D DESIGN GUIDELINES

Chapter Outline:

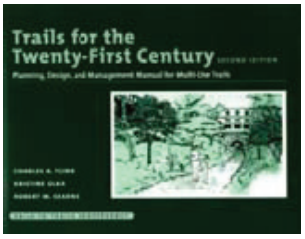
D.0 OVERVIEW

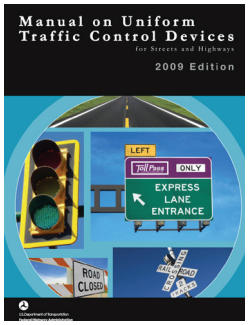
These recommended guidelines originate from and adhere to national design standards as defined by the American Association of State Highway Transportation Officials (AASHTO), the Americans with Disabilities Act (ADA), the Federal Highway Administration (FHWA) Pedestrian Facilities Users Guide, the Manual on Uniform Traffic Control Devices (MUTCD), and the NCDOT. Another major source of information in this chapter is the Pedestrian and Bicycle Information Center, found online at http://www.walkinginfo.org. Should the national standards be revised in the future and result in discrepancies with this chapter, the national standards should prevail for all design decisions. A qualified engineer or landscape architect should be consulted for the most up to date and accurate cost estimates.

The sections below serve as an inventory of pedestrian and bicycle design elements/treatments and provide guidelines for their development. These treatments and design guidelines are important because they represent minimum standards for creating a pedestrian and bicycle-friendly, safe, accessible community. The guidelines are not, however, a substitute for a more thorough evaluation by a landscape architect or engineer upon implementation of facility improvements. Some improvements may also require cooperation with the NCDOT for specific design solutions.

Pedestrian and Bicycle Information Center

AASHTO
THE VOICE OF TRANSPORTATION





The Pedestrian and Bicycle Information Center, AASHTO, the MUTCD, nationally recognized trail standards, and other sources have all informed the content of this chapter.

D

D.1 SIDEWALKS AND WALKWAYS

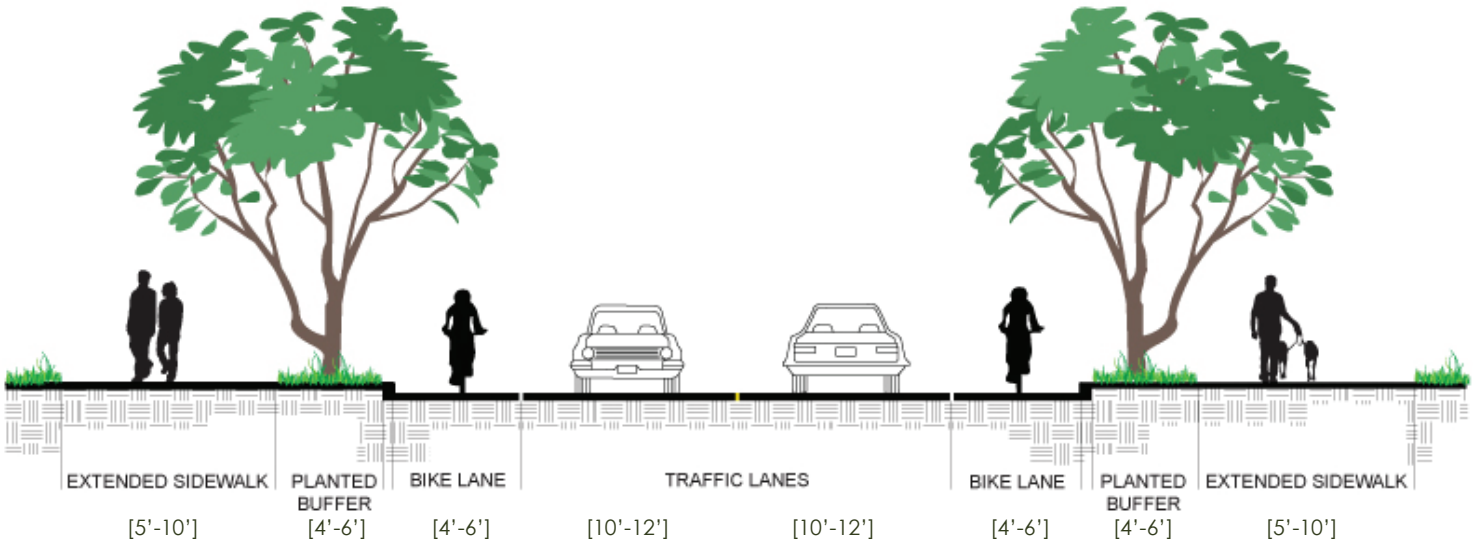
Sidewalks and walkways are extremely important public right-of-way components often times adjacent to, but separate from automobile traffic. In many ways, they act as the seam between private residences, stores, businesses, and the street.

There are a number of options for different settings, for both downtown and more rural and/or suburban areas. From a wide promenade to, in the case of a more rural environment, a simple asphalt or crushed stone path next to a secondary road, walkway form and topography can vary greatly. In general, sidewalks are constructed of concrete although there are some successful examples where other materials such as asphalt, crushed stone, or other slip resistant material have been used. The width of the walkways should correspond to the conditions present in any given location (i.e. level of pedestrian traffic, building setbacks, or other important natural or cultural features). The Federal Highway Administration (FHWA) and the Institute of Transportation Engineers both suggest five feet as the minimum width for a sidewalk. This is considered ample room for two people to walk abreast or for two pedestrians to pass each other. Often downtown areas, near schools, transit stops, or other areas of high pedestrian activity call for much wider sidewalks.

A well designed residential sidewalk will have a width of at least five feet. (Image from http://www.walkinginfo.org)

Sidewalk with a vegetated buffer zone. Notice the sense of enclosure created by the large canopy street trees. (Image from http://www.walkinginfo.org)

Below: Typical street with bicycle lanes and adjacent sidewalk.



SIDEWALKS AND WALKWAY GUIDELINES:

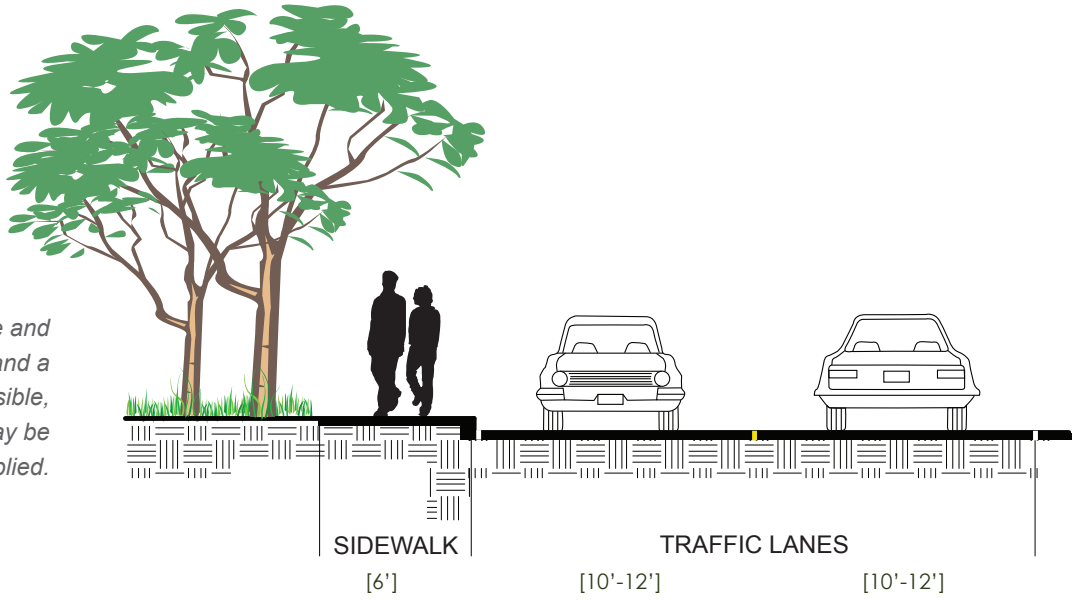
Sidewalk Guideline Sources:

American Association of State Highway and Transportation Officials. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.

Metro Regional Government. (2005). Portland, Oregon: Transportation Information Center. http://www.oregonmetro.gov

- Concrete is preferred surface, providing the longest service life and requiring the least maintenance. Permeable pavement such as porous concrete may be considered to improve water quality.
- Sidewalks should be built as flat as possible to accommodate all pedestrians; they should have a running grade of 5% or less; with a 2% maximum cross-slope.
- Concrete sidewalks should be built to minimum depth of four inches; six inches at driveways.
- Sidewalks should be a minimum of five feet wide; sidewalks serving mixed use and commercial areas shall be a minimum of 8 ft in width (12–15 feet is required in front of retail storefronts). The maximum cross-slope should be no more than 2% (1:50)*.
- Buffer zone of two to four feet in local or collector streets; five to six feet in arterial or major streets and up to eight feet in busy streets and downtown to provide space for light poles, street trees,f and other street furniture. See the Landscaping section later in this chapter for shade and buffer opportunities of trees and shrubs.
- Motor vehicle access points should be kept to minimum.

** If a greater slope is anticipated because of unusual topographic or existing conditions, the designer should maintain the preferred slope of 1:50 within the sidewalk area, if possible. This can be accomplished either by raising the curb so that the cross-slope of the entire sidewalk can be 1:50, or by placing the more steeply angled slope within the area between the sidewalk and the road.*



Right: Where space and topography are limiting and a planted buffer is not possible, this cross section may be applied.

- If a sidewalk with buffer on both sides is not feasible due to topography and right-of-way constraints, then a sidewalk on one side is better than no facility. Each site should be examined in detail to determine placement options.

D.2 GREENWAY TRAILS

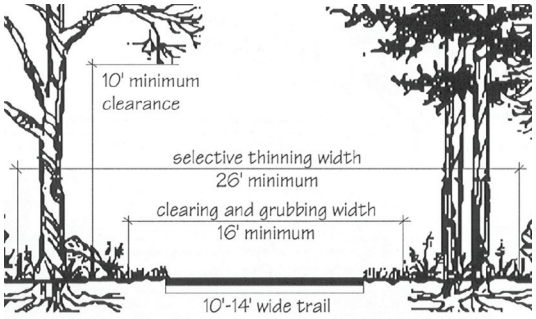
A greenway is defined as a linear corridor of land that can be either natural, such as rivers and streams, or manmade, such as abandoned railroad beds and utility corridors. Many greenways contain trails. Greenway trails can be paved or unpaved, and can be designed to accommodate a variety of trail users, including bicyclists, walkers, hikers, joggers, skaters, horseback riders, and those confined to wheelchairs. Single-tread, multi-use trails are the most common trail type in the nation. These trails vary in width and can accommodate a wide variety of users.

