CITY OF MEMPHIS BICYCLE DESIGN MANUAL

Technical Memorandum on Current City Practices, Peer Cities & Best Practices

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Prepared For

City of Memphis

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1 Introduction

In an effort to establish consistent and appropriate bicycle accommodation standards within the City of Memphis, the development of a bicycle design manual was commissioned by the City. The final design manual is to include standards, policies, and practices to serve as a guide for the planning, design, and implementation of bicycle facilities within the City of Memphis.

This Technical Memorandum presents a review of current standards, policies, and practices that impact the planning, design, and implementation of bicycle facilities within the City of Memphis. Also, included in this memorandum are the practices used in the City of Memphis compared to the practices utilized by the peer cities. Additionally, a listing of best practices throughout the United States relative to the design and implementation of bicycle facilities are presented. These findings are intended to serve as a foundation to the development of the City of Memphis Bicycle Design Manual.

To aide in the development of the design manual, a detailed review of current bicycle practices employed by the City of Memphis was conducted. The key policy plans and documents reviewed as part of this effort included:

- City of Memphis Design and Review Policy Manual - Current
- City of Memphis Subdivision Regulations - Current
- City of Memphis/Shelby County Unified Development Code (Staff Review Draft)
- Medical Overlay District and Board Avenue Corridor Urban Code (Staff Review Draft)
- City of Memphis Design Standards & Standard Construction Specifications - Current
- Memphis Area Transit Authority (MATA) Policies - Current
- Memphis MPO Regional Bicycle and Pedestrian Plan, adopted January 2005
- Memphis MPO 2026 Long Range Transportation Plan, amended September 2007

In addition, six peer cities were identified that have implemented successful practices related to bicycle accommodations. Based on a comparison of demographics, land area, and known bicycle practices by other cities throughout the United States, the following six cities were selected as peer cities:

- Baltimore, Maryland
- Charlotte, North Carolina
- Chicago, Illinois
- Denver, Colorado
- Milwaukee, Wisconsin
- Nashville, Tennessee

For the peer cities, copies of each jurisdiction's most recent bicycle design provisions, bicycle plans, development codes, and/or design standards were reviewed.

In addition to peer city practices, a review of emerging and/or best practices employed by other locations throughout the United States were also identified. The purpose of analyzing these practices was to identify effective and innovative guidelines that are being used around the nation to implement safe and efficient bicycle facilities. It is important to note that emerging practices are often what is defined as "experimental" meaning the practice has yet to be established as a standard national practice. In some cases, best practices are documented national standards but have yet to be accepted practices in all states which limit their application by many jurisdictions throughout the United States.

This technical memorandum has been organized into two categories: on-street bicycle facilities and off-street bicycle facilities. Under each of these categories are a series of subsections which further detail components and functions of each category of bicycle accommodations. Current City of Memphis practices are described followed by a summary description of practices by each peer city. Additionally, emerging and/or best practices are listed when appropriate.

The technical memorandum concludes with a review and discussion of practices for selecting appropriate design treatments to accommodate bicyclists. This section presents methods used by other cities to evaluate roadways and determine the appropriate bicycle facility accommodations.

Lastly, the *Guide for the Development of Bicycle Facilities* published by the American Association of State Highway and Transportation Officials (AASHTO) was reviewed as part of this effort given the fact that many jurisdictions consider the publication to be the documented national standards for bicycle facility accommodations. Other resources including the 2003 edition of the *Manual on Uniform Traffic Control Devices* (MUTCD) were reviewed in developing this technical memorandum and are appropriately cited when referenced.

2 On-Street Bicycle Facilities

Roadway–based bicycle facilities include shared roadways, signed bike routes, wide curb lanes, paved shoulders, and bike lanes. The following section describes each of these on-street bicycle facilities along with design considerations employed by the City of Memphis and each of the peer cities. Where AASHTO guidelines are used, such applications are noted. Additionally, where innovate and/or best practices are being used, such applications are described.

2.1 Shared Roadways – Unsigned & Signed

Since bicyclists are legally able to use all roadways (with the exception of controlled-access freeways or those facilities specifically restricting bicycle use), all roads are technically classified as "shared roadways".

Unsigned Shared Roadway

The AASHTO *Guide* defines a shared roadway as a roadway which is not officially designated and marked as a bicycle route or having bike lanes, but which is open to both bicycle and motor vehicle travel. This may be an existing roadway, street with wide curb lanes, or a road with paved shoulders. In the United States, most shared roadways have no provisions for bicycle travel. Shared roadways function well on local streets and minor collectors, and on low volume rural roads and highways.

Signed Shared Roadway

A signed, shared roadway is the same as a shared roadway with the addition of bicycle route signs posted alongside it. The signage serves to advise vehicular drivers that bicycles are present. The signage also serves to provide directional information to bicyclists when route numbers or route names are provided. The AASHTO *Guide* describes signed shared roadways (bike routes) as "those that have been identified by signing as preferred bike routes."

MUTCD Bike Route Sign

The AASHTO *Guide* cites the following reasons for designating bike routes:

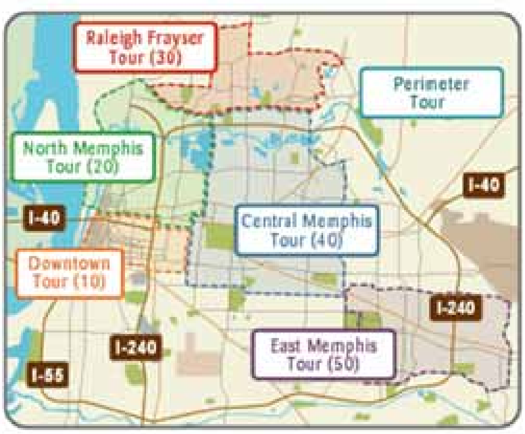
- The route provides a linkage to other bicycle facilities, such as bike lanes and multi-use paths.
- The road is a common route for bicyclists through a high-demand corridor.
- The route is preferred for bicycling in rural areas due to low traffic volumes or paved shoulder availability.
- The route extends along local neighborhood streets and collectors that lead to internal neighborhood destinations, such as a park or school.
- Bike route signs may also be used on streets with bike lanes, as well as on off-road trails. Regardless of the type of facility or roadway they are used on, it is recommended that bike route signs include destination, direction, and distance information.

Bike Route Sign in Nashville

<u>City of Memphis</u>

Memphis has approximately 61 miles of signed bike routes located within the City. There are five "neighborhood" route tours and one longer "Memphis" route tour. These routes are intended for recreation, as well as for commuter use and to link neighborhoods, commercial areas and many city attractions. Destinations include downtown, Memphis riverfront, city parks, museums, gardens, the nature center and the Memphis Zoo.

The City uses numbered bike route and directional signs for the designated bike routes, which is consistent with the AASHTO *Guide* and the MUTCD.



Map of Memphis Bicycle Routes

Bicycle Route Sign in Memphis

Peer Cities

Each peer city adheres to the AASHTO *Guide* and the MUTCD relative to signed shared roadways. The City of Charlotte uses signed connections to provide connectivity between facilities and to provide direction to bicyclists. At a minimum in Charlotte bike route signs are used with directional arrows. Below are a few practices employed by peer cities which augment traditional design standards for signed shared roadways.

The City of Baltimore uses on-street bike route signs which are modified from the bicycle route signs provided in the MUTCD. In addition, Baltimore uses special on-street route signs that include the route/partnership logo and special destination reference information.

City of Baltimore Bike Route Signs

The City of Chicago uses the directional signs on bicycle routes as shown in the top left picture. Also, Chicago utilizes the sign shown in the bottom left picture for the shared roadways.

Directional Bike Route Signs (Top) and Share the Road Sign (Bottom) in Chicago

The City of Denver uses names and numbers, as shown in the picture to the right, along their bicycle routes. This type of signage gives direction to the bicyclist on the routes.

Bike Route Signs in Denver

Bike Route and Shared Roadway Sign in Nashville

The City of Nashville uses the standard MUTCD bicycle route signs and the standard MUTCD share the road signs.

<u>Emerging Practice</u>

An emerging shared roadway practice that is likely to be a standard practice is the use of pavement markings in conjunction with the signing of shared roadways. In a 2004 study commissioned by the City of San Francisco on shared lane pavement markings, the following pavement marking applications were evaluated.

Shared Roadway Pavement Marking in Gainesville, FL

Shared Pavement Markings in San Anselmo, CA

Shared Roadway Pavement Markings in Denver, CO

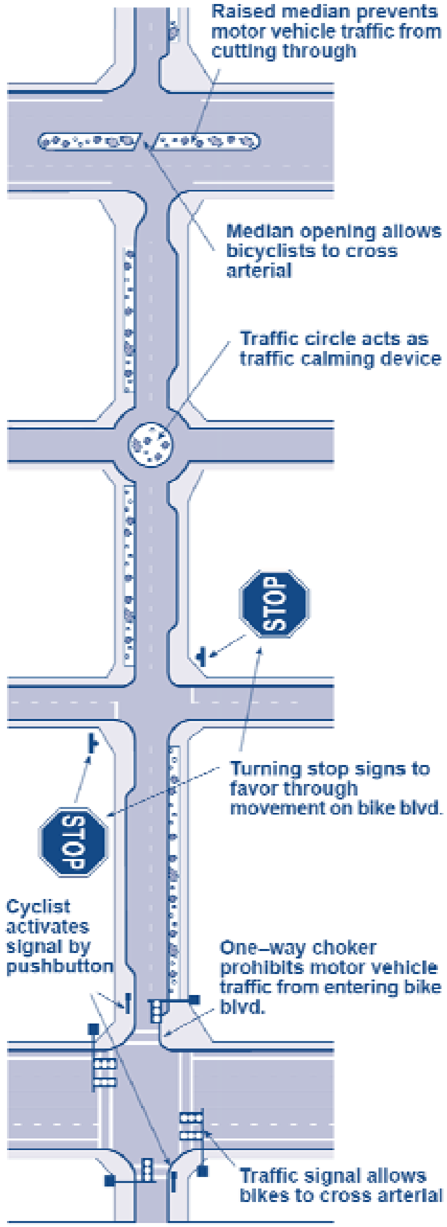
The research concluded that the preferred shared roadway pavement marking is the "chevron" over the bike. This pavement marking is what the City of San Francisco currently uses and is being considered for inclusion in the next update of the MUTCD.

Shared Pavement Marking Used by the City of San Francisco

Another emerging shared roadway application is what is known as a "bicycle boulevard" which is a shared roadway which has been optimized for bicycle traffic. A bicycle boulevard is created by modifying the operation of a local street to function as a through street for bicycles while maintaining local access for automobiles.

Traffic calming devices are used to control traffic speeds and discourage through trips by automobiles. For instance, diverters with bicycle cut-outs at mid-block allow motorists to enter the block in order to park or otherwise access a property, and allow cyclists to continue to the next block as well, but do not allow motorists to continue. Typically, these modifications are thought to calm traffic and improve pedestrian safety as well as encouraging bicycling.

The following is an illustration of typical provisions associated with a bicycle boulevard.



Bicycle Boulevard Illustration
from the City of Portland, OR

Examples exist in a few cities, including Berkeley, California; Palo Alto, California; San Luis Obispo, California; Portland, Oregon; Eugene, Oregon; and Vancouver, British Columbia.

2.2 Wide Outside Lanes

The AASHTO *Guide* defines wide outside lanes, or wide curb lanes, as the right-most through traffic lane that is substantially wider than 12 feet. In general, 14 feet of usable lane width is recommended for shared use in a wide outside lane. Usable width is measured from edge stripe to lane stripe or from the longitudinal joint of the gutter pan to the lane stripe (the gutter pan should not be included as usable width).

Wide outside lanes have three widely accepted advantages. They can:

- Accommodate shared bicycle/motor vehicle use without reducing the roadway capacity for motor vehicle traffic.
- Minimize both the real and perceived operating conflicts between bicycles and motor vehicles.
- Increase the number of bicyclists capable of being accommodated.

Many other benefits are claimed for wide outside lanes ranging from assisting turning vehicles in entering the roadway without encroaching into another lane to better accommodating buses and other wider vehicles.

Wide outside lanes require the least amount of additional maintenance of the different facilities. The sweeping effect of passing motor vehicles and routine highway maintenance is usually enough to keep the lane free of debris and in good condition for bicycling.

<u>City of Memphis</u>

The City of Memphis's current Subdivision Regulations and Unified Development Code (UDC) provide for wide outside lanes for roadways classified as major collectors. The City's major collector classification calls for a 16 foot travel lane exclusive of the curb and gutter. Other roadway classifications within the City (local streets and minor collectors) have varying pavement width standards ranging from 28 feet to 48 feet of pavement. A wide outside lane could be achieved under most of these roadway classifications, if striped to provide a minimum 14 foot outside lane.

