestrian movements ***(47).***

In general, pedestrian routes should be preserved in urban and commercial suburban areas. Alternative routing should be discouraged.

The highway agency in charge of the TTC zone should regularly inspect the activity area so that effective pedestrian TTC is maintained.

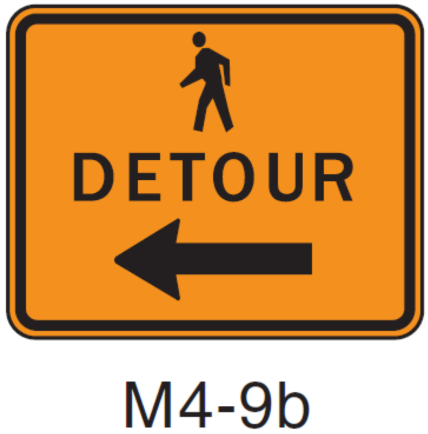


Figure 14-60 Pedestrian Facility DETOUR Sign

14.3.12.2 Accessibility Considerations

The extent of pedestrian needs should be determined through engineering judgment or by the individual responsible for each TTC zone situation. Adequate provisions should be made for pedestrians with disabilities.

When existing pedestrian facilities are disrupted, closed, or relocated in a TTC zone, the temporary facilities shall be detectable and include accessibility features consistent with the features present in the existing pedestrian facility. Where pedestrians with visual disabilities normally use the closed sidewalk, a barrier that is detectable by a person with a visual disability traveling with the aid of a long cane shall be placed across the full width of the closed sidewalk.

If a pushbutton is used to provide equivalent TTC information to pedestrians with visual disabilities, the pushbutton should be equipped with a locator tone to notify pedestrians with visual disabilities that a special accommodation is available, and to help them locate the pushbutton.

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