Note: A greenway trail located along a roadway corridor is sometimes referred to as a 'sidepath'.

TRAIL GUIDELINES:

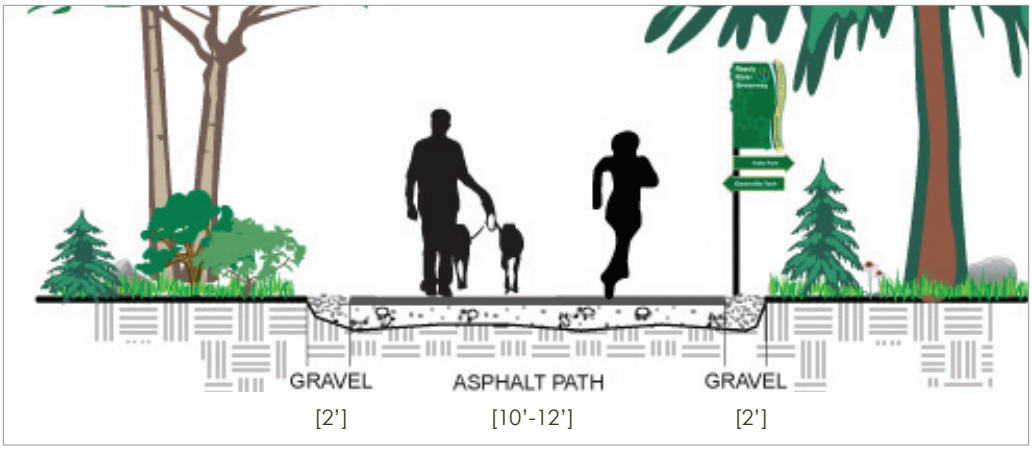
- The minimum width for two-directional trails is 10', however 12'-14' widths are preferred where heavy traffic is expected. Vertical clearance under bridges and other structures should be 8' to 10'.
- Centerline stripes should be considered for paths that generate substantial amounts of pedestrian traffic, or along curved portions of the trail, where sight-lines are limited. Radii minimums should also be considered depending on the different user groups.
- While the vegetative clearing needed for these trails varies with the width of the trail, the minimum width for clearing and grubbing a 10' wide trail is 16'. Selective thinning increases sight lines and distances and enhances the safety of the trail user. This practice includes removal of underbrush and limbs to create open pockets within a forest canopy, but does not include the removal of the forest canopy itself.
- Crossings should be a safe enough distance from neighboring intersections to not interfere (or be interfered) with traffic flow.
- A roadway with flat topography is desirable to increase motorist visibility of the path crossing.
- Motorists and trail users should be warned, such as with signage (including trail stop signs), changes in pavement texture, flashing beacons, raised crossings, striping, etc.
- A refuge is needed where crossing distance is excessive and in conditions exhibiting high volumes/speeds and where the primary user group crossing the roadway requires additional time, such as schoolchildren and the elderly.
- The crossing should occur as close to perpendicular (90 degrees) to the roadway as possible.
- If possible, it may be desirable to bring the path crossing up to a nearby signalized crossing in situations with high speeds/ADT and

Below: Vegetation clearing guidelines



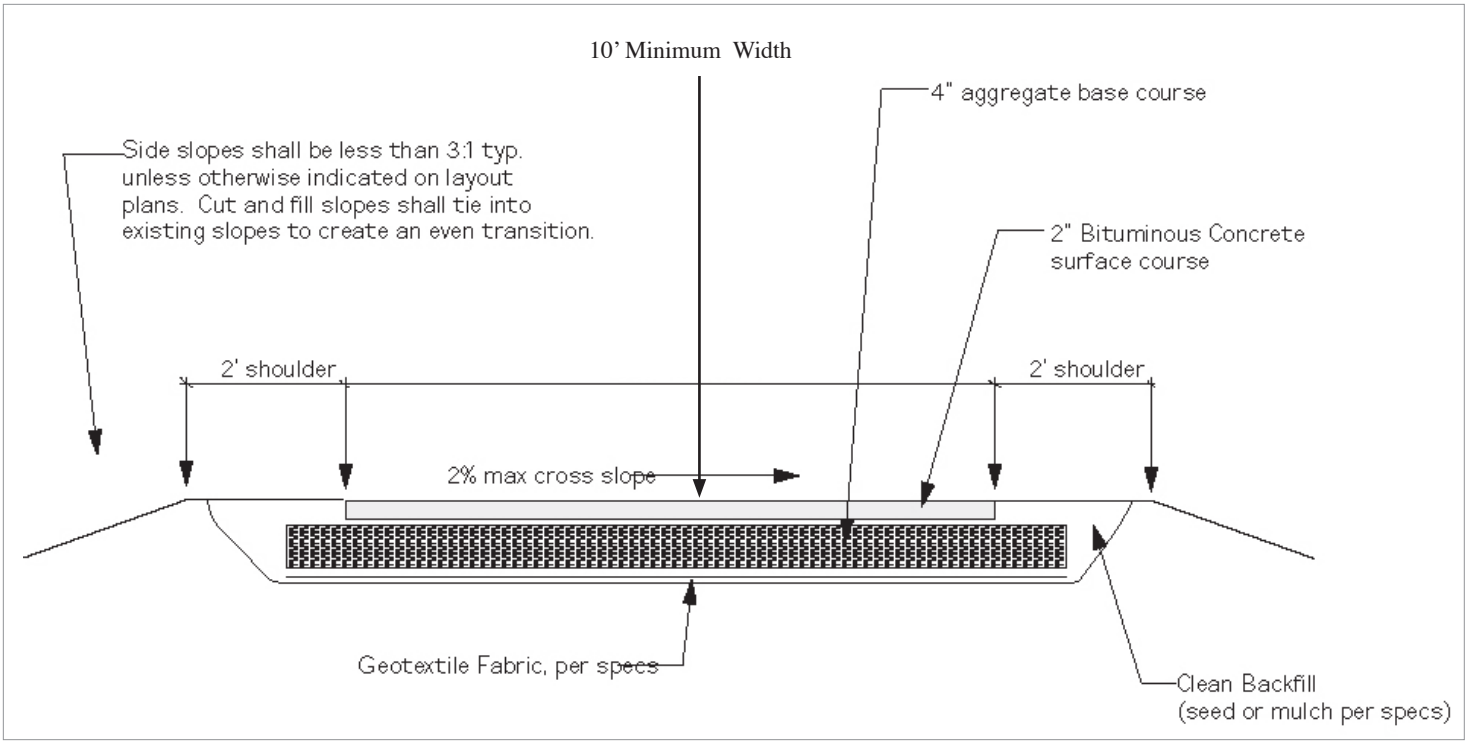
(continued on page D-6)

Right: Typical asphalt path section



Right: Typical natural surface trail section

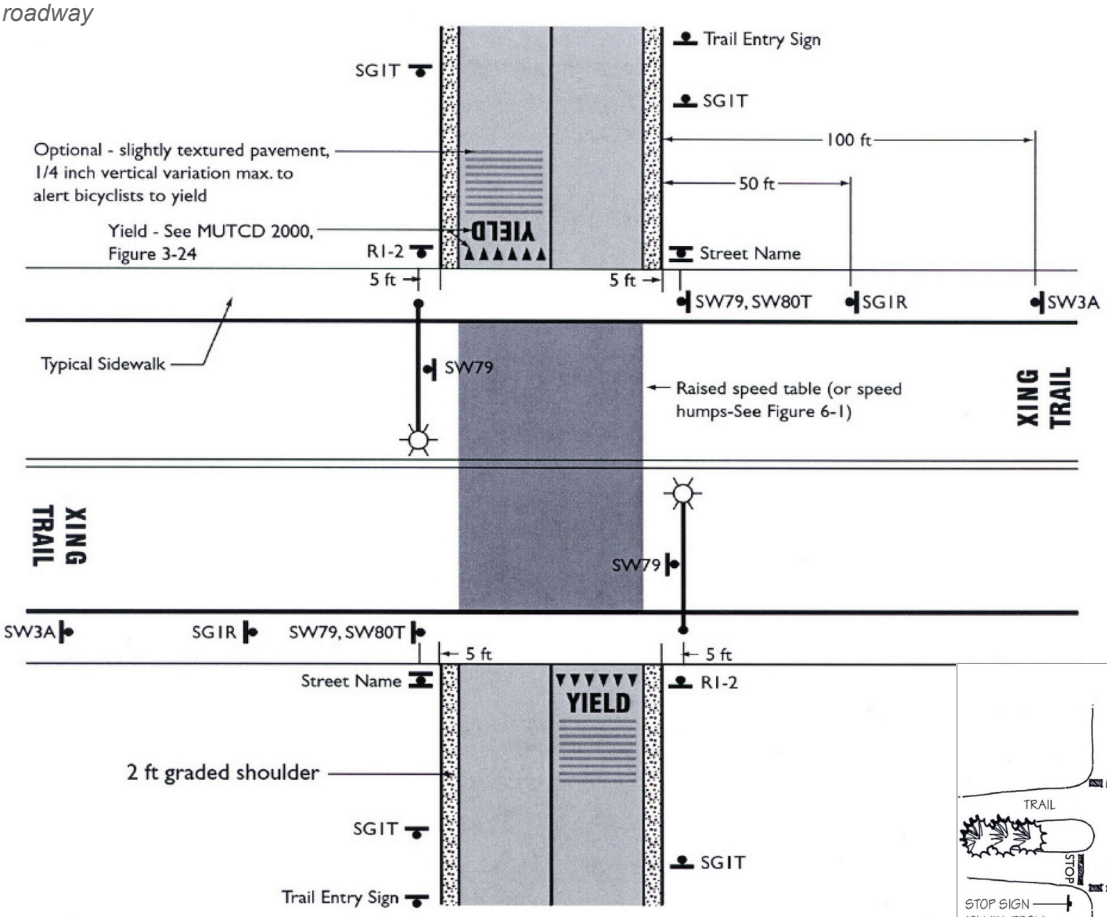
Below: Asphalt pavement construction detail

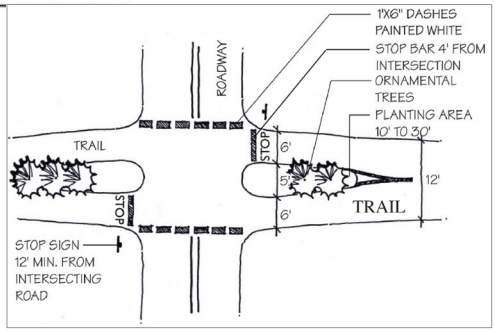


design and/or physical constraints.