The City follows AASHTO design guidelines when determining actual roadway lane widths. On roadways classified as an "arterial" within the City, typical lane widths are 12 feet which is also the same as the typical roadway cross-section for arterials used by the Tennessee Department of Transportation (TDOT). However, TDOT typical roadway cross-section standards do allow for 14 to 16 foot outside lane widths when bicycle lane provisions are required.

<u>Peer Cities</u>

Peer city practices vary but for the most part adhere to the AASHTO *Guide* relative to wide outside lane standards. The following summarizes peer city practices:

- In Baltimore, Nashville, and Milwaukee, the minimum curb lane width for arterials and collectors is 14 feet exclusive of the gutter.

- In Charlotte, the standard outside lane width is 14 feet for new or reconstructed thoroughfares and collectors with curb and gutter. On arterial and collector roadways with high speed limits, high volumes of traffic, or on street parking, the recommended outside curb lane width is 16 feet.

- Denver's Standard Right-of-Way Cross-Sections for arterial roadways provides a 14 foot outside curb lane for both four-lane and six-lane arterials.

Wide Outside Lane in Charlotte, NC

<u>Emerging Practice</u>

The Federal Highway Administration's (FHWA) *Selecting Roadway Design Treatments to Accommodate Bicycles* advises 14 to 16-foot lanes depending on the number of lanes, motor traffic intensity, sight distance, and the presence or absence of on-street parking.

The NCDOT *North Carolina Bicycle Facilities Planning and Design Guidelines* says "On roadways that accommodate both bicycles and motor vehicles within the travel lanes, 14 feet of usable width should be provided on the outside through lanes."

The Oregon DOT *Bicycle and Pedestrian Plan* says "Design on busy streets where bike lanes cannot be provided due to physical constraints, a wide curb lane may be provided to accommodate bicycle travel. To be effective, a wide lane should be 14 to 15 feet wide. Usable width is normally measured from curb face to the center of the lane stripe, but adjustments need to be made for drainage grates, parking and the ridge between the pavement and gutter."

The Wisconsin DOT *Bicycle Facility Design Handbook* says, "A useable lane width of at least 14 feet, not including the standard 2-foot gutter pan, is needed for a motor vehicle and bicycle to operate side by side. As an alternative, a lane width of 15 feet may be used with a 1-foot gutter pan and 1-foot curb head."

Wide Outside Lane with Parking

Additionally, there are numerous local practices in which existing highways are retrofitted to create wide outside lanes. Methods used to accomplish this include reducing the center lane width and widening the outside lane, widening the roadway to pave a shoulder, removing parking (either on one or both sides of the roadway), or reducing the number of lanes and adding a center turn lane. These practices are generally the least expensive and easiest to implement, and are most commonly applied throughout the country.

2.3 Paved Shoulders

A paved shoulder refers to the part of the highway that is adjacent to the regularly traveled portion of the roadway and is on the same grade as the roadway.

A well maintained wide paved shoulder allows cyclists to travel outside the main roadway and provides motor vehicles a passing area without entering the shoulder. Wide paved shoulders not only benefit motorists, but reduce road maintenance costs and may improve safety for bicyclists.

Paved Shoulder

According to *The Policy on Geometric Design of Highways and Streets,* published by AASHTO, paved or stabilized shoulders provide:

- usable area for vehicles to pull onto during emergencies
- elimination of rutting adjacent to the edge of travel lane
- adequate cross slope for drainage of roadway
- reduced maintenance; and
- lateral support for roadway base and surface course.

The AASHTO *Guide* states that paved shoulders should be at least 4 feet wide to accommodate bicycle travel (excluding the width of a gutter pan). The shoulder widths should be increased if there is a high number of bicyclists, if the motor vehicle speeds are above 50 mph, if there is a high percentage of truck and bus traffic, or if static obstructions exist at the right side of the roadway.

In general, AASHTO's recommendations for shoulder width (as described in *The Policy on Geometric Design of Highways and Streets*) are the best guide for bicycles, since wider shoulders are recommended on heavily traveled, high-speed roads and those carrying a large number of trucks.

<u>City of Memphis</u>

Current Subdivision Regulations of the City of Memphis allow for paved shoulders on rural roadways classified as collector or local. The provision of paved shoulders on these rural roadways is 10 feet. No specifications are given for paved shoulders in any of the City's other roadway classifications, although in some cases the available pavement width would allow for the provision of a paved shoulder.

At the state level, TDOT design standards for paved shoulder roadways adhere to *The Policy on Geometric Design of Highways and Streets* published by AASHTO. TDOT shoulder width standards vary depending on the roadway classification. For local and collector roadways the shoulder width ranges from 2 feet to 8 feet (RD-TS-1, RD-TS-2) depending on design speeds and design hour traffic volumes and for arterial roadways the shoulder width varies from 4 feet to 10 feet (RD-TS-3) depending on design speeds and design hour volumes.

Paved Shoulder on a State Highway in Tennessee

Peer Cities

Peer city practices follow AASHTO standards relative to the provision of paved shoulders. The following are several noteworthy aspects of peer city practices:

- The City of Charlotte's *Urban Street Design Guidelines* call for the provision of 10 feet wide paved shoulders on roadways classified as Parkways. The Parkway roadway classification is essentially a major arterial.

- The City of Baltimore's *Bicycle Facility Design Toolkit*, provides strategies for gaining extra space that can be redistributed for bicycle use in the roadway. Examples provided include:
  - On multi-lane roadways reducing travel lanes to 10 or 11 feet.
  - On streets with raised medians, the median could be narrowed providing more pavement width.
  - Road diets can be employed, if appropriate, to eliminate one or two travel lanes.
  - If parking supply exceeds demand, parking can be consolidated and limited to one side of the street, or eliminated altogether if it is truly unnecessary.

  Strategies above are described as ways to accommodate a wide outside lane, a striped shoulder, or bike lane on roadways that do not already have such accommodations.

- Nashville's roadway design standards provide for paved shoulders in non-residential areas and specify a 4 foot shoulder for roadways constructed with a shoulder.

Emerging Practice

Wisconsin DOT has a policy of providing a three foot paved shoulder on all highways with an average daily traffic count (ADT) in excess of 1,000 vehicles. An increased shoulder width is recommended if a moderate number of bicyclists are currently using or are anticipated to use the road.

2.4 Bike Lanes

A bike lane is a portion of the roadway that has been designated by striping, signing and pavement markings for the preferential or exclusive use of bicyclists. In general, bike lanes should always be located on both sides of the road (except one-way streets), and carry bicyclists in the same direction as adjacent motor vehicle traffic.

Bike lanes are typically considered for high-volume, urban roadways, including collector roadways. According to the AASHTO *Guide*, bike lanes benefit both bicyclists and motorists by segregating users, thereby increasing overall capacity, and making the movements of the motorists and bicyclists more predictable.

The AASHTO *Guide* states that for roadways with no curb and gutter, the minimum width of a bike lane should be four feet. If curb and gutter exists, the recommended width is five feet from the face of the curb or guardrail to the bike lane stripe.

<u>City of Memphis</u>
Currently there are no existing bike lanes located within the City of Memphis. The *Memphis MPO Regional Bicycle and Pedestrian Plan*, which incorporates the City of Memphis, includes design guideline recommendations for bike lanes. These recommendations follow that of the AASHTO *Guide*.

<u>Peer Cities</u>
All of the peer cities follow the AASTHO *Guide* related to the location, construction, and signage of bike lanes. The following pictures show the use of bike lanes in several of the peer cities.

Baltimore has constructed bike lanes, like the one shown in the picture to the right, in an effort to provide bicycle facilities for all user levels.

Bike Lane in Baltimore

Bike Lane in Chicago

Chicago uses bike lanes on roads to better regulate the travel pattern of motorists and bicyclists. Chicago does not stripe a bike lane less than five feet in width. The picture to the left shows a typical bike lane in Chicago.

Bike Lane located on Seneca Lane in Charlotte

Charlotte has striped bike lanes in areas where delineating the bicycle traffic from the vehicular traffic is desirable. An example of this is shown in the picture to the left on Seneca Lane.

Nashville has identified roadways that are desirable locations for bike lanes and has begun constructing the bike lanes as development or repaving projects have occurred. The picture to the right shows the bike lane on the Demonbreun Street Bridge crossing over the interstate.

Bike Lane in Nashville on Demonbreun Street

2.4.1 Bike Lanes with Parking Lanes

Bike lanes located next to on-street parking is a common practice in many cities. The AASHTO *Guide* states that where parking areas are present the bike lane should be a minimum of 5 feet wide and should be placed between the parking area and the travel lane.

Providing a 4-inch solid white line between the bike lane and the parking lane is optional. The AASHTO *Guide* recognizes that this second line encourages parking closer to the curb, providing additional separation from motor vehicles.

City of Memphis

The draft Unified Development Code for the City provides typical sections for bike lane provisions for roadways classified as major collectors with on-street parking. The City's major collector classification calls for a parking lane plus bike lane with a total width of 13 feet, exclusive of the curb and gutter. Assuming a parking width of 7 feet, the bike lane width should be 6 feet which is consistent with the AASHTO *Guide* and practices in the peer cities of Baltimore, Charlotte, Chicago, and Denver.

Peer Cities

Each of the peer cities have current bike lane accommodations within their respective municipalities including facilities where on-street parking is provided. Each peer city follows the AASHTO *Guide* relative to bike lanes with on-street parking. Where bike lanes are provided, Baltimore recommends the parking lane be 9 feet wide with 7 feet as a minimum. Also, a 4-inch wide solid white line is used to separate the parking lane from the bike lane. Charlotte follows the guidelines set by NCDOT for bike lane widths when on-street parking is present. Examples of peer city practices are provided below.

Bike Lane with On-street Parking in Chicago

In Chicago, when on-street parking is present bike lane widths range from 5.5 feet to 6 feet. Bike lanes are marked with three different lines. When a bike lane is striped against a curb and parking is prohibited, an 8-inch solid white line is used to separate the bike lane from the adjacent travel lane. On streets with on-street parking, a 4-inch wide solid white line defines the parking lane and a 6-inch wide solid white line defines the outer edge of the bike lane.

Nashville provides bike lanes where on-street parking is also provided. The picture to the right shows the bike lanes provided on Belmont Boulevard.

Bike Lanes with On-street Parking in Nashville

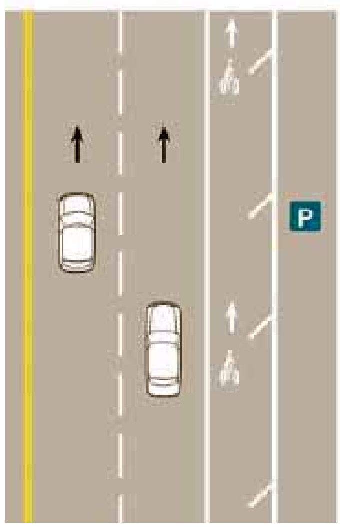
Bike Lanes with On-street Parking in Denver

As shown in the picture to the left, Denver provides bike lanes on roads with on-street parking

Emerging Practice

Emerging practices for bike lane accommodations with on-street parking focus on efforts to reduce the conflict between parked cars and bicyclists. The "door zone" is the area in the bike lane that is crossed when the driver of a parked car opens the door. This poses a problem for bike lanes located next to on-street parking. There are three emerging strategies for increasing awareness of the "door zone":

- Install "Look for Bike" signs to alert drivers to look for bicyclists when opening the driver's side door.
- Increase the width of the bike lane so that bicyclists can travel outside the "door zone" without entering into the motorists travel lane.
- Stripe pavement markings on the right side of the bike lane that mark the "door zone"



"Door Zone" Pavement Markings from San Francisco Bicycle Plan

Sign to Alert Motorists to look for Bicycles

2.4.2 Bike Lanes at Intersections

Special provisions are required to ensure the safety of bicyclists maneuvering through intersections. The AASHTO *Guide* states that bike lanes should not be striped through the intersection. The striping should stop at the crosswalk or stop line. There are also specific guidelines as to the striping of the bike lane on an approach that provides a right turn lane that minimizes conflicts between the bicyclist and motorist.

Peer Cities

The peer cities utilize the AASHTO *Guide* and MUTCD standards for striping bike lanes at intersections. Additionally, the City of Chicago's *Bike Lane Guide* is often referred to as a best practice guide for bike lane accommodations with detailed signing and striping standards for various intersection and mid block configurations.

Bike Lane Intersection Striping in Nashville

The picture to the left shows the typical bike lane striping for an approach to an intersection with a right turn lane in Nashville. This striping is consistent with the AASHTO *Guide* in which the lines are dashed and the dash (or dot) is 2 feet long and 6 inches wide.

Emerging Practice

Denmark and Germany have implemented the use of an advanced bicycle box. This box is the same as the advanced stop line except that different color paint is used on the pavement between the vehicular stop line and the advanced stop line. This gives the bicyclist more visibility at the intersection and improves the ability of the cyclists to turn left.