- Signalized crossings may be necessary on trails with significant usage when intersecting with demanding roadways, but MUTCD warrants must be met for the installation of a signalized crossing.
- Sidepaths should be constructed along corridors with relatively few intersections and driveways, reducing conflict points.
- Typical pavement design for a paved, off-road, multi-use trail should be based upon the specific loading and soil conditions for each project. Asphalt or concrete trails should be designed to withstand the loading requirements of occasional maintenance and emergency vehicles.
- Concrete Trail: In areas prone to frequent flooding, it is recommended that concrete be used because of its excellent durability. Concrete surfaces are capable of withstanding the most powerful environmental forces. They hold up well against the erosive action of water, root intrusion and subgrade deficiencies such as soft soils. Most often, concrete is used for intensive urban applications. Of all surface types, it is the strongest and has the lowest maintenance requirement, if it is properly installed.
- Asphalt Trail: Asphalt is a flexible pavement and can be installed on virtually any slope. One important concern for asphalt trails is the deterioration of trail edges. Installation of a geotextile fabric beneath a layer of aggregate base course (ABC) can help to maintain the edge of a trail. It is important to provide a 2' wide graded shoulder to prevent trail edges from crumbling.
- Trail and Roadway Intersections: The images below present detailed specifications for the layout of intersections between trail corridors and roadways. Signage rules for such intersections are available in the Manual for Urban Traffic Control Devices (MUTCD).

Below: Typical greenway trail approaches to a roadway





TRAIL-ROADWAY INTERSECTIONS

• Site the crossing area at a logical and visible location; the crossing should be a safe enough distance from neighboring intersections to not interfere (or be interfered) with traffic flow; crossing at a roadway with flat topography is desirable to increase motorist visibility of the path crossing; the crossing should occur as close to perpendicular (90 degrees) to the roadway as possible.

• Warn motorists of the upcoming trail crossing and trail users of the upcoming intersections; motorists and trail users can be warned with signage (including trail stop signs), changes in pavement texture, flashing beacons, raised crossings, striping, etc.

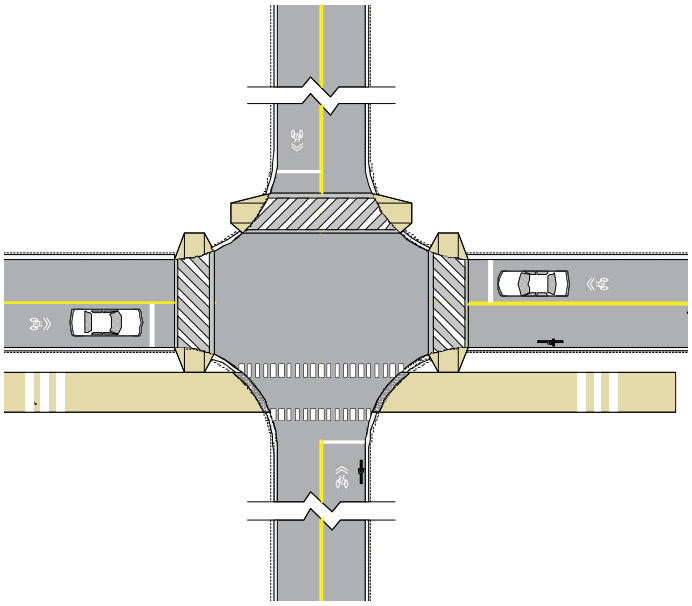
• Maintain visibility between trail users and motorists by clearing or trimming any vegetation that obstructs the view between them.

• Intersection approaches should be made at relatively flat grades so that cyclists are not riding down hill into intersections.

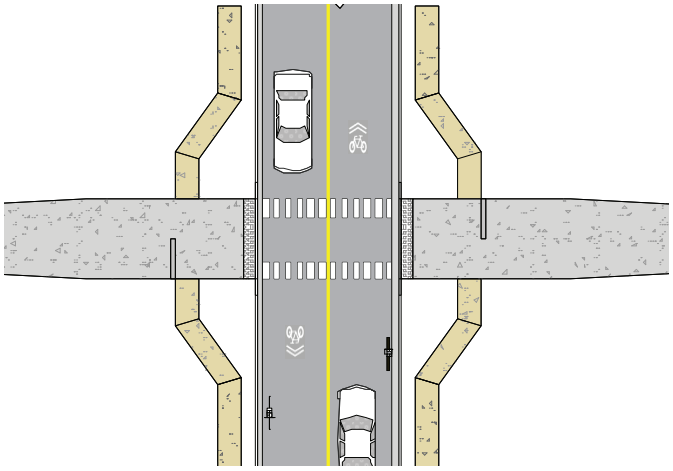
• If the intersection is more than 75 feet from curb to curb, it is preferable to provide a center median refuge area; a refuge is needed in conditions exhibiting high volumes/speeds and where the primary user group crossing the roadway requires additional time, such as schoolchildren and the elderly.

• If possible, it may be desirable to bring the path crossing up to a nearby signalized crossing in situations with high speeds/ADT and design and/or physical constraints.

• In 4-way Intersection Crossing with Shared Use Path (diagram at right) – This is also a depiction of a "sidepath" intersecting a roadway. Trail users would navigate this crossing like a common pedestrian.

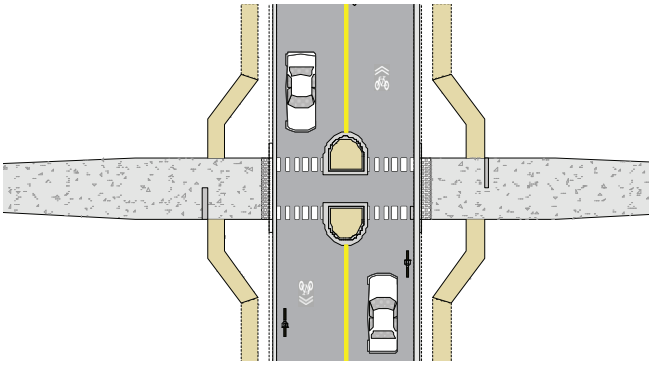


4-Way Intersection Crossing
Shared Use Path

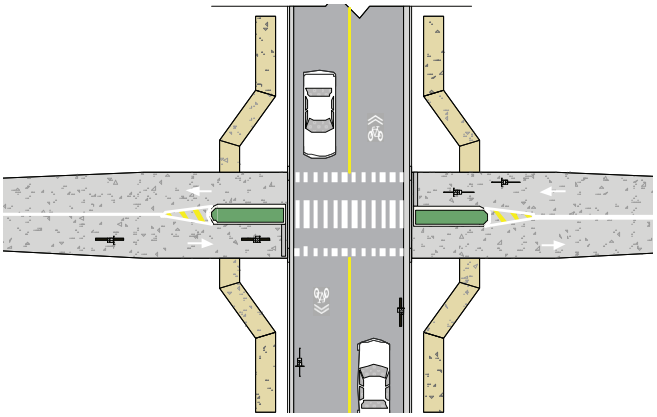


Mid-block Intersection
Shared Use Path with Sidewalks

TRAIL-ROADWAY INTERSECTIONS (CONTINUED)



Median Refuge
Shared Use Path with Sidewalks

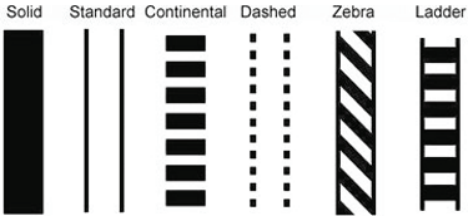


Mid-block Crossing
Shared Use Path with Sidewalks and Medians

TRAIL-ROADWAY INTERSECTIONS (SIGNALIZED)

• Signalized crossings may be necessary on trails with significant usage when intersecting with demanding roadways, but MUTCD warrants must be met for the installation of a signalized crossing. Consult the MUTCD or NCDOT Division of Bicycle and Pedestrian Transportation for signal, sign and light placement.

• FHWA issued an interim approval for the optional use of rectangular rapid flashing beacons (RRFBs, shown at left) as warning beacons supplementing pedestrian crossing or school crossing warning signs at crossings across uncontrolled approaches. An analysis by the Center for Education and Research in Safety found them to have much higher levels of effectiveness in making drivers yield at crosswalks than the standard over-head and side-mount round flashing beacons.



A variety of patterns are possible in designating a crosswalk; an example of a 'continental' design is shown above.

D.3 MARKED CROSSWALKS

A marked crosswalk designates a pedestrian right-of-way across a street. It is often installed at controlled intersections or at key locations along the street (a.k.a. mid-block crossings). Every attempt should be made to install crossings at the specific point at which pedestrians are most likely to cross: a well-designed traffic calming location is not effective if pedestrians are instead using more seemingly convenient and potentially dangerous location to cross the street. Marked pedestrian crosswalks may be used under the following conditions: 1) At locations with stop signs or traffic signals, 2) At non-signalized street crossing locations in designated school zones, and 3) At non-signalized locations where engineering judgment dictates that the use of specifically designated crosswalks are desirable.

There is a variety of form, pattern, and materials to choose from when creating a marked crosswalk. It is important however to provide crosswalks that are not slippery, are free of tripping hazards, or are otherwise difficult to maneuver by any person including those with physical mobility or vision impairments. Although attractive materials such as inlaid stone or certain types of brick may provide character and aesthetic value, the crosswalk can become slippery. Potential materials can be vetted by requesting case studies from suppliers regarding where the materials have been successfully applied. Also, as some materials degrade from use or if they are improperly installed, they may become a hazard for the mobility or vision impaired.

CROSSWALK GUIDELINES:

- Should not be installed in an uncontrolled environment [at intersections without traffic signals] where speeds exceed 40 mph. (AASHTO, 2004)
- Crosswalks alone may not be enough and should be used in conjunction with other measures to improve pedestrian crossing safety, particularly on roads with average daily traffic (ADT) above 10,000
- Width of marked crosswalk should be at least six feet; ideally ten feet or wider in downtown areas.

Crosswalk Guideline Sources:

American Association of State Highway and Transportation Officials. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.

Metro Regional Government. (2005). Portland, Oregon: Transportation Information Center. www.oregonmetro.gov

- Curb ramps and other sloped areas should be fully contained within the markings.
- Crosswalk markings should extend the full length of the crossings.
- Crosswalk markings should be white per MUTCD.
- Either the 'continental' or 'ladder' patterns are recommended for intersection improvements for aesthetic and visibility purposes. Lines should be one to two feet wide and spaced one to five feet apart.
- NCDOT typically requires pedestrian facilities (sidewalks) on both sides of a roadway when placing crosswalks.

D.4 CURB RAMPS

Curb ramps are critical features that provide access between the sidewalk and roadway for wheelchair users, people using walkers, crutches, or handcarts, people pushing bicycles or strollers, and pedestrians with mobility or other physical impairments. In accordance with the 1973 Federal Rehabilitation Act and to comply with the 1990 Federal ADA requirements, curb ramps must be installed at all intersections and mid-block locations where pedestrian crossings exist (Pedestrian and Bicycle Information Center: http://www.walkinginfo.org/engineering/roadway-ramps.cfm). In addition, these federal regulations require that all new constructed or altered roadways include curb ramps.

Two separate curb ramps should be provided at each intersection (see image below). With only one large curb ramp serving the entire corner, there is not safe connectivity for the pedestrian. Dangerous conditions exist when the single, large curb ramp inadvertently directs a pedestrian into the center of the intersection, or in front of an unsuspecting, turning vehicle.

Curb Ramp Guideline Sources:

Metro Regional Government. (2005). Portland, Oregon: Transportation Information Center. http://www.oregonmetro.gov

Left: The curb ramps shown have two separate ramps at the intersection (visable across the street) (Image from http://www.walkinginfo.org).

For additional information on curb ramps see Accessible Rights-of-Way: A Design Guide, by the U.S. Access Board and the Federal Highway Administration, and Designing Sidewalks and Trails for Access, Parts I and II, by the Federal Highway Administration. Visit: www.access-board.gov for the Access board's right-of-way report.

CURB RAMP GUIDELINES:

- Two separate curb ramps, one for each crosswalk, should be provided at corner of an intersection.

- Curb ramp should have a slope no greater than 1:12 (8.33%). Side flares should not exceed 1:10 (10%); it is recommended that much less steep slopes be used whenever possible.

D.5 RAISED OR LOWERED MEDIANS

Medians are barriers in the center portion of a street or roadway. When used in conjunction with mid-block or intersection crossings, they can be used as a crossing island to provide a place of refuge for pedestrians. They also provide opportunities for landscaping that in turn can help to slow traffic. A center turn lane can be converted into a raised or lowered median thus increasing motorist safety.

A continuous median can present several problems when used inappropriately. If all left-turn opportunities are removed, there runs a possibility for increased traffic speeds and unsafe U-turns at intersections. Additionally, the space occupied may be taking up room that could be used for bicycle lanes or other treatments. An alternative to the continuous median is to create a segmented median with left turn opportunities.

Raised or lowered medians are best suited for high-volume, high-speed roads, and they should provide ample cues for people with visual impairments to identify the boundary between the crossing island and the roadway.

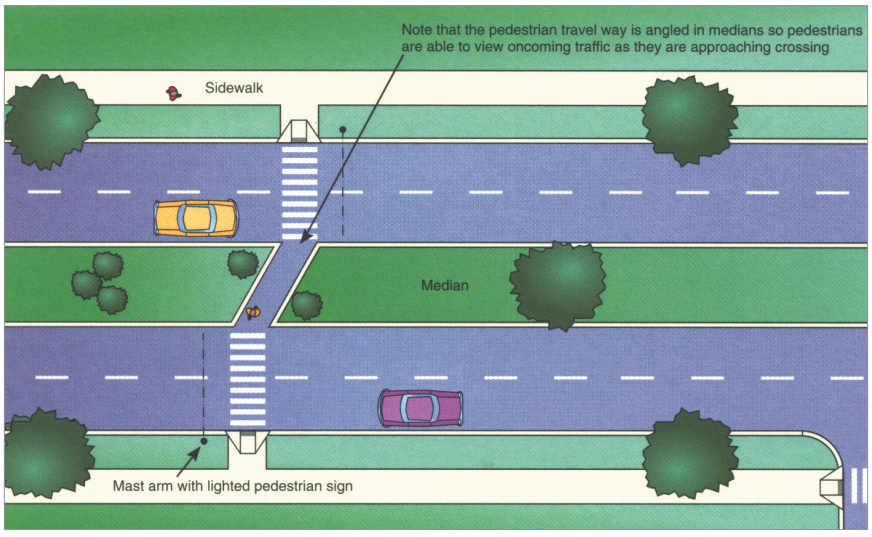
MEDIAN GUIDELINES:

- Median pedestrian refuge islands should be provided as a place of refuge for pedestrians crossing busy or wide roadways at either mid-block locations or intersections. They should be utilized on high speed and high volume roadways.
- Medians should incorporate trees and plantings to change the character of the street and reduce motor vehicle speed.
- Landscaping should not obstruct the visibility between motorists and pedestrians.
- Median crossings should provide ramps or cut-throughs for ease of accessibility for all pedestrians.
- Median crossings should be at least 6 feet wide in order to accommodate more than one pedestrian, while

Median Guideline Sources:

American Association of State Highway and Transportation Officials. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.

Metro Regional Government. (2005). Portland, Oregon: Transportation Information Center. http://www.oregonmetro.gov



Above: A median used in conjunction with mid-block crossing, serving as a refuge for pedestrians. (Image from AASHTO).

D.6 MID-BLOCK CROSSINGS

A Mid-Block Crosswalk is any crosswalk that is not located within an intersection. Midblock crossings are often installed in areas with heavy pedestrian traffic to provide more frequent crossing opportunities. They may also be added near major pedestrian destinations, such as schools or busy commercial areas, where people might otherwise cross at unmarked locations.

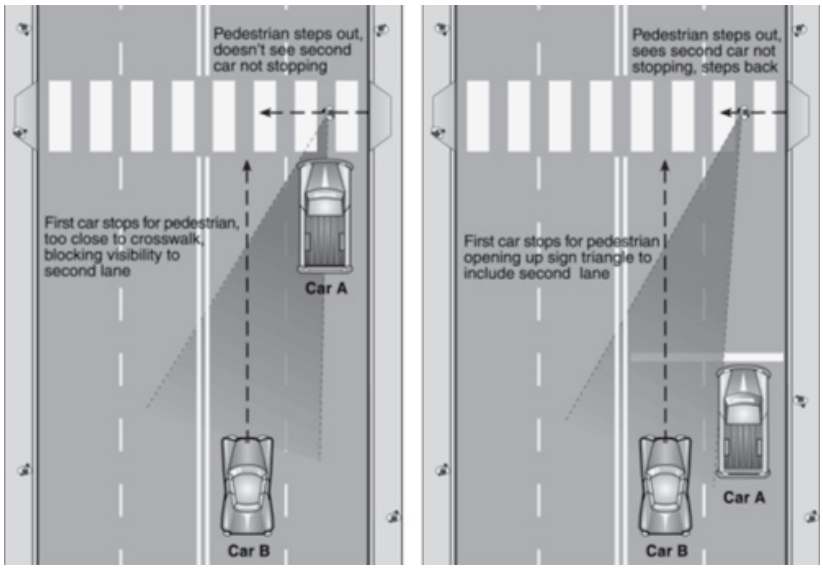
MID-BLOCK CROSSING GUIDELINES:

- Crosswalks at mid-block should not be installed within 300 ft. of another signalized crossing point.
- Utilize advance warning signs when mid-block crossings are present.
- Raised crosswalks are typically used on two-lane streets with less than 35 MPH speed limit.
- It will be the standard practice of NCDOT to install Mid-Block Crosswalks based on an engineering study. All Mid-Block Crosswalks shall be signed and marked in compliance with the Manual on Uniform Traffic Control Devices (MUTCD), the North Carolina Supplement to the MUTCD, the current NCDOT Roadway Standard Drawings, and the standards the NCDOT Policy on Mid-Block Crossings.
- The NCDOT Policy on Mid-Block Crossings can be found at www.ncdot.gov/doh/preconstruct/traffic/teppl/topics/C-36/C-36_pr.pdf

D.7 ADVANCE STOP BARS

Moving the vehicle stop bar 15–30 feet back from the pedestrian crosswalk at signalized crossings and mid-block crossings increases vehicle and pedestrian visibility. Advance stop bars are 1–2 feet wide and they extend across all approach lanes at intersections. The time and distance created allows a buffer in which the pedestrian and motorist can interpret each other's intentions. Studies have shown that this distance translates directly into increased safety for both motorist and pedestrian. One study in particular claims that by simply adding a "Stop Here for Pedestrians" sign reduced pedestrian motorist conflict by 67%. When this was used in conjunction with advance stop lines, it increased to 90% (Pedestrian and Bicycle Information Center: http://www.walkinginfo.org/engineering/crossings-enhancements.cfm).

Below: Advance stop bars enhance visibility for pedestrians (Image from www.walkinginfo.org).



a width of 10 feet (where feasible) should be provided for bicycles, wheelchairs, and groups of pedestrians.