Example of Advanced Bicycle Box

Painted Conflict Area in Portland, Oregon

In Portland, Oregon a study was conducted to determine if painting bike lanes at motorist-bicyclist conflict areas would improve safety at these areas. The results of the study showed that motorists yielded to the bicyclists more and the bicyclist stayed in the recommended path.

Some US cities are making use of painted pavement to bring attention to bicyclist in conflict areas where there are high bicycle volumes and/or high incidences of bicycle/vehicular collisions

2.4.3 Bike Lane Symbols & Signing

The AASHTO *Guide* states that bike lanes should be marked with standard pavement symbols which include a bicycle symbol and a directional arrow. As an alternative, the words "BIKE LANE" accompanied by a directional arrow can be used. Bike lane signs can be installed along with the pavement markings according to the MUTCD.

<u>Peer Cities</u>

The following are several example applications from the peer cities.

Bike Lane Sign at an Intersection in Chicago

Shown in the picture to the left is a sign developed in Chicago that illustrates the location of the bike lane for an intersection approach that provides a right turn lane.

The bike lane sign shown in the picture to the right was designed for Baltimore to use where new bike lanes are being constructed to inform motorists of the change.

Bike Lane Sign Created for Baltimore

Bike Lane Sign Used in Denver

The picture to the left shows the standard AASHTO Bike Lane sign which is used in Denver.

Bike Lane Ends Sign Used With Share the Road Sign in Nashville

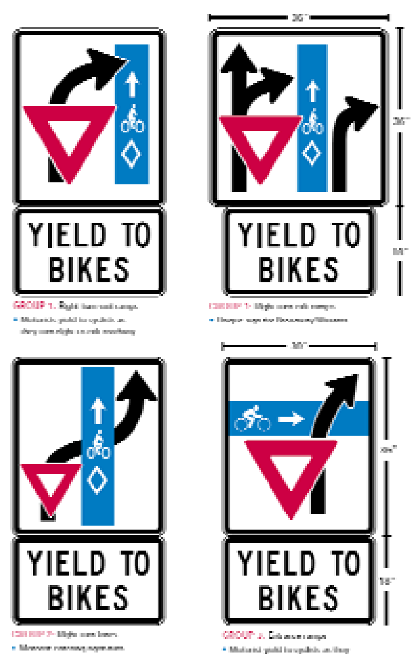
In Nashville the transition from a bike lane to a shared roadway is indicated by the two signs shown in the picture to the left.

Emerging Practice

Recommended pavement markings and signs found in the AASHTO *Guide* and in the 2003 Edition of the MUTCD provide a range of viable options for use with bike lane accommodations. In addition to these provisions, several cities throughout the United States are experimenting with various applications to further increase the safety of bicycle travel. The following are a few such emerging practices.

Blue Markings - A 1996 study in Montreal, Quebec found the use of blue markings at five intersections resulted in a small but significant decrease in conflicts. The study also found that cyclists exercised greater caution after the installation of colored markings and significantly increased the number of cyclists following the delineated path. To determine whether such colored markings help improve safety at bicycle-motor vehicle crossings in the United States, the City of Portland in 1999 conducted its own research using blue pavement markings at select conflict areas within the City. The study resulted in positive benefits and thus the City now uses such applications as do a few other cities throughout the United States.

Blue Bike Lane in Cambridge, MA



Signage Used at Blue Bike Lane Locations in Portland, Oregon

The Oregon DOT is experimenting with a few new warning signs including a new "bike lane ends" sign and a "railroad crossing" sign as depicted below.

Bike Lane Ends Sign Used by Oregon DOT

Railroad Crossing Warning Sign Used by Oregon DOT

2.5 Other Considerations for On-Street Bicycle Facilities

There are a variety of other design considerations related to on-street bicycle accommodations. Typically these considerations address specific safety issues and/or are intended to improve the overall provision of bicycle accommodations. Such design considerations include:

- Drain Grates
- Rumble Strips
- Railroad Crossings
- Traffic Signal Accommodations
- Bike Parking
- Bikes and Transit
- Traffic Calming and Roundabouts

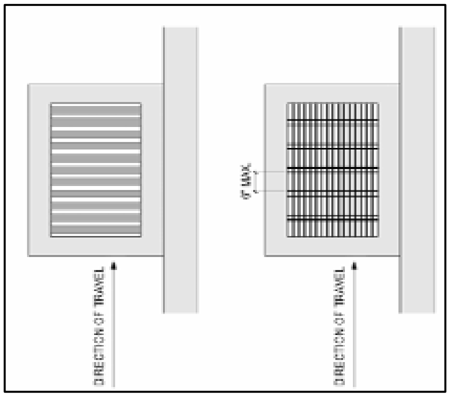
Each of these design considerations are described below along with peer city and/or best practices. Where the City of Memphis has specific practices for these design considerations they are also noted.

2.5.1 Drain Grates

Drain grate inlets and utility covers can be hazards for bicyclists. Typical problems with grates and covers include:

- drainage grate slots that can trap or divert bicycle wheels
- slippery utility cover or grate surfaces
- surfaces not flush with the roadway
- collection of debris and water
- grates placed in driveways or curb cuts

The drain grate should be installed so that the bars are perpendicular to the direction of travel. If the bars are installed parallel to the direction of travel a bicycle tire can get caught in the grate, as shown in the picture to the right.



Example Bike Friendly Drain Grates

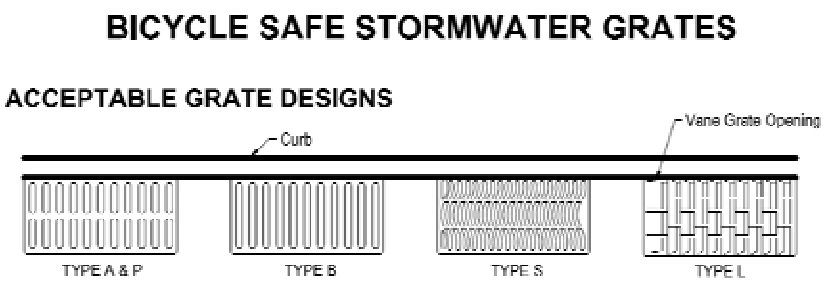
Drain Grate that Runs Parallel to the Direction of Travel

City of Memphis

The City of Memphis is in the process of retrofitting existing drain grates within the City which are not considered bicycle friendly.

Peer Cities

Much like the City of Memphis each of the peer cities now employ bicycle safe (or bicycle friendly) drain grates. Below is a peer city example from the City of Baltimore.



The City of Baltimore Has Four Types of Acceptable Grate Designs Which Are Bicycle Safe

2.5.2 Rumble Strips

Rumble strips are grooved rows of pavement that run perpendicular to the lane of travel and alert motorists by making noise and vibrating when the vehicle tires travel over them. If inappropriately placed, rumble strips installed in the shoulder of highways decrease the amount of travel width for bicyclists and present an unsafe surface for the cyclist.

Rumble Strips Placed in the Shoulder of a Highway

The AASHTO *Guide* states that rumble strips or raised pavement markers are not recommended where shoulders are used by bicyclists unless there is a minimum clear path of 1 foot from the rumble strip to the traveled way, 4 feet from the rumble strip to the outside edge of paved shoulder, or 5 feet to adjacent guardrail, curb or other obstacle. If existing conditions preclude achieving the minimum desirable clearance, the width of the rumble strip may be decreased.

City of Memphis

The City of Memphis does not utilize rumble strips, although TDOT does on controlled access facilities (e.g. interstates) and some state highways throughout the urban area of Memphis.

Peer Cities

Practice not used by peer cities. The use of rumble strips is typically the practice of a state DOT, not that of a local municipality.

Emerging Practice

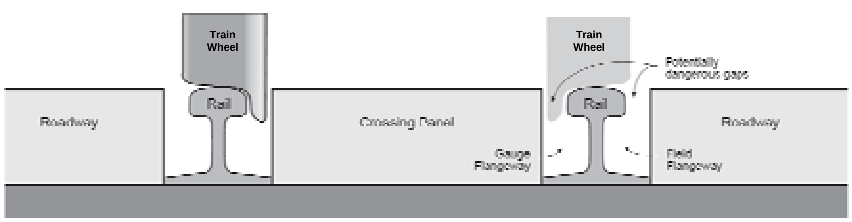
Some State highway agencies have instituted policies that prohibit the use of shoulder rumble strips on roads designated as bike routes or where there is insufficient paved shoulder room remaining to accommodate bicycle travel. Others evaluate the use of rumble strips on a case-by-case basis and often opt to install them only at locations with a history of run-off-road crashes.

Other designs being used or investigated employ a skip pattern of rumble strip that provides a smoother travel path throughout portions of the strip and thus allows bicyclists to move to the left when needed. Furthermore, some State highway agencies are providing an aid to cyclists and all travelers in general by posting roadside signs, such as "RUMBLE STRIPS AHEAD", alerting the traveler to the presence of the shoulder rumble strip.

Example Warning Sign

2.5.3 Railroad Crossings

Numerous bicycle crashes have resulted from dangerous highway railroad crossings. Special care should be taken wherever a roadway crosses railroad tracks at grade. The most important crossing features for bicyclists are the crossing angle and the presence of a gap on either side of the track's rail; and the crossing's smoothness.



Potential Dangers of a Railroad Crossing

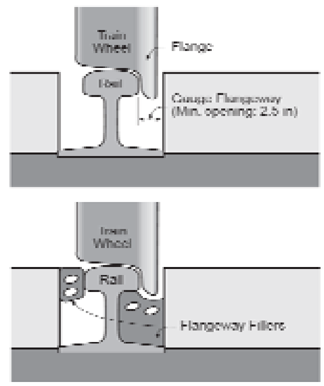
Railroad crossings should ideally be straight and at a 90-degree angle to the rails. The more the crossing deviates from this ideal angle, the greater the potential for a bicyclist's front wheel to be diverted by the gap on either side of the rail — or even by the rail, itself. Crossing angles of 30 degrees or less are considered exceptionally hazardous, particularly when wet.

Emerging Practice

Many communities call for having bicycle facilities constructed to cross over railroad tracks perpendicular to the track. This approach is intended to keep the tire from becoming caught in the railroad track. Flaring the approach of the bicycle facilities to the railroad tracks, as shown in the following picture, allows room for the bicyclist to maneuver to cross the tracks perpendicular to the travel direction.

Other practices used by many communities include installing fillers made of rubber or polymer to minimize the gap between the railroad track and the roadway surface. While not a complete solution to the problem it can help to reduce the gap between the side of the railroad track and the roadway surface which is the primary source of the problem for bicyclists in crossing a railroad track.

Flared Approach to Railroad Tracks



Flangeway Fillers

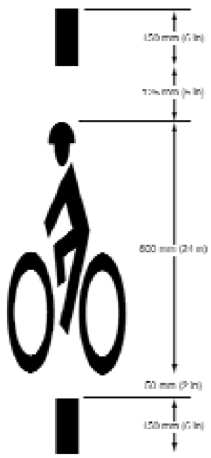
2.5.4 Traffic Signal Accommodations for Bicyclists

There are several design treatments that can be employed at signalized intersections to help improve the safety of bicycle travel on roadways. These treatments include:

- bicycle detection devices at signalized intersections, and
- bicycle signals at critical intersection locations.

Traffic Signal Bicycle Detection

The detection of bicyclists at signalized intersections can improve efficiency, decrease delay to bicyclists, and discourage red light running by cyclists without causing inordinate delays to motorists. While there are several technologies for detection of bicyclists at signalized intersections well placed loop detectors with pavement markings are currently the most reliable technology for bicycle detection.



The MUTCD pavement symbol marking to the left is used to identify the bicycle-sensitive location on the loop detection.

Standard loop detectors will detect bicyclists, but the sensitivity must be adjusted so that bicyclists are detected, and the loops must be placed in a location where a bicyclist's movements can be registered. Detection using loop detectors does not depend on the presence of conductive metals as commonly thought. Instead, most in-pavement loop detectors commonly used today are inductive loops, which are triggered by a break in the magnetic field. Therefore, it does not necessarily require a heavy metal frame to be detected by these mechanisms.

Where bicycle detection is provided at an intersection, signs and pavement markings should be provided to identify the area of detection and explain the markings to cyclists.

<u>City of Memphis</u>
While at present there are no existing detection design procedures specifically for signals within the City of Memphis, the *Memphis MPO Regional Bicycle and Pedestrian Plan*, which incorporates the City, does include design guideline recommendations for bicycle loop detection provisions. These recommendations follow that of the AASHTO *Guide* and MUTCD.