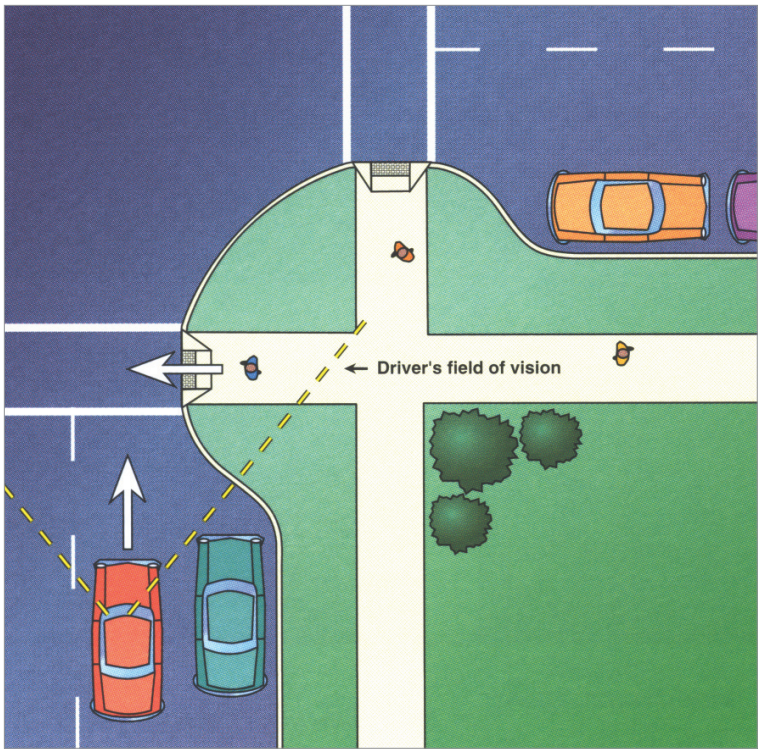
- Median crossings should possess a minimum of a 4 foot square level landing to provide a rest point for wheelchair users.
- Pedestrian push-buttons should be located in the median of all signalized mid-block crossings, where the roadway width is in excess of 60 feet.

D.8 BULB-OUTS

A bulb-out, or curb extension, is a place where the sidewalk extends into the parking lane of a street. Because these curb extensions physically narrow the roadway, a pedestrian's crossing distance—and consequently the time spent in the street—is reduced. They can be placed either at mid-block crossings or at intersections.

Sightlines and pedestrian visibility are reduced when motor vehicle parking encroaches too close to corners creating a dangerous situation for pedestrians. When placed at an intersection, bulb-outs preclude vehicle parking too close to a crosswalk. Also, bulb-outs at intersections can greatly reduce turning speed, especially if curb radii are set as tight as possible* (Pedestrian and Bicycle Information Center: www.walkinginfo.org/engineering/crossings-curb.cfm). Finally, bulb-outs also reduce travel speeds when used in mid-block crossings because of the reduced street width.

**The curb radius of a street corner affects traffic speed and crosswalk length. In general, a smaller (narrow) curb radius is better for pedestrians. A larger (wide) curb radius creates a greater crosswalk length and allows vehicles to move faster around the turn. Reducing the curb radius, especially across busy multi-lane arterials, can increase pedestrian safety by slowing vehicles and minimizing pedestrian crossing distances.*



Above: By reducing a pedestrian's crossing distance, less time is spent in the roadway, and pedestrian vehicle conflicts are reduced (Image from AASHTO).

Bulb-outs should only be used where there is an existing on-street parking lane and should never encroach into travel lanes, bicycle lanes, or shoulders (Pedestrian and Bicycle Information Center.

BULB-OUT GUIDELINES:

- Bulb-outs should be used on crosswalks in heavy pedestrian areas where parking may limit the driver's view of the pedestrian.
- Where used, sidewalk bulb-outs should extend into the street for the width of a parking lane (a minimum five feet) in order to provide for a shorter crossing width, increased pedestrian visibility, more space for pedestrian queuing, and a place for sidewalk amenities and planting.
- Curb extensions should be used on mid-block crossing where feasible.
- Curb extensions may be inappropriate for use on corners where frequent right turns are made by trucks or buses.

D

D.9 PEDESTRIAN OVERPASS/UNDERPASS

Pedestrian overpasses and underpasses efficiently allow for pedestrian movement across busy thoroughfares. These types of facilities are problematic in many regards and should only be considered under suitable circumstances or where no other solution is possible. Perhaps the best argument for using them sparingly is that research proves pedestrians will avoid using such a facility if they perceive the ability to cross at grade as taking about the same amount of time (Pedestrian and Bicycle Information Center:http://www.walkinginfo.org/engineering/crossings-overpasses.cfm).

The other areas of contention arise with the high cost of construction. There are also ADA requirements for stairs, ramps, and elevators that in many cases once complied with result in an enormous structure that is visually disruptive and difficult to access.

Example trail overpass (above) and underpass (below).

Overpasses work best when existing topography allows for smooth transitions. Underpasses as well work best with favorable topography when they are open and accessible, and exhibit a sense of safety. Each should only be considered with rail lines, high volume traffic areas such as freeways, and other high volume arteries.

OVERPASS/UNDERPASS GUIDELINES:

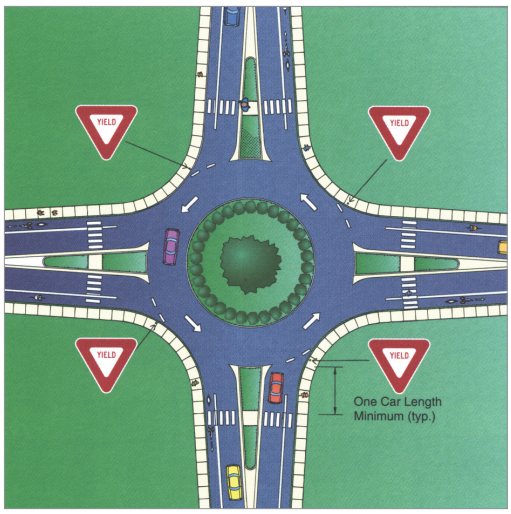
- Over and underpasses should be considered only for crossing arterials with greater than 20,000 vehicle trips per day and speeds 35 - 40 mph and over.
- Minimum widths for over and underpasses should follow the guidelines for sidewalk width.
- Underpasses should have a daytime illuminance minimum of 10 fc achievable through artificial and/or natural light provided through an open gap to sky between the two sets of highway lanes, and a night time level of 4 foot-candle.
- Consider acoustics measures within underpasses to reduce noise impacts to pedestrians and bicyclists.

D.10 ROUNDABOUTS

A roundabout is a circular intersection that maneuvers traffic around in a counterclockwise direction so that cars make a right-hand turn onto a desired street. Vehicles from approaching streets are generally not required to stop although approaching vehicles are required to yield to motorists in the roundabout. It is believed that this system eliminates certain types of crashes at traditional intersections.

Every effort must be made to prompt motorists to yield to pedestrians crossing the roundabout. A low design speed is required to improve pedestrian safety. Splitter islands and single lane approaches both lend to pedestrian safety as well as other urban design elements discussed in this chapter.

Typical roundabout (Image from AASHTO)



Problems also arise with the vision-impaired because there are not proper audible cues associated with when to cross. Studies are underway to develop and test solutions. Auditory accessible pedestrian signals placed on sidewalks and splitter islands are one solution, but again there is no research to prove their efficacy.

ROUNDABOUT GUIDELINES:

- The recommended maximum entry design speed for roundabouts ranges from 15 mph for 'mini-roundabouts' in neighborhood settings, to 20 mph for single-lane roundabouts in urban settings, to 25 mph for single-lane roundabouts in rural settings.
- Refer to roundabout diagram for typical crosswalk placement.
- Please refer to FHWA's report, Roundabouts, an Information Guide, available online through: www.fhrc.gov. The report provides information on general design principles, geometric elements, and provides detailed specifications for the various types of roundabouts.

Above: A pedestrian walks through a pedestrian refuge island, as part of a roundabout.

D.11 TRAFFIC SIGNALS

Traffic signals assign the right of way to motorists and pedestrians and produce openings in traffic flow, allowing pedestrians time to cross the street. When used in conjunction with pedestrian friendly design, proper signalization should allow for an adequate amount of time for an individual to cross the street. The suggested amount of pedestrian travel speed recommended in the Manual on Uniform Traffic Control Devices (MUTCD) is 4ft/sec; however, this does not address the walking speed of the elderly or children. Therefore, it is suggested that a lower speed of 3.5ft/sec be used whenever there are adequate numbers of elderly and children using an area.

Engineering, as well as urban design judgment, must be used when determining the location of traffic signals and the accompanying timing intervals. Although warrants for pedestrian signal timing have been produced by the MUTCD, each site must be analyzed for factors including new facility and amenity construction (i.e. a popular new park or museum) to allow for potential future pedestrian traffic volume. In addition, creating better access to existing places may in fact generate a higher pedestrian volume.

Fixed timed sequencing is often used in high traffic volume commercial or downtown areas to allow for a greater efficiency of traffic flow. In such instances, the pedestrian speed must be carefully checked to ensure safety.

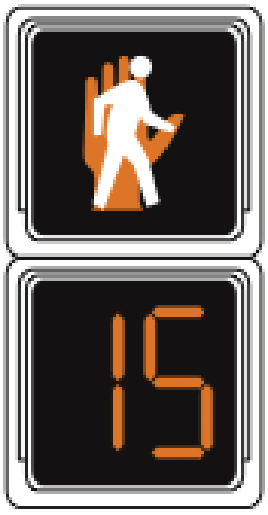
A low cost sign that restricts right-hand turns at a red light (Image from http://www.walkinginfo.org).

RIGHT TURN ON RED RESTRICTIONS

Introduced in the 1970s as a fuel saving technique, the Right Turn on Red (RTOR) law is thought to have had a detrimental effect on pedestrians. The issue is not the law itself but rather the relaxed enforcement of certain caveats within the law such as coming to a complete stop and yielding to pedestrians. Often motorists will either nudge into a crosswalk to check for oncoming traffic without looking for pedestrians or slow, but not stop, for the red-light while making the turn.

There is legitimate concern that eliminating an RTOR will only increase the number of right-turn-on-green conflicts where all of the drivers who would normally have turned on red, now are anxious to turn on green. As discussed in the prior section, LPI or exclusive pedestrian intervals my help to alleviate this problem. Eliminating RTOR should be considered on a case-by-case basis and only where there are high pedestrian volumes. This can be done by simple sign postings as illustrated at right.

D.12 PEDESTRIAN SIGNALS



Typical Pedestrian Signal Indicators (with countdown display).

There are a host of traffic signal features and enhancements that can greatly improve the safety and flow of pedestrian traffic. Some include countdown signals, the size of traffic signals, positioning of traffic signals, audible cues, and timing intervals which are discussed below (Pedestrian and Bicycle Information Center: http://www.walkinginfo.org/engineering/crossings-signals.cfm).

As of 2008, new federal policy requires all new pedestrian signals to be of the countdown variety. In addition, all existing signals must be updated to countdown within 10 years (updated in MUTCD). Countdown signals have proven to be an effective measure of crash reduction (25% crash reduction in 2007 FHWA study).

Countdown signals are pedestrian signals that show how many seconds the pedestrian has remaining to cross the street. The countdown can begin at the beginning of the WALK phase, perhaps flashing white or yellow, or at the beginning of the clearance, or DON'T WALK phase, flashing yellow as it counts down. Audible cues can also be used to pulse along with a countdown signal.

Audible cues can also be used to pulse along with a countdown signal.

Signals should be of adequate size, clearly visible, and, in some circumstances, accompanied by an audible pulse or other messages to make crossing safe for all pedestrians. Consideration should be paid to the noise impact on the surrounding neighborhoods when deciding to use audible signals.

The timing of these or other pedestrian signals needs to be adapted to a given situation. In general, shorter cycle lengths and longer walk intervals provide better service to pedestrians and encourage better signal compliance. For optimal pedestrian service, fixed-time signal operation usually works best. Pedestrian pushbuttons may be installed at locations where pedestrians are expected intermittently. Quick response to the pushbutton or feedback to the pedestrian (e.g.- indicator light comes on) should be programmed into the system. When used, pushbuttons should be well-signed and within reach and operable from a flat surface for pedestrians in wheelchairs and with visual disabilities. They should be conveniently placed in the area where pedestrians wait to cross. Section 4E.09 within the MUTCD provides detailed guidance for the placement of pushbuttons to ensure accessibility (Pedestrian and Bicycle Information Center: http://www.walkinginfo.org/engineering/crossings-signals.cfm).

There are three types of signal timing generally used: concurrent, exclusive, and leading pedestrian interval (LPI). The strengths and weaknesses of each will be discussed with an emphasis on when they are best employed.

When high-volume turning situations conflict with pedestrian movements, the exclusive pedestrian interval is the preferred solution. The exclusive

pedestrian intervals stop traffic in all directions. In order to keep traffic flowing regularly, there is often a greater pedestrian wait time associated with this system. Although it has been shown that pedestrian crashes have been reduced by 50% in some areas by using these intervals, the long wait times can encourage some to cross when there is a lull in traffic (Pedestrian and Bicycle Information Center: http://www.walkinginfo.org/engineering/crossings-signals.cfm).

An LPI gives pedestrians an advance walk signal before the motorists get a green light, giving the pedestrian several seconds to start in the crosswalk where there is a concurrent signal. This makes pedestrians more visible to motorists and motorists more likely to yield to them. This advance crossing phase approach has been used successfully in several places, such as New York City, for two decades and studies have demonstrated reduced conflicts for pedestrians. The advance pedestrian phase is particularly effective where there is a two-lane turning movement. There are some situations where an exclusive pedestrian phase may be preferable to an LPI, such as where there are high-volume turning movements that conflict with the pedestrians crossing.

The use of infrared or microwave pedestrian detectors has increased in many cities worldwide. These devices replace the traditional push-button system. They appear to be improving pedestrian signal compliance as well as reducing the number of pedestrian and vehicle conflicts. The best use of these devices is when they are employed to extend crossing time for slower moving pedestrians.

PEDESTRIAN SIGNAL GUIDELINES:

- Pedestrian signals should be placed in locations that are clearly visible to all pedestrians.
- Larger pedestrian signals should be utilized on wider roadways, to ensure readability.
- Pedestrian signal pushbuttons should be well-signed and visible.
- Pedestrian signal pushbuttons should clearly indicate which crossing direction they control.
- Pedestrian signal pushbuttons should be reachable from a flat surface, at a maximum height of 3.5 feet and be located on a level landing to ensure ease of operation by pedestrians in wheelchairs.
- Walk intervals should be provided during every cycle, especially in high pedestrian traffic areas.

D.13 LANDSCAPING

The introduction of vegetation in an urban environment can provide a welcomed intervention of nature into a place that is otherwise hardened from buildings, concrete, and asphalt. It can be used to provide a separation buffer between pedestrians and motorists, reduce the width of a roadway, calm traffic by creating a visual narrowing of the roadway, enhance the street environment, and help to generate a desired aesthetic.

Street trees and other plantings provide comfort, a sense of place, and a more natural and inviting setting for pedestrians. Landscaping and the aforementioned street furniture make people feel welcome.

There are also some instances where islands of vegetation are created to collect and filter stormwater from nearby streets and buildings. These islands are referred to as constructed wetlands, rain gardens, and/or bioswales. When these devices are employed, the benefits listed above are coupled with economic and ecologic benefits of treating stormwater at its source. There are many examples of this in Oregon and Washington, particularly Seattle's Green Streets Program. Using thoughtful design to treat stormwater as an amenity rather than waste to be disposed of in an environmentally harmful manner is gaining popularity nationwide.

An issue with this or any landscaping treatment is that of ongoing maintenance. The responsibility often falls on local municipalities although there are instances where local community groups have provided funding and volunteers for maintenance. The best way to address the maintenance issue is to design using native plant material that is already adapted to the local soil and climate. Growth pattern and space for maturation, particularly with larger tree plantings, are important to avoid cracking sidewalks and other pedestrian obstructions.

Landscaping used on the Sea Street in Seattle, Washington shows how stormwater treatment can be tied to aesthetically pleasing plantings. (Image from Seattle, WA, Public Utilities: Seattle.gov)

Street trees buffer and soften often urban environments in a number of psychological, physical, and ecological ways; their shade is particularly helpful to pedestrians in North Carolina during summer months.

D.14 ROADWAY LIGHTING IMPROVEMENTS

Proper lighting in terms of quality, placement, and sufficiency can greatly enhance a nighttime urban experience as well as create a safe environment for motorists and pedestrians. Two-thirds of all pedestrian fatalities occur during low-light conditions (AASHTO, 2004: Guide for the Planning, Design, and Operation of Pedestrian Facilities). Attention should be paid to crossings so that there is sufficient ambience for motorists to see pedestrians. To be most effective, lighting should be consistent, adequately spaced, and distinguished, providing adequate light.

In most cases, roadway street lighting can be designed to illuminate the sidewalk area as well. The visibility needs of both pedestrian and motorist should be considered. In commercial or downtown areas and other areas of high pedestrian volumes, the addition of lower level, pedestrian-scale lighting to streetlights with emphasis on crossings and intersections may be employed to generate a desired ambiance. A variety of lighting choices include mercury vapor, incandescent, or less expensive high-pressure sodium lighting for pedestrian level lighting. Roadway streetlights can range from 20-40 feet in height while pedestrian-scale lighting is typically 10-15 feet.

Above: An example of pedestrian-scale lighting.

It is important to note that every effort should be made to address and prevent light pollution. Also known as photo pollution, light pollution is 'excess or obtrusive light created by humans'.

GUIDELINES:

- Ensure pedestrian walkways and crossways are sufficiently lit.
- Consider adding pedestrian-level lighting in areas of higher pedestrian volumes, downtown, and at key intersections.
- Install lighting on both sides of streets in commercial districts.
- Use uniform lighting levels
- Use full cut-off light fixtures to avoid excess light pollution

D.15 STREET FURNITURE AND WALKING ENVIRONMENT

As part of a comprehensive sidewalk and walkway design, all street furniture should be placed in a manner that allows for a safe, pleasurable, and accessible walking environment. Good-quality street furniture will show that the community values its public spaces and is more cost-effective in the long run. Street furniture includes benches, trash bins, signposts, newspaper racks, water fountains, bicycle racks, restaurant seating, light posts, and other ornaments that are found within an urban street environment. Street furniture should mostly be considered in the downtown area and other important pedestrian-active areas.

In addition to keeping areas free of obstruction from furniture, a walking environment should be clean and well maintained. Attention to removing debris, trimming vegetation, allowing for proper stormwater drainage, providing proper lighting and sight angles, and repairing or replacing broken or damaged paving material can make an enormous difference in pedestrian perception of safety and aesthetics. Special attention should be paid to the needs of the visually impaired so that tripping hazards and low hanging obstructions are removed.

The street furniture shown here is placed in such a manner so as to create a safe, pleasurable, and accessible walking environment

GUIDELINES:

- Ensure proper placement of furniture; do not block pedestrian walkway or curb ramps or create sightline problems.
- Wall mounted Objects = not to protrude more than 4” from a wall between 27” and 7’ from the ground
- Single post mounted Objects = not to protrude more than 4” from each side of the post between 27” and 7’ from the ground
- Multiple Post Mounted Objects = lowest edge should be no higher than 27” and no lower than 7’
- Place street furniture at the end of on-street parking spaces rather than in middle to avoid vehicle-exiting conflict.

D.16 TRANSIT STOP TREATMENTS

Where transit opportunities are available, it is appropriate to consider some of the basic elements of a well designed, accessible, and functional transit stop.

Bus or other transit stops should be located in places that are most suitable for the passengers. For example, stops should be provided near higher density residential areas, commercial or business areas, and schools, and connected to these areas by sidewalk. Some of the most important elements to consider are the most basic: sidewalk connectivity to the stops, proper lighting, legible and adequate transit stop signage, shelter, seating, trash bins, bicycle and even car parking. Transit stops create an area of activity and may generate additional business and pedestrian traffic. Therefore, an opportunity is created to provide adequate sidewalks and other pedestrian oriented design elements. At a minimum, marked crosswalks (especially at mid-block stops), curb ramps, and proper sidewalk widths should be considered.

As with any human scale design element discussed, safety is an important factor to consider when locating bus stops. In the case of a bus stop, special attention should be paid to the number of lanes and direction of traffic when deciding to locate a stop on the near or far side of an intersection. Also special consideration must be paid to the wheelchair lifts in terms of how and where the mobility impaired will exit and enter the bus.

Local walking and bicycling maps should also be provided at bus stops, so that people are aware of the nearby destinations and how best to get there without an automobile.

This typical transit stop has all of the key features of shelter, ample seating, bicycle parking, landscaping, and trash bins (Image from http://www.walkinginfo.org).

For a step-by-step guide to help non-professionals participate in the process of developing and designing a signage system, as well as information on the range of signage types, visit the Project for Public Places website: http://www.pps.org/info/amenities_bb/signage_guide

D.17 PEDESTRIAN SIGNS AND WAYFINDING

Signage provides important safety and wayfinding information to motorist and pedestrian residents and tourists. From a safety standpoint, motorists should be given advance warning of upcoming pedestrian crossings or of traffic calming areas. Signage of any type should be used and regulated judiciously. An inordinate amount of signs creates visual clutter. Under such a condition, important safety or wayfinding information may be ignored resulting in confusion and possible pedestrian vehicle conflict. Regulations should also address the orientation, height, size, and sometimes even style of signage to comply with a desired local aesthetic.