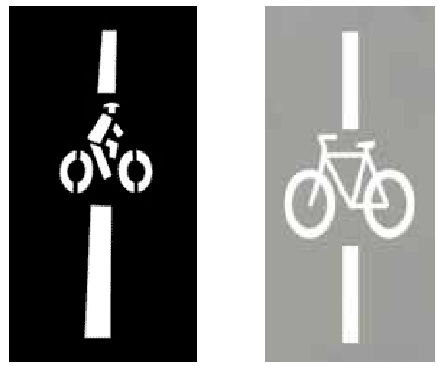
<u>Peer Cities</u>
A review of peer city plans indicate that the installation of bicycle detection technologies at signalized intersections is supported. The City of Denver *Bicycle Master Plan* includes recommendations for bicycle detection improvements at several locations within Denver as does the City of Chicago *Bike 2015 Plan* for the City of Chicago. In Denver, typical locations for consideration include existing signalized intersections with high levels of bicycle travel.

<u>Emerging Practice</u>
Many cities in California have bicycle detection devices that are often cited as best practices. Other communities within the United States utilizing bicycle detection devices that are noteworthy are Washington County, Oregon and Madison, Wisconsin.

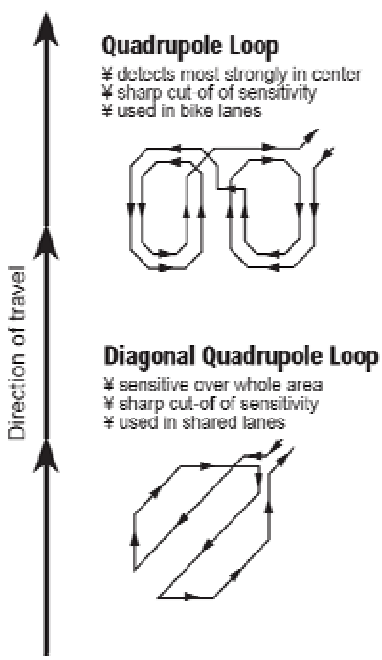
Technician Uses Bicycle to Identifying Ideal Sensor Spot

As illustrated in the picture to the left, Washington County, Oregon Traffic Engineering personnel identify what they call the “sweet spot” and then mark it with a logo similar to the one shown below. Cyclists then know that positioning their bike over the logo as shown provides the greatest potential for detection and activation of that signal approach.

To the right are two example pavement marking symbols that are often used to illustrate the location where a cyclist should be situated to trigger the traffic light. The symbol to the far right is what is utilized in Washington County, Oregon.



Example Pavement Markings Used at Signals



Preferred detector loops for bicycles is the quadrupole loop, as illustrated to the left, given their higher sensativty than other loop dections.

These loop detection configurations are standards used by numerous municipatites throughout the United States including the DOTs of California and Massachusetts.

Bike Signals

A bicycle signal is an electrically powered traffic control device that is typically used in combination with an existing traffic signal. Bicycle signals direct bicyclists to take specific actions and are used to address an identified safety or operational problem involving bicycles. Bicycle signal heads are commonly used around the world in such places as the Netherlands, England, Germany, and China. The MUTCD addresses signalization for bicycles; however, most applications of bicycle signals are addressed in a state's supplement to the MUTCD such as that of the State of California.

Bike Signal Used in Europe

The signal design is similar to a standard traffic signal, except that it uses red, yellow and green bike icons rather than red, yellow and green "balls."

<u>Peer Cities</u>

Currently none of the peer cities are using bicycle signals, although most of the peer city's design guidelines support the application of bicycle traffic signal accommodations.

<u>Emerging Practice</u>

The first United States application was used in the City of Davis, California. The City of Davis has been using a bicycle traffic control device (also referred to as a "bicycle signal head") since the mid-1990s. The City of Davis began using this type of traffic signal to help expedite the safe movement of bicycles through the City's more heavily used intersections (one intersection where these are in use has had counts of over 1,000 bicycles per hour).

Bike Signal Used in Davis, CA

2.5.5 Bike Parking

Providing bicycle parking facilities is an essential element in an overall effort to promote bicycling. Bicycle parking facilities should be provided at both the trip origin and trip destination and should offer protection from theft and damage. There are two levels of fixed structured parking for bicyclist:

- **Short-term Bike Parking**: The most common type of short-term bicycle parking used is bicycle racks which are low-cost devices that provide a location to secure a bicycle. Bicyclists are able to lock both their frame and wheels, and the racks are usually compatible with any type of bicycle lock. The bicycle rack is secured to the ground in a highly-visible location where there is good surveillance. Short-term bicycle parking is commonly used for short trips, when cyclists are planning to leave their bicycles for a few hours or less.

- **Long-term Bike Parking**: For long-term bicycle parking, bicycle lockers are commonly used. Bicycle lockers are covered storage units that can be locked individually, providing secure parking for one bicycle. Also used for long-term parking are bicycle stations which are secure areas with limited-access doors. Occasionally, they are attended, and they may offer services such as repair, rentals, or sales. Both of these means are designed to provide complete enclosure of a bicycle; therefore providing bicyclists with a high level of security so that they feel comfortable leaving their bicycles for long periods of time. They are appropriate for employees of large buildings and at transit stations.

City of Memphis

While bike racks exist in the City and several Memphis Area Transit Authority (MATA) transit stops are equipped with bicycle lockers the City of Memphis currently does not have specific bike rack design standards nor bike rack accommodation requirements. However, the City's Zoning Regulations do have provisions for amenity incentives in association with multifamily and central business districts. By providing various amenities (e.g. bike racks, benches, and other pedestrian accommodations) as part of a development request, certain development incentives are attributed to the specific development.

Peer Cities

The following are several noteworthy peer city practices:

- Since 1993 the "Inverted U" type bike rack has been the City of Denver's required bicycle parking rack.
- In Milwaukee, the City's zoning ordinance requires a specific number of bicycle parking spaces per square footage for newly constructed buildings. The ordinance also states where the bicycle parking should be located and other specifications such as the use of a U-mounted rack to secure the bicycle with a cable or lock.
- Baltimore and Charlotte use bicycle racks which follow the recommendations of the Association of Pedestrian and Bicycle Professionals *Bicycle Parking Guidelines* published by in 2002.
- Chicago provides covered or sheltered bicycle parking at large sporting events or special events.
- The City of Nashville's *Downtown Streetscape Elements Design Guidelines*, Nashville has established four specialized bike rack designs for use in various locations throughout the downtown area.

Bicycle Station located in Chicago at Wrigley Field

Covered Bike Racks in Baltimore

To the right is each of the bike rack designs that are utilized in downtown Nashville. Specific districts have been established in the downtown and the use of each rack design is limited to those specific districts.

Required bike rack designs in downtown Nashville

<u>Emerging Practice</u>

The Association of Pedestrian and Bicycle Professionals (APBA) published in 2002 the report *Bicycle Parking Guidelines* which contains a set of industry standards for the selection and placement of short-term bicycle parking. The guidelines discuss four major components which are described below:

- The guidelines state that the rack element which is the device that supports the bicycle should:
    - Support the bicycle upright by its frame in two places
    - Prevent the wheel of the bicycle from tipping over
    - Enable the frame and one or both wheels to be secured
    - Support bicycles without a diamond-shaped frame with a horizontal top tube

- The rack consists of a grouping of rack elements. The rack elements may be attached to a single frame or remain single elements mounted within close proximity to each other. The rack element is not to be easily detachable from the rack frame or easily removed from the mounting surface. The rack is to be anchored so that it cannot be stolen with the bikes attached—vandal resistant fasteners can also be used to anchor a rack in the ground if the rack is not large and heavy.

Typical U-Mounted Rack

- Combining multiple racks turns an area into a bicycle parking lot. A rack area or "bicycle parking lot" is an area where more than one rack is installed. Aisles separate the racks. The aisle is measured from tip to tip of bike tires across the space between racks. The minimum separation between aisles should be 48 inches which is enough space for one person to walk one bike. In high traffic areas where many users park or retrieve bikes at the same time, such as a college classroom, the recommended minimum aisle width is 72 inches. Large rack areas with a high turnover rate are to have more than one entrance to facilitate the arriving and departing of cyclists and pedestrians. The guidelines suggest when possible rack areas be protected from outside weather conditions.

- The location of the rack and the relationship of the rack to the building entrance it serves is important for useful bicycle parking areas. The best location for a rack area is immediately adjacent to the entrance it serves. Racks should not be placed so that they block the entrance or inhibit pedestrian flow in or out of the building. Racks that are far from the entrance and hard to find are perceived to be vulnerable to bicycle theft and will not be used by most cyclists.

APBA's bicycle parking guidelines strongly recommend against the comb, toast, schoolyard, or other wheel bending racks that provide no support for the bicycle frame.

2.5.6 Bikes and Transit

To enhance the use between public transit and bicyclists, it is important for public transit such as buses, subways, and rails to accommodate bicycles both on the vehicles and at the stations. Often bicycle racks or areas are provided on buses, subways, and rails, and policies are in place to ensure that bicyclists can easily utilize the public transit.

<u>City of Memphis</u>

Memphis Area Transit Authority (MATA) has bike on bus accommodations on newer vehicles as depicted in the picture to the right. The MATA bike on bus racks can accommodate two bicycles at a time. In addition to on-vehicle accommodations several MATA stations are also equipped with bike lockers.

MATA Bus with Bike Rack

Peer Cities

Like the City of Memphis each peer city provides bike on bus accommodations. The following summarizes several of the peer city practices:

- Chicago Transit Authority (CTA) allows bicycles on buses equipped with attached front exterior bicycle racks. Bicycle parking racks are also installed outside most CTA rail stations. In total, 68 stations have racks which have been installed indoors or in sheltered locations at these stations.
- Charlotte Authority Transit System allows bicycles on buses equipped with attached front exterior bicycle racks. Racks accommodate two bicycles at a time.
- All of Nashville Metro Transit Authority's fixed route vehicles are equipped with bike on bus racks. Additionally, the Regional Transportation Authority which operates the Music City Star, a commuter rail line from Nashville to Wilson County, also allows bikes onboard at no charge with bike storage areas on each rail car.

CAT Bus with Bike Rack

Nashville MTA
Bus with Bike Rack

Emerging Practice

The City of Phoenix, Arizona has the longest running bike on bus program starting in 1991 as an experimental pilot. At the time, three bus routes serving the Arizona State University campus were picked for a six-month experiment, during which time more than 5,500 bicycles were carried along with their passengers. The experiment proved that combining transit and bicycling could work and the City quickly approved the installation of bike racks on all its buses.

Other cities with noted successful bike on bus programs include:

- Seattle, Washington
- San Francisco, California
- Portland, Oregon
- Miami, Florida

2.5.7 Traffic Calming & Roundabouts

Traffic calming utilizes a variety of design techniques to create streets that are more livable and less dominated by the automobile. This is typically accomplished either by reducing the volume of automobile traffic directly with diversions or by reducing the volume of automobile traffic indirectly by making the street a slower route for automobiles. One objective of traffic calming is to create a safer and more comfortable environment for bicycles and pedestrians. Lower automobile volumes and slower speeds can create a more comfortable biking environment and may reduce the number of collisions and their severity. However, some traffic calming techniques can actually be counterproductive, creating an environment that is less comfortable for bicycles.

Peer Cities

In Charlotte, speed humps are installed several feet from the edge of pavement to allow for bicycle travel.

Speed Hump with Bicycle Access in Charlotte, NC

Traffic Circle with Bike Signs in Charlotte, NC

Baltimore recommends that where traffic calming is required striped facilities, such as bike lanes or shoulders, be used to narrow the travel lane and slow traffic.

Emerging Practice

It is important that while installing traffic calming devices to slow traffic, provisions are made to enable bicycle travel through the area. This includes installing speed humps a minimum of 3 feet from the edge of pavement as constructed in Charlotte. Also, as shown in the picture to the right, it is recommended that where chicanes are installed the bike lane should continue along the edge of pavement.

Bike Lane installed at a Chicane

2.6 Maintenance of On-Street Bicycle Facilities

Maintenance is required for all bicycle facilities to remain usable. The pavement should be adequately maintained so that there is a smooth surface for the bicyclists. Maintenance activities include sweeping the bicycle facilities so that it remains clear of debris, broken glass, and gravel. Also the pavement markings and signage should be replaced as they become faded and unreadable.

Bicycles and bicyclists tend to be particularly sensitive to maintenance problems. Since bicyclists often ride near the right margin of the road they use areas that are generally not maintained like the main lanes. On higher speed roads, the passage of motor vehicle traffic tends to sweep debris to the right, again where most bicyclists travel. In addition, ridges, like those found where a new asphalt overlay does not quite cover the older roadway surface, can catch a wheel and create a dangerous situation.

City of Memphis

The City's Public Works Division is responsible for the maintenance of the City's infrastructure which includes streets and highways, bridges, and storm drains. This Division is responsible for the repair and maintenance, including asphalt overlay and pothole repairs on more than 3,400 miles of roadway within the City; routine maintenance and emergency repair service to existing drainage systems within the City's right-of-way; street lighting; and heavy equipment services to support City maintenance and emergency activities. Like most urban areas, the City utilizes a dedicated call-in number to report street maintenance requests such as the repair of a pothole.

Peer Cities

Each of the peer cities are very similar to Memphis in the sense that maintenance services are supported through the city's public works (or transportation division). A few noteworthy practices of the peer cities include:

- In Baltimore, the City is in the process of developing maintenance procedures and guidelines with visuals in a small version for distribution to city maintenance crews. Training of maintenance personnel will also occur so these individuals can identify conditions of concern to bicyclists such as small potholes, glass, pavement cracks, overgrown vegetation, improperly installed signs, crumbling curbs, and dangling wires and take appropriate steps to resolve the specific issue. Baltimore is also in the process of establishing a bicycle related improvement request system through the City's 311 call center and website.

- One of the goals in the City of Charlotte's bicycle plan calls for the implementation of bicycle-friendly maintenance procedures. Several strategies of this goal include:
  - establishing a spot improvement program for implementation of low cost improvements to maintain and enhance bicycle facilities in the city.
  - when resurfacing, mill the asphalt uniformly from the edge of pavement to a tolerance of ¼ inch at the gutter seam.
  - sweep streets with bike lanes or paved shoulders every six weeks.
  - work with local organizations to develop an "Adopt a Bike Lane" campaign to clean bike lanes of debris.

- Denver provides a dedicated maintenance line for bike facilities. Denver is working to increase citizen awareness of the City's maintenance phone number (720-865-BIKE) by placing signage on trails, bridges, and other off-street bicycle facilities. The signs are to inform citizens of the phone number for the city agency responsible for the maintenance of the facility.

Emerging Practice

A couple of successful, noteworthy bicycle maintenance programs include:

- Seattle's Bicycle Spot Improvement Program which is regarded as one of the best in the nation and allows for the construction of low cost improvements to enhance bicycle safety and convenience. Examples of the types of improvements addressed through this program include surface improvements such as patching potholes and filling seams between concrete panels in the street, replacing drain grates, signing and striping motor vehicle warning signs at trail crossings, adjusting electronic detection for bicyclists at traffic signals, installing sidewalk bicycle racks, and other low cost bicycle improvements as appropriate. The City of Portland, Oregon also has a spot-improvement program similar to that of Seattle's. An interesting aspect of Portland's is the use of postage-paid, pre-addressed postcards which are made available to the public, to be sent in when they notice a needed improvement.

- The City of Corvallis, Oregon has a well established bicycle facility maintenance program which maintains 60 miles of bike lanes on an ongoing, year-round basis. All bike lanes are swept every ten days, except during the Fall Leaf Collection Program (November/December) when they are swept daily, Monday through Friday. All bike lane markings are redone annually, and pothole patching and other problems are responded to when identified. Corvallis also has 13 miles of shared-use path within the city which is swept 18 times a year by a private contractor.

2.7 Work Zones & Temporary Traffic Controls

It is not uncommon, particularly in urban areas, that road work and the associated temporary traffic controls affect existing bicycle facilities. Temporary lane restrictions, detours and other traffic control measures instituted during construction should be designed to accommodate non-motorized travelers whenever possible, especially in areas where bicycling is common.

City of Memphis

The 2003 Edition of the *Manual for Uniform Traffic Control Devices (MUTCD)* contains standards and guidance for accommodating bicyclist through work zones. The MUTCD is used by the City of Memphis and each of the peer cities with specific standards applied depending on the type of work zone activity and work zone environment.

Peer Cities

In addition to MUTCD standards, the City of Chicago is in the process of developing bicycle-friendly construction standards. Items being considered include the use of temporary steel plates that are skid-proof and flush with the surrounding pavement and restoring pavement surfaces and markings, particularly along designated bikeways, to their original condition as soon as possible to minimize negative impacts to bicyclists.

Denver frequently employees bicycle detour signs during construction activities to minimize the impact of flow to existing bicycle travel, as depicted in the picture to the right.

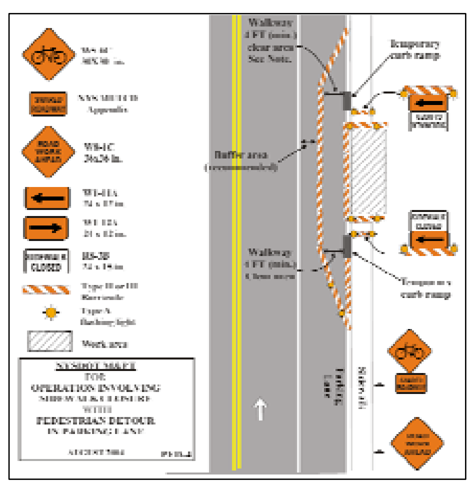
Bicycle & Pedestrian Detour Sign, Denver

Emerging Practice

The following are a couple of noteworthy practices being employed by other municipalities:

- The New York State DOT's *Traffic Engineering and Highway Safety Work Zone Traffic Control Manual* contains several standard work zone diagrams which provide detailed standards for accommodating bicyclists through work zones. The manual is often referred as a best practice.

- The Maryland DOT has an established public policy statement that the best engineering practices regarding the needs of bicyclists and pedestrians shall be employed in all phases of transportation planning, including highway design, construction, reconstruction, and repair. From this policy statement, the Maryland State Highway Authority has developed the following guidelines for providing space for cyclists and



Work Zone Traffic Control Diagram from New York DOT Manual walkers through work zones:

- A four foot minimum, five foot preferred width should be maintained through work zones to accommodate bicycles. Care should be taken to ensure that obstacles such as bridge abutments, equipment, construction materials, traffic control devices, etc. do not encroach into the bicycle space.
- Where the posted speed limit is 50 mph or lower and a minimum 4 foot shoulder width cannot be maintained, bicycles will typically be required to share the road with motorists. Installing “Share the Road” signs may also be considered.
- No accommodations will be considered for bicycle access through work zones on roadways where bicycles are designated by signing as being prohibited. This includes all interstate highways and some controlled access highways.

3 Off-Street Bicycle Facilities

3.1 Shared-Use Paths

Off-street bike facilities or shared-use paths (also commonly referred to as bike paths, trails, sidepaths, and greenways), are largely non-motorized facilities most often built on exclusive rights-of-way with relatively few motor vehicle crossings. A shared-use path is a facility that is physically separated from motor vehicle traffic by an open space or barrier, and may be within the roadway right-of-way or within an open space. Paths are normally two-way facilities.

Shared-use path along an existing railroad line

Generally, shared-use paths are used to serve corridors not served by streets and highways or where wide utility or former railroad right-of-way exists, permitting such facilities to be constructed away from the influence of parallel streets. Shared use paths offer opportunities not provided by the road system. They can provide a recreational opportunity or, in some instances, can serve as direct commute routes if cross-flow by motor vehicles and pedestrians is minimized. The most common applications are along rivers, canals, limited access freeways, utility rights-of-way, former or active railroad rights-of-way, within college campuses, or within and between parks.

Memphis Riverwalk Path

Shared-use paths are considered a complementary system of off-road transportation routes for bicyclists and others that serve as a necessary extension to the roadway network. The Riverwalk in Memphis is a prime example of a shared-use path which provides connections along the riverfront to various points in the downtown area to a variety of users, as shown in the picture to the left.

3.2 Design Considerations

Like streets and highways there are numerous design aspects that must be considered with a shared-use path. Because these paths serve a variety of users (walkers, cyclists, rollerbladers, runners, joggers, etc.) of all ages (kids, adults, and seniors) and because these facilities often cross and/or connect to streets and highways the design considerations of a shared-use path have different design challenges and considerations as compared to other bicycle facility types.

These considerations include:

- The design width, speed, sight distance, clearance, grade, and drainage of a shared-use path.
- The separation distance between a shared-use path and a roadway.
- The connection and crossing of a shared-use path with a roadway or other facility.
- The signs, symbols, and traffic control devices used in association with a shared-use path.
- The presence and use of under and over-passes, bridges, and tunnels with a shared-use path.
- Other design considerations such as path heads, rest stops, and the use of lighting.

While not an exhaustive list of all design considerations, these items cover a large share of the design issues associated with a shared-use path and are discussed below. Where standards exist for the City of Memphis and peer cities as related to these design considerations they are noted. Also, where best practices exist for these design considerations they are noted.

3.2.1 Widths, Speeds, Sight Distance, Clearance, Grades, & Drainage

The following design considerations are discussed below:

- **Widths** - The AASHTO *Guide* states under most conditions a recommended minimum all-paved width for two directional shared-use paths is 10 feet. Eight feet is considered the absolute minimum width but only if there is low bicycle use, little expected pedestrian use, and no anticipated maintenance vehicle loading conditions that could cause damage to the pavement edges. Many communities and states have gone to a 10 foot minimum width for shared-use paths and a 12-foot width in high-use areas.

- **Design Speed** - The design of a shared-use path should take into account the likely speed of users, the ability of bicyclists to turn corners without falling over, skidding, or hitting their pedal on the ground as they lean over. The AASHTO *Guide* has a number of tables, and equations to help designers meet the tolerances of a bicyclist based on the following key numbers:

  - 20 miles per hour is the minimum design speed to use in designing a bike path
  - 30 miles per hour should be used where downgrades exceed 4 percent
  - 15 miles per hour should be used on unpaved paths where bicyclists tend to ride more slowly (and cannot stop as fast without skidding or sliding on a loose surface)

  The result is a series of recommended desirable minimum curve radii for corners.

- **Sight Distance** - The ability of a cyclist to stop or slow down to avoid a collision or crash is affected by many things. The rider must have time to identify a potential problem and react accordingly, which means that they must be able to see approaching intersections or corners in plenty of time even when they are traveling at the design speed of the trail. The bicycle itself must be able to be stopped or brought under control in time, which is affected by the braking ability of the bike, the surface material (a loose surface requires greater stopping distance), and the weather (wet conditions require greater stopping distances than dry). The AASHTO *Guide* and most state/local manuals have tables and charts to calculate the appropriate sight distances in a range of situations.

- **Horizontal and Vertical Clearances** – A 2 foot wide graded area adjacent to both sides of a shared-use path is listed in the AASHTO *Guide* as the minimum clearance distance from trees, poles, walls, fences, guardrails, or other lateral obstructions. A wider graded area (3 feet or more) on either side of the shared-use path is listed as, preferred. The additional space can serve as a separate jogging path as well. The minimum vertical clearance to obstructions and, in undercrossings and tunnels, is noted in the AASHTO *Guide* as 8 feet. However, the *Guide* states the vertical clearance may need to be greater to permit passage of maintenance vehicles – listing a clearance of 10 feet as the desirable height.

- **Grades and Cross Slopes** - Another critical factor in shared-use path design is the grade or slope of the path. Generally, grades greater than 5 percent (one feet of climbing for every 20 feet traveled forward) are undesirable as they are hard for bicyclists to climb and may cause riders to travel downhill at a speed where they cannot control their bicycle. However, recognizing that trails cannot always remain quite flat, the AASHTO *Guide* offers the following suggested lengths for certain grades:

  - 5-6 percent is acceptable for up to 800 feet
  - 7 percent is acceptable for up to 400 feet
  - 8 percent is acceptable for up to 300 feet
  - 9 percent is acceptable for up to 200 feet
  - 10 percent is acceptable for up to 100 feet
  - 11 percent plus is acceptable for up to 50 feet

  And, suggestions are offered for ways to mitigate the impact of steeper slopes, such as:

  - adding 4-6 feet of additional width to the trail to allow sufficient space for a cyclist to dismount and walk their bicycle without blocking the trail, or to allow cyclists to pass each other
  - alerting cyclists to the approaching grade with appropriate signs and markings posting a recommended descent speed
  - exceeding the usual minimum stopping sight distances to allow for the higher speeds
  - exceeding the usual minimum thresholds for providing recovery areas and railings
  - using a series of short switchbacks to contain the speed of descending riders

- **Drainage** - The AASHTO *Guide* recommends a minimum cross slope of 2 percent to provide adequate drainage. Since paths are also used by pedestrians, their design also needs to comply with ADA requirements and a cross slope of 2 percent is consistent with ADA requirements.

<u>City of Memphis</u>

The *Memphis MPO Regional Bicycle and Pedestrian Plan*, which incorporates the City of Memphis, includes design guideline recommendations for shared-use paths. These recommendations follow those of the AASHTO *Guide*.

Peer Cities

Based on a review of plans and guidelines from peer cities, each city appears to follow at a minimum, the recommendations of the AASHTO *Guide*. A few of the peer cities have established the preferred or desired recommendations from the *Guide* as their minimums. For example, in Denver the minimum vertical clearance is set at 10 feet for under and over-pass structures.