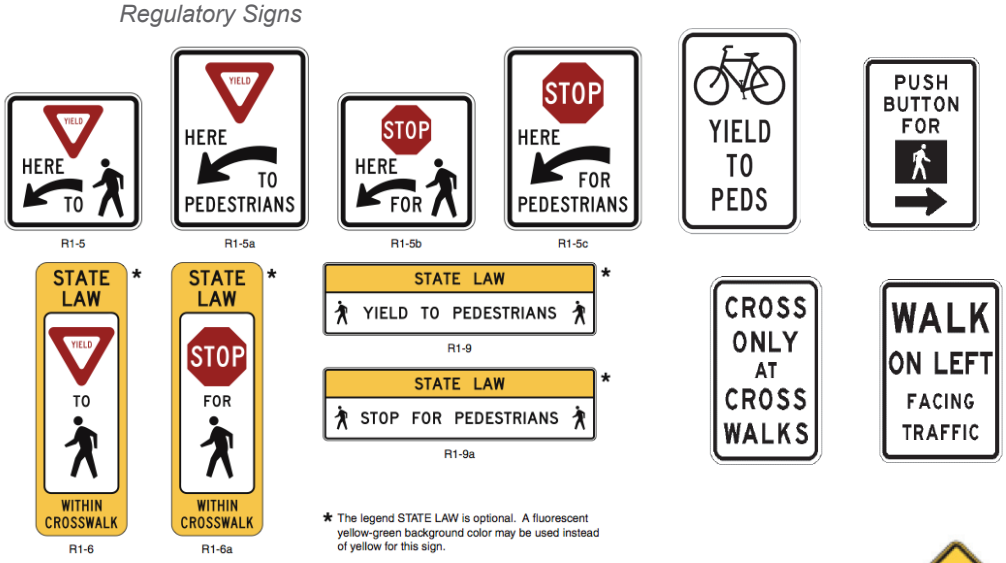
Regulatory signage is used to inform motorists or pedestrians of a legal requirement and should only be used when a legal requirement is not otherwise apparent (AASHTO, 2004: Guide for the Planning, Design, and Operation of Pedestrian Facilities).

Below: Typical traffic signs found around pedestrian friendly places.

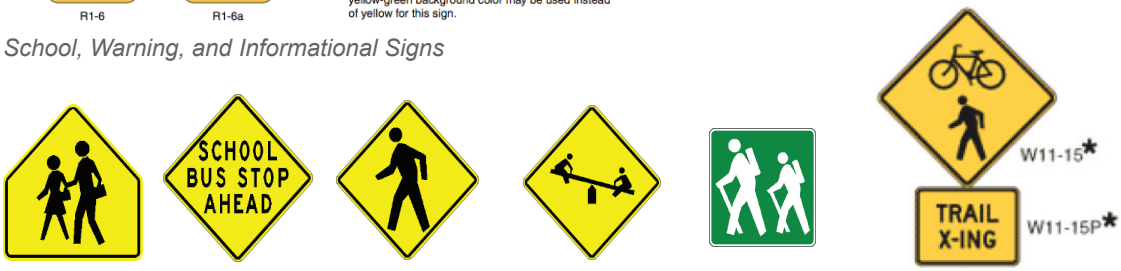
Sign	MUTCD Code	MUTCD Section	Conventional Road	
Yield here to Peds	R1-5	2B.11	450x450 (18x18)	Regulatory
Yield here to Peds	R1-5a	2B.11	450x600 (18x24)	
In-Street Ped Crossing	R1-6, R1-6a	2B.12	300x900 (12x36)	
Peds and Bikes Prohibited	R5-10b	2B.36	750x450 (30x18)	
Peds Prohibited	R5-10c	2B.36	600x300 (24x12)	
Walk on Left Facing Traffic	R9-1	2B.43	450x600 (18x24)	
Cross only at Crosswalks	R9-2	2B.44	300x450 (12x18)	
No Ped Crossing	R9-3a	2B.44	450x450 (18x18)	
No Hitch Hiking	R9-4	2B.43	450x600 (18x24)	
No Hitch Hiking (symbol)	R9-4a	2B.43	450x450 (18x18)	
Bikes Yield to Peds	R9-6	9B.10	300x450 (12x18)	
Ped Traffic Symbol	R10-4b	2B.45	225x300 (9x12)	
School Advance Warning	S1-1	7B.08	900x900 (36x36)	School, Warning, informational
School Bus Stop Ahead	S3-1	7B.10	750x750 (30x30)	
Pedestrian Traffic	W11-2	2C.41	750x750 (30x30)	
Playground	W15-1	2C.42	750x750 (30x30)	
Hiking Trail	I-4	--	600x600 (24x24)	

1. Larger signs may be used when appropriate.
2. Dimensions are shown in millimeters followed by inches in parentheses and are shown as width x height.
3. First dimension in millimeters; dimensions in parentheses are in inches.
4. All information in table taken directly from MUTCD.

Regulatory Signs



School, Warning, and Informational Signs

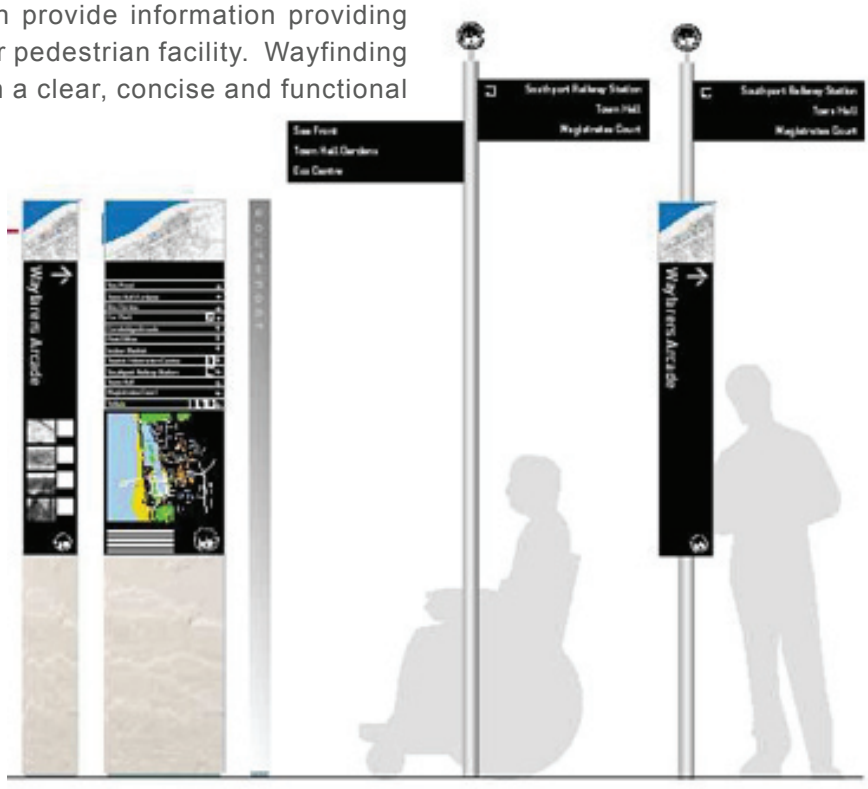


Warning signage is used to inform motorists and pedestrians of unexpected or unusual conditions. When used, they should be placed to provide adequate response times. These include school warning signs and pedestrian crossing signs3.

Informational and wayfinding signage can provide information providing guidance to a location along a trail or other pedestrian facility. Wayfinding signage should orient and communicate in a clear, concise and functional manner. It should enhance pedestrian circulation and direct visitors and residents to important destinations. In doing so, the goal is to increase the comfort of visitors and residents while helping to convey a local identity.

Maintenance of signage is as important as walkway maintenance. Clean, graffiti free, and relevant signage enhances guidance, recognition, and safety for pedestrians.

Below: Wayfinding signs promote aesthetics as well as provide important information (image from Stefton, UK: http://www.sefton.gov.uk



D.18 BRIDGES

Provisions should always be made to include a walking facility as a part of vehicular bridges, underpasses, or tunnels, especially if the facility is part of the Pedestrian Network. All new or replacement bridges, other than those for controlled access roadways, should accommodate pedestrians with wide sidewalks on both sides of the bridge. Even though bridge replacements do not occur regularly, it is important to consider these in longer-term pedestrian planning.

It is DOT bridge policy that within Urban Area boundaries (which are ambiguously defined as the "outer limits of potential urban growth"), sidewalks shall be included on new bridges with curb and gutter approach roadways with no controlled access. Sidewalks should not be included on controlled access facilities. A determination on whether to provide sidewalks on one or both sides of new bridges will be made during the planning process according to the DOT Pedestrian Policy Guidelines. When a sidewalk is justified, it should be a minimum of five to six feet wide with a minimum handrail height of 42".

It is also DOT bridge policy that bridges within the Federal-aid urban boundaries with rural-type roadway sections (shoulder approaches) may warrant special consideration. To allow for future placement of ADA acceptable sidewalks, sufficient bridge deck width (typically 7.5' for one side) should be considered on new bridges in order to accommodate the placement of sidewalks. The full Bridge Policy for DOT can be download as a Microsoft Word document at this address:

www.ncdot.org/doh/preconstruct/altern/value/manuals/bpe2000.doc

BRIDGE GUIDELINES:

- Sidewalks should be included on roadway bridges with no controlled access with curb and gutter approach in Urban Areas.
- Sufficient bridge deck width should be considered on new bridges with rural-type shoulder approaches for future placement of sidewalks.
- Sidewalk should be 5' to 6' wide.
- Minimum handrail height should be 42''

D.19 HIGH-INTENSITY ACTIVATED CROSSWALK (HAWK) SIGNAL

Above: HAWK signal.