Emerging Practice

The Florida DOT has produced several publications which provide excellent examples of preferred design practices for shared-use paths. Most of the publications build upon the AASHTO *Guide* and provide recommended standards which tend to be above the minimum guidance of the AASHTO *Guide*. For example, the Florida DOT standard for a two directional shared-use path is a paved width of 12 feet and a minimum horizontal clearance of 4 feet.

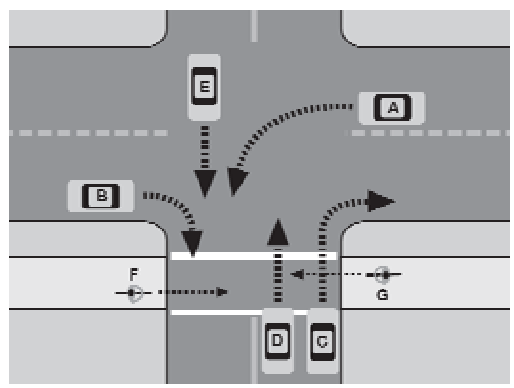
Florida DOT Publications

- *Trail Intersection Design Handbook*
- *Designing Trail Termini Report*
- *Florida Bicycle Facilities Planning and Design Handbook*

Florida Publications

3.2.2 Separation between Shared-Use Paths and Roadways

National and state design manuals strongly caution against developing shared-use paths immediately adjacent to highways. The AASHTO *Guide* states when two-way shared-use paths are located immediately adjacent to a roadway (a sidepath); increased operational problems are likely to occur. However, in some cases, paths along highways for short sections are permissible, given an appropriate level of separation between facilities. Some problems with paths located immediately adjacent to roadways are:



Potential Conflict Points

- If it is a two-way path located next to the roadway, one direction of bicycle traffic rides against motor vehicle traffic which is contrary to normal rules of the road.
- 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.
- 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.
- 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.
- 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.
- Stopped cross-street motor vehicle traffic or vehicles exiting side streets or driveways may block the path crossing.

- 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, can complicate maintenance of the facility, and can cause other problems as well.

For the above reasons and depending upon traffic conditions, other types of bikeways are likely to be better suited to accommodate bicycle traffic along highway corridors. However, when a two-way shared use path is located adjacent to a roadway, the AASHTO *Guide* recommends as wide a separation between the shared-use path and the adjacent highway as possible, with a minimum of 5 feet of horizontal separation, or a physical barrier of sufficient height.

Shared-use path with landscaped separation, NY

City of Memphis

The City of Memphis follows the recommendations of the AASHTO *Guide*.

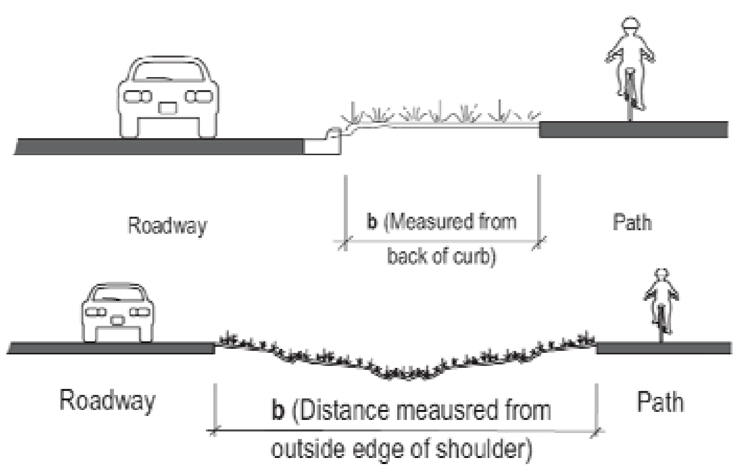
Peer Cities

Each of the peer cities follows the recommendations of the AASHTO *Guide*. Several of the state DOTs for these cities have established more refined guidance on separation standards between shared-use paths and roadways. For example, the Wisconsin DOT *Bicycle Facility Design Handbook* provides several examples of how best to deal with the placement of shared-use paths next to roadways.

Shared-use path adjacent to road in Minnesota

Emerging Practice

The Minnesota DOT *Bikeway Facility Design Manual* provides standards for separation distances for shared-use paths adjacent to roadways, based on the speed limit and the presence of a curb. These standards are shown in the following diagram and table.



Curb		No Curb	
Speed Limit (MPH)	**Separation (b)**	**Speed Limit (MPH)**	**Separation (b)**
30 or less	5 ft (minimum) 3 ft (minimum, w/parking)	40 mph or less	20 ft (desirable) 10 ft (minimum)
35 - 40	5 ft (minimum)		
45 or greater	10 ft (desirable) 5 ft (minimum)	45 mph or greater	24 ft - 35 ft
Freeway	50 ft (minimum)	Freeway	50 ft (minimum)

Source: Minnesota DOT

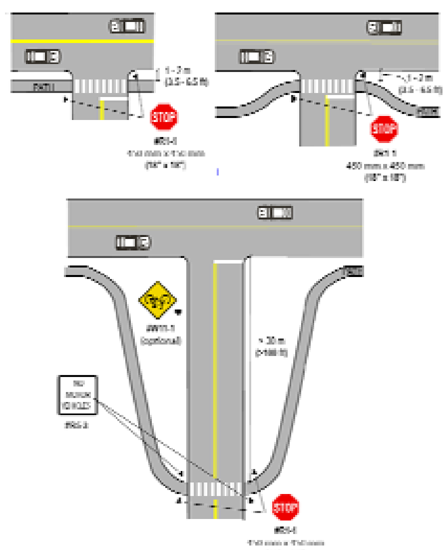
As illustrated in the table above, greater separation distance is required as roadway speeds increase.

3.2.3 Roadway Intersections, Crossings, & Connections

Where shared-use paths must cross roadways, driveways, or other paths, it is important that the path design facilitate the safest and most convenient crossing movements possible. Shared-use path intersections with roadways offer special design challenges, especially since most users may have a wide range of cycling skills and diverse characteristics.

Unsignalized Crossing in Oregon

There are three basic categories of path-roadway intersections noted in the AASHTO *Guide*: midblock, adjacent path, and complex. Each of these intersection types may cross any number of roadway lanes, divided or undivided, with varying speeds and volumes of motor vehicle traffic, and may be uncontrolled, or more typically, sign or signal controlled.



Typical Intersection Crossings

FHWA provides the following general guidelines for at-grade intersections of shared-use paths with roads:

- The shared-use path should intersect the road at a 90-degree angle
- Increase path width at the intersection to reduce user conflicts
- Provide good sight lines for both motorists and path users
- Provide signage to alert motorists of the shared-use path crossing
- Provide a visible crosswalk across the intersection to increase path user and motorist awareness
- Signs, both on the road and the shared-use path, should clearly indicate whether motorists or path users have the right of way
- Curb ramps and detectable warnings are required to alert path users with vision impairments of the street crossing.

Signed Mid-Block Crossing

Railroad Crossing

Medians and refuge islands make it easier for path users to cross busy roadways

City of Memphis

The City of Memphis follows the recommendations of the AASHTO *Guide* and MUTCD.

Peer Cities

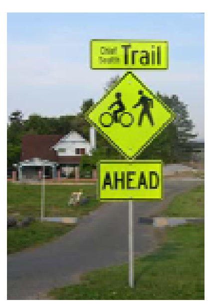
Peer cities follow the recommendations of the AASHTO *Guide* and MUTCD.

Emerging Practice

The Florida DOT *Trail Intersection Design Handbook* has some of the best examples of design treatments for shared-use paths and intersections. Over 60 trail intersections throughout Florida were evaluated in compiling the handbook along with a review of designs and standards currently in use abroad and in the United States.

Seattle, Washington's *Bicycle Master Plan* includes the practice of trail warning signs which provide advance warning of trail crossings. Below are several pictures which illustrate the use of these signs at trail/-roadway crossings.

Advance Warning Signs



Advance Warning Signs with Subplates

Example Trail-Roadway Crossing with Trail Yield Treatment

3.2.4 Signs, Symbols & Traffic Control Devices

Adequate signing and marking are essential on shared-use paths and fall into the same three main categories found in roadway signing and marking: regulatory, warning, and informational devices. Each category is associated with certain colors. Regulatory controls are associated with red, black, and white; warning devices with yellow and fluorescent yellow-green; informational devices with blue, green and brown. In striping, however, yellow is also a regulatory color.

Regulatory controls alert users to a legal condition that otherwise might not be obvious. Basically, they tell people what to do.

Path sign in Carrboro, North Carolina

Path signs in Denver

Warning devices are used to alert users to hazardous (or potentially hazardous) conditions on or adjacent to a shared-use path. They are also used to let others (e.g., motorists on a cross street) know about the presence of the path and the potential for conflicts.

Path Sign in Minneapolis, Minnesota

Path Sign in Franklin, TN

Information signs and markings are intended to simply and directly give users essential information that will help them on their way. They guide path users along paths; inform them of interesting routes; direct them to destinations; and identify nearby rivers, streams, parks, and historical sites.

Informational sign used in Alexandria, VA

Informational signs from the MUTCD used with a shared-use path

Traffic signals for path-roadway intersections are appropriate under certain circumstances. The MUTCD lists 8 warrants for traffic signals, and although path crossings are not addressed, bicycle traffic on the path may be functionally classified as vehicular traffic and the warrants applied accordingly. Special loop detectors (which can detect bicycles) as well as bicycle oriented signal call buttons can facilitate the crossing.

Example Bicycle Traffic Signal

Refer to Section 2.5.4 (Traffic Signal Accommodations for Bicyclists) of this technical memorandum for appropriate practices.

City of Memphis

The City of Memphis follows the recommendations of the AASHTO *Guide* and MUTCD.

Peer Cities

Peer cities follow the recommendations of the AASHTO *Guide* and MUTCD.

Emerging Practice

The DOTs of California, Florida, Maryland, Minnesota, Oregon, and Wisconsin have some of the most comprehensive signing and marking collections for shared-use paths.

In Maryland, the State Highway Authority's *Bicycle and Pedestrian Design Guidelines* promote the use of:

- High Intensity Activated Crosswalk (HAWK) Signals,
- PELICAN (pedestrian light control activated) Signals, and
- Toucan (Two can cross the roadway) Signals

for roadway crossings by bicyclists and pedestrians. The use of these traffic signal treatments have proven to provide safe crossing accommodations to both pedestrians and cyclists. The City of Tucson, Arizona is credited with the first use of Toucan device in the United States and for creating the HAWK traffic signal.

The Toucan (Two can cross the roadway) signal assists pedestrians and bicyclists with crossing an arterial type roadway where a full traffic control signal is not warranted. This is the only signal that provides a push button or other type of detection for bicyclists as well as a push button for pedestrians. The separate detection for pedestrians and bicyclists allows for the clearance interval to change depending on the speed of the user crossing the roadway.

Toucan Signal used in Tucson, AZ

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

This treatment is profiled in ITE's *Traffic Control Devices Handbook*.

HAWK Signal

The PELICAN (pedestrian light control activated) crossing is used at midblock locations with median refuge islands. This type of signal is valuable because it minimizes vehicular delay and is relatively easy to fit within an existing arterial synchronization system.

PELICAN Signal

3.2.5 Bridges, Tunnels, & Overpasses

One of the great advantages and unique features of shared-use paths is that they often have grade separated intersections with the highway system and other crossings, and have bridges to carry them over rivers or stream valleys. However, not all corridors have this asset and structures of all kinds are needed to carry path users under or over obstacles such as highways, rivers, and freeways.

The critical dimensions to use in designing under and over-passes, bridges, and tunnels include:

- the minimum width of the path should be maintained through the structure
- the clear distance of two feet on either side of the path surface should also be maintained through the structure - otherwise, riders will tend to ride in the center of the path to stay away from the wall or railing of the structure
- an overhead clearance of a minimum 8 feet, with good horizontal and vertical clearance, and good sightlines, should be maintained through an underpass or tunnel (with 10 feet as the desirable height)
- railings, fences or barriers on both sides of a path on a structure should be at least 42 inches high, and where they are higher than this a rub rail should be provided at the approximate handlebar height of 42 inches
- clearances should allow for maintenance and emergency vehicles, as should the strength of the bridge (live loading)

Highways, particularly freeways, can be significant barriers to bicycle movement. In many cases bridges can be retrofitted to provide a bicycle crossing under the barrier. In some instances, the existing bicycle crossing can be upgraded to provide bicycle access.

The following pictures illustrate example design treatments of each of the various applications.

Path Tunnel under Highway

Path Bridge

Path Underpass in Denver

<u>City of Memphis</u>
The City of Memphis follows the recommendations of the AASHTO *Guide*.

<u>Peer Cities</u>
Peer cities follow the recommendations of the AASHTO *Guide*.

<u>Emerging Practice</u>
Structure design practices are typically unique to the specific project and project constraints/opportunities. Numerous design practices exist for both large and small types of facilities. The following are several examples illustrating the diversity of shared-use path structure design practices.

Path Tunnel in Indiana

Path Bridge in Knoxville, TN

Path Bridge in Cary, NC

Path Bridge in Nashville, TN

Overpass in Phoenix, AZ

Underpass in North Carolina

3.2.6 Other Design Considerations (Path Heads, Rest Stops & Lighting)

Path Heads and Rest Stops

Any long shared-use path or path network needs rest stops. These should be at intermediate points, scenic lookouts, or near amenities such as restaurants, convenience stores, beaches, picnic areas, parking lots, etc. Any rest stop should be away from the path so bicyclists can pull off the path and not block traffic. A rest stop should have, as a minimum, a bench, shade, a parking rack, and a trash receptacle. In addition, water fountains and restroom facilities should be included at one or more rest stops on the pathway.

Emergency Call Box along Path

Other amenities which should be considered include interpretive signage, informational kiosks, emergency call boxes (pay phones where cost effective), emergency weather instructions, shelters, watering facilities for horses (where applicable), hitching posts, rest rooms, and intermodal connections.

Example Informational Marker along Trail

Example Trailhead with Various Amenities

Example Restrooms along Trail

Lighting

Shared use paths in urban and suburban areas often serve travel needs both day and night, for example commuter routes and trails accessing college campuses. Fixed source lighting improves visibility along trails and at intersections, and is critical for lighting tunnels and underpasses. The AASHTO *Guide* recommends using average maintained illumination levels of between 5 and 22 lux.

The above pictures are examples of typical path lighting applications

Fixed source lighting can reduce crashes along shared-use paths and at intersections. In addition, lighting allows the bicyclist to see the path direction, surface conditions and obstacles. Lighting for shared-use paths is important and should be considered where riding at night is expected. Paths receiving nighttime usage commonly serve college students or commuters.

<u>City of Memphis</u>

The City of Memphis follows the recommendations of the AASHTO *Guide*.

<u>Peer Cities</u>

Peer cities follow the recommendations of the AASHTO *Guide*.

3.3 Maintenance of Off-Street Bicycle Facilities

Maintenance is an important consideration for all transportation facilities including shared-use paths. Good maintenance practices, such as periodic sweeping, surface repairs, tree pruning, mowing, trash removal, litter pick-up, new pavement markings, etc., are important elements of a routine maintenance schedule.

Maintenance practices described under on-street bicycle facilities are applicable to shared-use paths. Refer to Section 2.6 - Maintenance of On-Street Bicycle Facilities for appropriate practices.

3.4 Work Zones & Temporary Traffic Controls

Agencies use temporary traffic control signs to help motorists get through or around a work zone. The same approach is used for shared-use path users. Putting a barrier across a path without warnings and directional aids can create a hazard, particularly for bicyclists riding at dusk or at night.

Each temporary traffic control zone is different. Many variables, (e.g., location, user speeds, lighting) affect the needs of each zone. Most jurisdictions use the MUTCD for temporary traffic control zones applying appropriate provisions for shared-use path. In many cases, an advance warning sign on either end of a work zone with proper directional aids to a safe detour is adequate.

Work zone and temporary traffic control practices described under on-street bicycle facilities are applicable to shared-use paths. Refer to Section 2.7 - Work Zones & Temporary Traffic Controls for appropriate practices.

Temporary traffic control practices used in Denver on a shared-use path in the City

<u>City of Memphis</u>

The MUTCD is used by the City of Memphis and each of the peer cities with specific standards applied depending on the type of work zone activity and work zone environment.

<u>Peer Cities</u>

The City of Denver frequently employees bicycle detour signs during construction activities to minimize the impact of flow to existing bicycle travel and could be classified as a best practice for bicycle-friendly construction practices.

4 Standards for Selecting Appropriate Bicycle Facilities

While many State and local agencies have adopted their own design practices or those of the AASHTO *Guide*, there is still considerable debate over the appropriate choice of bicycle facility type in any given set of circumstances. This section describes practices for selecting roadway design treatments to accommodate bicyclists. Due to limited information from peer cities on this topic, information presented in this section comes from four primary sources:

- *Bicycle Facilities Selection: A Comparison of Approaches*. Pedestrian and Bicycle information Center Highway Safety Research Center, University of North Carolina. Chapel Hill, NC, 2002.
- *Guide for the Development of Bicycle Facilities*. AASHTO, 1999.
- *Selecting Roadway Design Treatments to Accommodate Bicycles*. Federal Highway Administration, 1994.
- *The Effect of Bicycle Accommodations on Bicycle/Motor Vehicle Safety and Traffic Operations*. Final Report, FHWA-RD-92-069, Federal Highway Administration, November 1994.

Collectively these publications represent the current state of the practice for selecting roadway design treatments to accommodate bicyclists.

4.1 Common Basis of Selection

In general, standards for selecting appropriate bicycle facility accommodations are formed around three basic categories of concern:

- the skill level of the bicycle user,
- the type of roadway involved, and
- traffic operational factors.

A detailed description of each category is presented below.

Skill Level of the Bicycle User

Industry standards define three basic types of bicycle users:

- **A**dvanced or experienced riders are generally using their bicycles as they would a motor vehicle. They are riding for convenience and speed and want direct access to destinations with a minimum of detour or delay. They are typically comfortable riding with motor vehicle traffic; however, they need sufficient operating space on the traveled way or shoulder to eliminate the need for either themselves or a passing motor vehicle to shift position.

- **B**asic or less confident adult riders may also be using their bicycles for transportation purposes, e.g., to get to the store or to visit friends, but prefer to avoid roads with fast and busy motor vehicle traffic unless there is ample roadway width to allow easy overtaking by faster motor vehicles. Thus, basic riders are comfortable riding on neighborhood streets and shared-use paths and prefer designated facilities such as bike lanes or wide shoulder lanes on busier streets.

- **C**hildren, riding on their own or with their parents, may not travel as fast as their adult counterparts but still require access to key destinations in their community, such as schools, convenience stores and recreational facilities. Residential streets with low motor vehicle speeds, linked with shared-use paths and busier streets with well-defined pavement markings between bicycles and motor vehicles, can accommodate children without encouraging them to ride in the travel lane of major arterials.

These definitions suggest that bicyclists with different skill levels will prefer certain facility types. Advanced bicyclists, because of their advanced skills, desire for speed, convenience, and direct access, prefer direct routes even though these routes may also carry significant vehicle traffic, without any dedicated space for bicyclists. Children, however, prefer shared residential roads with little traffic or separated paths.

<u>The Type of Roadway Involved</u>

Another important consideration is whether the bicycle accommodation is being considered for new construction, reconstruction, or is a retrofit to an existing facility. Different opportunities are afforded to transportation planners and engineers depending on the type of project. For example, accommodating bicyclists with shared roadway signs and shared roadway markings could be done through a typical resurfacing project whereas constructing a new shared-use path on a new alignment is likely achieved as a capital improvement. The importance is that there are varying opportunities of providing bicycle facility accommodations whether it is routine maintenance and/or during the construction of a new roadway or development.

<u>Traffic Operational Factors</u>

A general consensus has emerged among transportation planners and engineers working with bicycle facilities regarding the traffic operations and design factors having the greatest effect on bicycle use. The six factors most often cited include:

- **Traffic Volume** - Higher motor vehicle traffic volumes represent greater potential risk for bicyclists and the more frequent overtaking situations are less comfortable for group B/C bicyclists unless special design treatments are provided.

- **Average Motor Vehicle Operating Speed** - The average operating speed is more important than the posted speed limit, and better reflects local conditions. Again, motor vehicle speed can have a negative impact on risk and comfort unless mitigated by special design treatments.

- **Traffic Mix** - The regular presence of trucks, buses, and/or recreation vehicles (i.e., approximately 30 per hour or more) can increase risk and have a negative impact on comfort for bicyclists. At high speeds, the wind blast from such vehicles can create a serious risk of falls. Many bicyclists will choose a different route or not ride at all where there is a regular presence of such traffic unless they are able to remove themselves several feet from these motor vehicles.

- **On-Street Parking** - The presence of on-street parking increases the width needed in the adjacent travel lane or bike lane to accommodate bicycles because of the risk of dooring. This is primarily a concern associated with streets and highways built with an urban section.

- **Sight Distance** - "Inadequate sight distance" for bicyclists primarily relates to situations where bicycles are being overtaken by motor vehicles and where the sight distance is likely less than that needed for a motor vehicle operator to either change lane positions or slow to the bicyclist's speed. This problem is primarily associated with rural highways, although some urban streets have sight distance problems due to poor design and/or sight obstructions.

- **Number of Intersections** - Intersections pose special challenges to bicycle and motor vehicle operators, especially when bike lanes or separate bike paths are introduced. The AASHTO *Guide* and various State design manuals include general guidelines for intersection treatments. When possible, the number and/or frequency of intersections should be considered when assessing the use of bike lanes.

4.2 Selection Methods

Early research in the United States on methods for selecting appropriate bicycle accommodations was first holistically studied in 1994 by the Federal Highway Administration (FHWA). In the report, *Selecting Roadway Design Treatments to Accommodate Bicycles*, recommended accommodation provisions are presented in a series of tables for particular roadway situations by bicycle user group. Five criteria were used to determine recommended bicycle facilities: traffic volume; average motor vehicle operating speed; traffic mix of automobiles, trucks, buses, and/or recreational vehicles; on-street parking; and sight distance. Values for these criteria were determined and tables were developed for urban and rural roadway sections for two groups of bicycle users.

The following tables present accommodation parameters from the report for urban roads with and without on-street parking by user group (e.g. Group A and Group B/C).

Roadway Design Treatments and Widths for Accommodating Bicyclists
Group A (Highly Skilled Adults) Bicyclists
on Urban Roads w/o On-Street Parking

	Average Annual Daily Traffic (AADT) Volume					
	less than 2,000		2,000 - 10,000		over 10,000	
Average Motor Vehicle Operating Speed	adequate sight distance	inadequate sight distance	adequate sight distance	inadequate sight distance	adequate sight distance	inadequate sight distance
Less than 30 mi/h	12' (SL)	14' (WC)	12' (SL)	14' (WC)	14' (WC)	14' (WC)
30 - 40 mi/h	14' (WC)	15' (WC)	14' (WC)	15' (WC)	14' (WC)	15' (WC)
41 - 50 mi/h	15' (WC)	15' (WC)	15' (WC)	6' (SH)	15' (WC)	6' (SH)
over 50 mi/h	6' (SH)	6' (SH)	6' (SH)	6' (SH)	6' (SH)	6' (SH)

Key
SL = Shared Lane
WC= Wide Curb Lane
SH = Shoulder
BL = Bicycle Lane n/a = not applicable
1 mi/h = 1.61 km/h

Notes:
- WC numbers represent "usable widths" of outer lanes measured from the lane stripe to the edge of the gutter pan. If no gutter pan is provided, add 1 ft. (0.3) minimum for shy distance from face of curb.
- BL numbers indicate minimum width from curb face. The bicycle lane stripe should lie at least 4' (1.2 m) from the edge of the gutter pan or drainage area.
- WC and SL numbers represent "usable widths" of outer lanes, measured from the lane stripe to the edge of the pavement if a smooth, firm, level shoulder is adjacent. If rough or dropped pavement edges or a soft shoulder exists, add 1 ft. (0.3 m) minimum for shy distance from the edge of the pavement.

Source: Selecting Roadway Design Treatments to Accommodate Bicycles, FHWA

Roadway Design Treatments and Widths for Accommodating Bicyclists
Group B/C Bicyclists (Average Skill Adults/Children)
on Urban Roads w/o On-Street Parking

	Average Annual Daily Traffic (AADT) Volume					
	less than 2,000		2,000 - 10,000		over 10,000	
Average Motor Vehicle Operating Speed	adequate sight distance	inadequate sight distance	adequate sight distance	inadequate sight distance	adequate sight distance	inadequate sight distance
Less than 30 mi/h	14' (WC)	14' (WC)	14' (WC)	14' (WC)	5' (BL)	5' (BL)
30 - 40 mi/h	5' (BL)	5' (BL)	5' (BL)	5' (BL)	5' (BL)	5' (BL)
41 - 50 mi/h	5' (BL)	5' (BL)	6' (BL)	6' (BL)	6' (BL)	6' (BL)
over 50 mi/h	6' (BL)	6' (BL)	6' (BL)	6' (BL)	6' (BL)	6' (BL)

Key
SL = Shared Lane
WC= Wide Curb Lane
SH = Shoulder
BL = Bicycle Lane n/a = not applicable
1 mi/h = 1.61 km/h

Notes:
- WC numbers represent "usable widths" of outer lanes measured from the lane stripe to the edge of the gutter pan. If no gutter pan is provided, add 1 ft. (0.3) minimum for shy distance from face of curb.
- BL numbers indicate minimum width from curb face. The bicycle lane stripe should lie at least 4' (1.2 m) from the edge of the gutter pan or drainage area.
- WC and SL numbers represent "usable widths" of outer lanes, measured from the lane stripe to the edge of the pavement if a smooth, firm, level shoulder is adjacent. If rough or dropped pavement edges or a soft shoulder exists, add 1 ft. (0.3 m) minimum for shy distance from the edge of the pavement.

Source: Selecting Roadway Design Treatments to Accommodate Bicycles, FHWA

Roadway Design Treatments and Widths for Accommodating Bicyclists Group A (Highly Skilled Adults) Bicyclists on Urban Roads with On-Street Parking						
	Average Annual Daily Traffic (AADT) Volume					
	less than 2,000		2,000 - 10,000		over 10,000	
Average Motor Vehicle Operating Speed	adequate sight distance	inadequate sight distance	adequate sight distance	inadequate sight distance	adequate sight distance	inadequate sight distance
Less than 30 mi/h	14' (WC)	14' (WC)	14' (WC)	14' (WC)	14' (WC)	14' (WC)
30 - 40 mi/h	14' (WC)	15' (WC)	14' (WC)	15' (WC)	14' (WC)	15' (WC)
41 - 50 mi/h	15' (WC)	15' (WC)	15' (WC)	6' (SH)	15' (WC)	6' (SH)
over 50 mi/h	n/a	n/a	n/a	n/a	n/a	n/a

Key
SL = Shared Lane
WC= Wide Curb Lane
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1 mi/h = 1.61 km/h

Notes:

- WC numbers represent "usable widths" of outer lanes measured from the lane stripe to the edge of the gutter pan. If no gutter pan is provided, add 1 ft. (0.3) minimum for shy distance from face of curb.
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- WC and SL numbers represent "usable widths" of outer lanes, measured from the lane stripe to the edge of the pavement if a smooth, firm, level shoulder is adjacent. If rough or dropped pavement edges or a soft shoulder exists, add 1 ft. (0.3 m) minimum for shy distance from the edge of the pavement.

Source: Selecting Roadway Design Treatments to Accommodate Bicycles, FHWA

Roadway Design Treatments and Widths for Accommodating Bicyclists Group B/C Bicyclists (Average Skill Adults/Children) on Urban Roads with On-Street Parking						
	Average Annual Daily Traffic (AADT) Volume					
	less than 2,000		2,000 - 10,000		over 10,000	
Average Motor Vehicle Operating Speed	adequate sight distance	inadequate sight distance	adequate sight distance	inadequate sight distance	adequate sight distance	inadequate sight distance
Less than 30 mi/h	14' (WC)	14' (WC)	14' (WC)	14' (WC)	5' (BL)	5' (BL)
30 - 40 mi/h	5' (BL)	5' (BL)	5' (BL)	5' (BL)	6' (BL)	6' (BL)
41 - 50 mi/h	6' (BL)	6' (BL)	6' (BL)	6' (BL)	6' (BL)	6' (BL)
over 50 mi/h	n/a	n/a	n/a	n/a	n/a	n/a

Key
SL = Shared Lane
WC= Wide Curb Lane
SH = Shoulder
BL = Bicycle Lane n/a = not applicable
1 mi/h = 1.61 km/h

Notes:

- WC numbers represent "usable widths" of outer lanes measured from the lane stripe to the edge of the gutter pan. If no gutter pan is provided, add 1 ft. (0.3) minimum for shy distance from face of curb.
- BL numbers indicate minimum width from curb face. The bicycle lane stripe should lie at least 4' (1.2 m) from the edge of the gutter pan or drainage area.
- WC and SL numbers represent "usable widths" of outer lanes, measured from the lane stripe to the edge of the pavement if a smooth, firm, level shoulder is adjacent. If rough or dropped pavement edges or a soft shoulder exists, add 1 ft. (0.3 m) minimum for shy distance from the edge of the pavement.

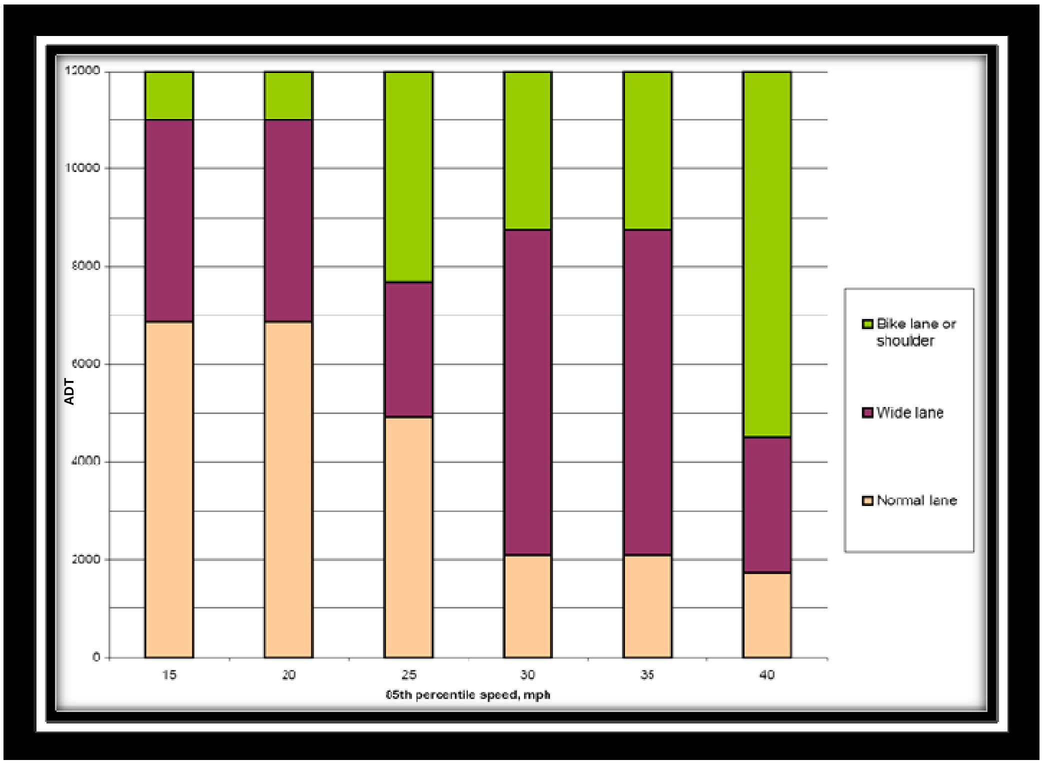
Source: Selecting Roadway Design Treatments to Accommodate Bicycles, FHWA

In a more recent study conducted in 2002, 16 practices were reviewed both within the United States and Europe on bicycle facility selection approaches. The report, *Bicycle Facility Selection: A Comparison of Approaches*, serves as one of the most comprehensive collections of current bicycle facility selection approaches. While the review did not find universal agreement among the guidelines, the research did point to some general ranges in which facility selection decisions are made.

Nearly all of the facility selection approaches reviewed were based on at least two common variables:

1. Traffic volumes (typically ADT volume)
2. Traffic speed (typically 85th percentile speed or speed limit)

Many of the approaches had other variables that were considered but were not common among all other approaches. Despite the many differences between the facility selection guidelines, the review did present an aggregate or composite chart that attempts to represent all guidelines from North America on a single chart.



Source: Bicycle Facility Selection: A Comparison of Approaches

This composite chart points to clear trends among all guidelines:

- Shared roads (also referred to as normal lanes) are recommended where traffic volumes and speeds are low.
- Wide curb lanes are recommended where traffic volumes and speeds are moderate.
- Bicycle lanes are recommended where traffic volumes and speeds are high.

The report concluded that engineering judgment and planning experience will continue to be vital elements in selecting appropriate bicycle facility types.

Two noteworthy practices included in the 2002 study include the design selection standards for the state DOTs of Minnesota and New Jersey. Minnesota's selection standards address all facility types for both 2 lane and 4 lane roadways while New Jersey's deal primarily with shoulders and shared lanes. Below are the accommodation selection tables for each of these state DOTs.

Minnesota DOT
Bikeway Design Selection for Urban (Curb and Gutter) Cross-Section

Motor Vehicle ADT (2 Lane)		<500	500-1,000	1,000-2,000	2,000-5,000	5,000-10,000	>10,000
Motor Vehicle ADT (4 Lane)		N/A	N/A	2,000-4,000	4,000-10,000	10,000-20,000	>20,000
Motor Vehicle Speed	25 mph	SL	WOL	WOL	WOL	BL = 5 ft	Not Applicable
	30 mph	SL with sign	WOL	BL = 5 ft	BL = 5 ft	BL = 6 ft	BL = 6 ft
	35 - 40 mph	WOL	BL = 5 ft	BL = 5 ft	BL = 6 ft	BL = 6 ft	BL = 6 ft or PS = 8 ft
	45 mph and greater	BL = 5 ft	BL = 5 ft	BL = 6 ft	BL = 6 ft	BL = 6 ft or PS = 8 ft	SUP or PS = 10 ft

BL=Bicycle Lane, SL=Shared Lane, WOL=Wide Outside Lane, SUP=Shared-Use

Source: Minnesota DOT Bikeway Facility Design Manual

Minnesota DOT
Bikeway Design Selection for Rural (Shoulder and Ditch) Cross-Section

Motor Vehicle ADT (2 Lane)		<500	500-1,000	1,000-2,000	2,000-5,000	5,000-10,000	>10,000
Motor Vehicle ADT (4 Lane)		N/A	N/A	2,000-4,000	4,000-10,000	10,000-20,000	>20,000
Motor Vehicle Speed	25 mph	PS = 4 ft or SL	PS = 4 ft or SL	PS = 4 ft or WOL	PS = 4 ft	PS = 4 ft	Not Applicable
	30 mph	PS = 4 ft or SL	PS = 4 ft or WOL	PS = 4 ft	PS = 4 ft	PS = 6 ft	PS = 6 ft
	35 - 40 mph	PS = 4 ft or SL	PS = 4 ft or WOL	PS = 6 ft	PS = 6 ft	PS = 6 ft	PS = 8 ft
	45 mph and greater	PS = 4 ft	PS = 4 ft	PS = 6 ft	PS = 8 ft	PS = 8 ft	SUP or PS= 10 ft

BL=Bicycle Lane, SL=Shared Lane, WOL=Wide Outside Lane, SUP=Shared-Use

Source: Minnesota DOT Bikeway Facility Design Manual

New Jersey DOT Design Guidelines for Bike Facilities on Roadways

Condition I
AADT 1200 -2000*

	URBAN W/PARKING	URBAN W/O PARKING	RURAL
<50 km/h (30 mph)	SL 3.6m (12 ft.)	SL 3.3m (11 ft.)	SL 3.0m (10 ft.)
50 km/h-65 km/h (31-40 mph)	SL 4.2m (14 ft.)	SL 4.2m (14 ft.)	SL 3.6m (12 ft.)
65 km/h-80 km/h (41-50 mph)	SL 4.5m (15 ft.)	SL 4.5m (15 ft.)	SH 0.9m (3 ft.)
>80 km/h (50 mph)	NA	SH 1.2m (4 ft.)	SH 1.2m (4 ft.)

* For volumes less than 1200 a shared lane is acceptable.

KEY: SH=shoulder SL=shared lane

Condition II
AADT 2000-10,000

	URBAN W/PARKING	URBAN W/O PARKING	RURAL
<50 km/h (30 mph)	SL 4.2m (14 ft.)	SL 3.6m (12 ft.)	SL 3.6m (12 ft.)
50 km/h-65 km/h (31-40 mph)	SL 4.2m (14 ft.)	SL 4.2m (14 ft.)	SH 0.9m (3 ft.)
65 km/h-80 km/h (41-50 mph)	SL 4.5m (15 ft.)	SL 4.5m (15 ft.)	SH 1.2m (4 ft.)
>80 km/h 50 mph	NA	SH 1.8m (6 ft.)	SH 1.8m (6 ft.)

Condition III
AADT over 10,000 or Trucks over 5%

	URBAN W/PARKING	URBAN W/O PARKING	RURAL
<50 km/h (30 mph)	SL 4.2m (14 ft.)	SL 4.2m (14 ft.)	SL 4.2m (14 ft.)
50 km/h-65 km/h (31-40 mph)	SL 4.2m (14 ft.)	SH 1.2m (4 ft.)	SH 1.2m (4 ft.)
65 km/h-80 km/h (41-50 mph)	SL 4.5m (15 ft.)	SH 1.8m (6 ft.)	SH 1.8m (6 ft.)
>80 km/h (50 mph)	NA	SH 1.8m (6 ft.)	SH 1.8m (6 ft.)

NOTE: NJDOT minimum shoulder width of 2.4 meters (8 feet) should be provided wherever possible on roadways having an AADT greater than 10,000 vehicles.

Source: New Jersey DOT Bicycle Compatible Roadways and Bikeways

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