The FHWA's Office of Safety Research recently completed a report on the High Intensity Activated Crosswalk (HAWK) — also known as the Pedestrian Hybrid Signal in the Manual on Uniform Traffic Control Devices (MUTCD). The HAWK is a pedestrian activated beacon located on the roadside and on mast arms over major approaches to an intersection. The HAWK signal head consists of two red lenses over a single yellow lens. It displays a red indication to drivers when activated, which creates a gap for pedestrians to use to cross a major roadway. The HAWK is not illuminated until it is activated by a pedestrian, triggering the warning flashing yellow lens on the major street. From the evaluation that considered data for 21 HAWK sites and 102 unsignalized intersections, the following changes in crashes were found after the HAWK was installed: a 29% reduction in total crashes, a 15% reduction in severe crashes, and a 69% reduction in pedestrian crashes. The HAWK is now an MUTCD approved device, so a request for experimentation is not necessary.

For more details, visit this website: http://mutcd.fhwa.dot.gov/htm/2009/part4/part4f.htm (Source: FHWA Office of Safety, Pedestrian Forum, Fall 2010)

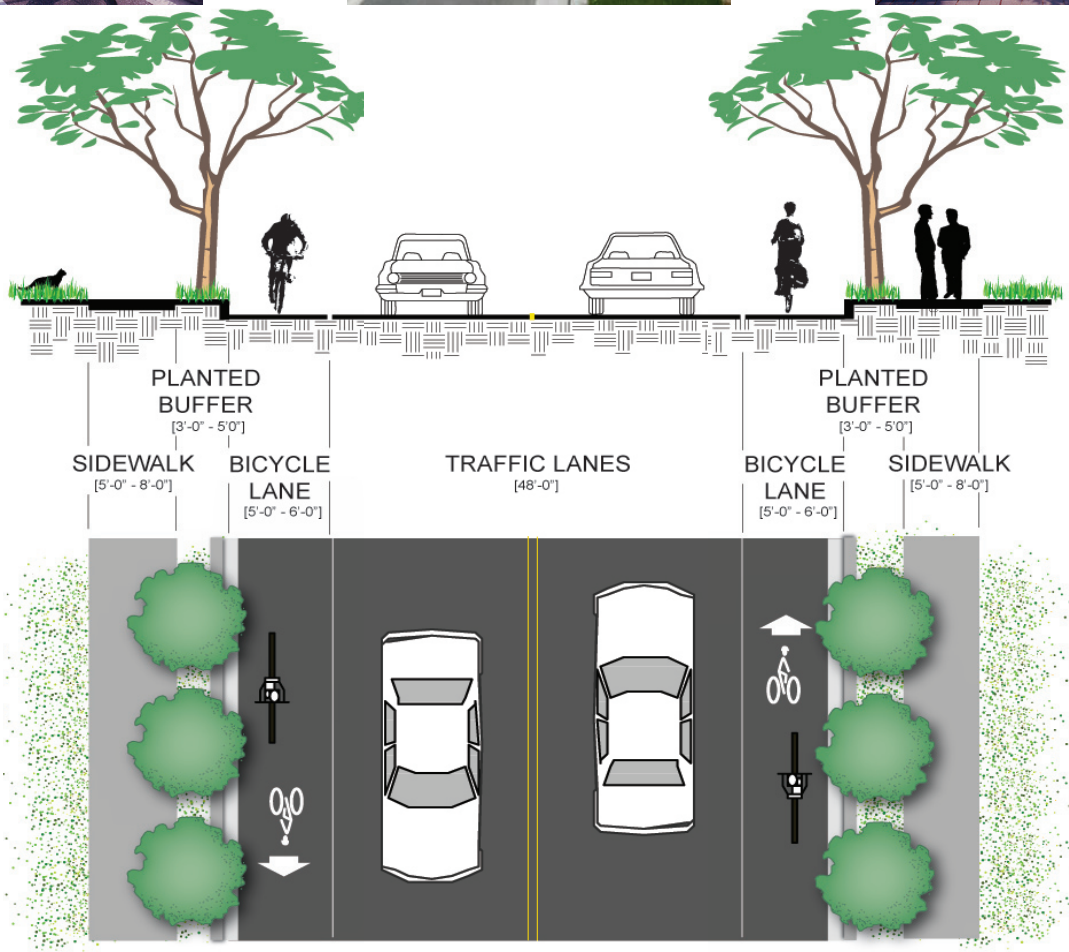
D.20 BICYCLE FACILITIES

BICYCLE LANE

A bicycle lane is a portion of the roadway that has been designated by striping, signing, and pavement markings for the preferential and exclusive use of bicyclists. Bicycle lanes are always located on both sides of the road (except one way streets), and carry bicyclists in the same direction as adjacent motor vehicle traffic. The minimum width for a bicycle lane is four feet; five- and six-foot bicycle lanes are typical for collector and arterial roads (greater width is needed for bicycle lanes where traffic volume and speed are higher).

NCDOT recommends a bicycle lane width of:

- 6’ from the curb face when a gutter pan is present (or 4’ from the edge of the gutter pan)
- 4’ from the curb face when no gutter pan is present
- Should be used on roadways with 3,000 or more ADT
- Not suitable where there are a high number of commercial driveways
- Suitable for 2-lane facilities and 4-lane divided facilities



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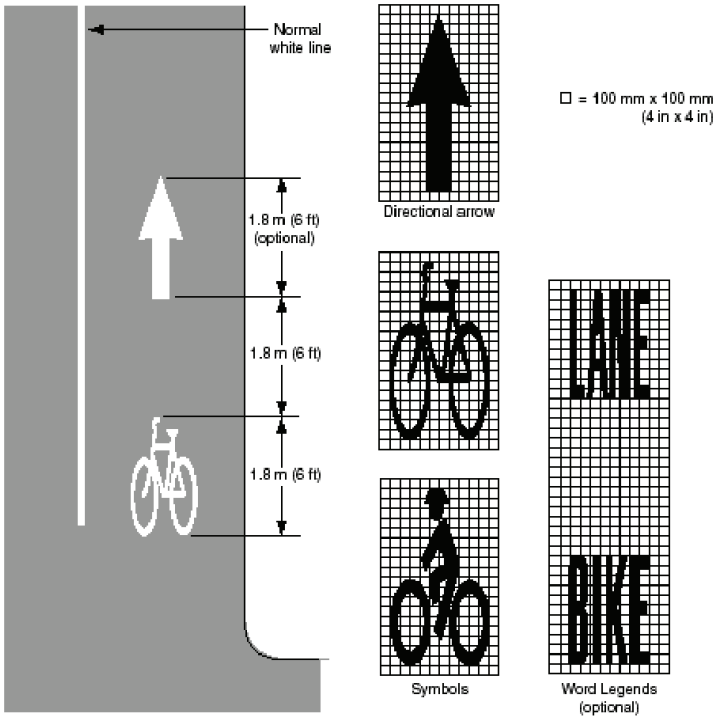
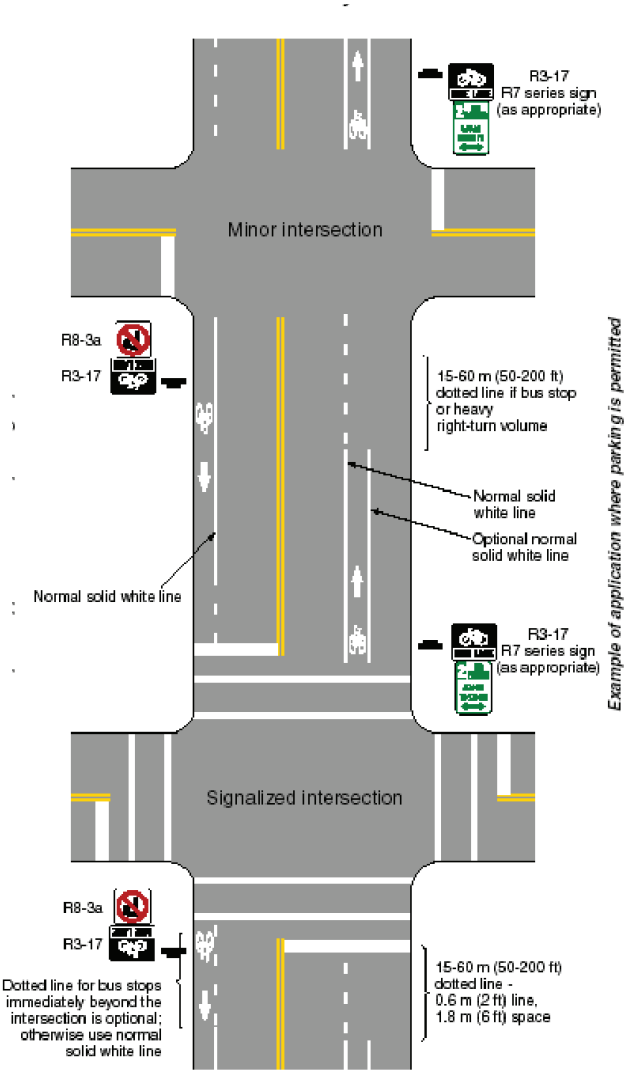
TYPICAL PAVEMENT MARKINGS AND INTERSECTION CONFIGURATION FOR BICYCLE LANES

The Manual on Uniform Traffic Control Devices (MUTCD) provides guidance for lane delineation, intersection treatments, and general application of pavement wording and symbols for on-road bicycle facilities and off-road paths (http://mutcd.fhwa.dot.gov/pdfs/millennium/12.18.00/9.pdf).



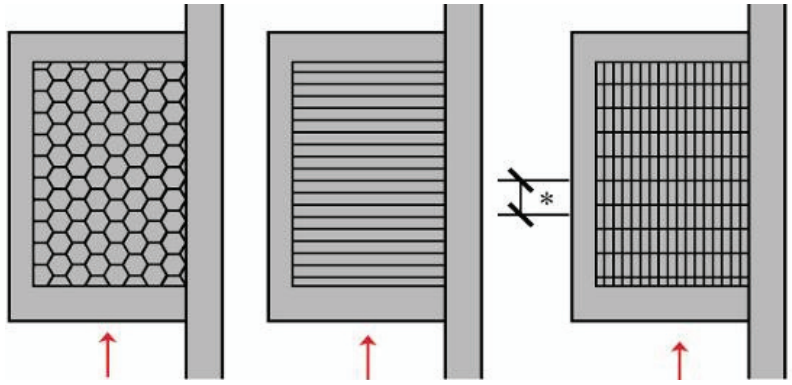
MUTCD examples of optional word and symbol pavement markings for bicycle lanes.



BICYCLE FRIENDLY DRAINAGE GRATES

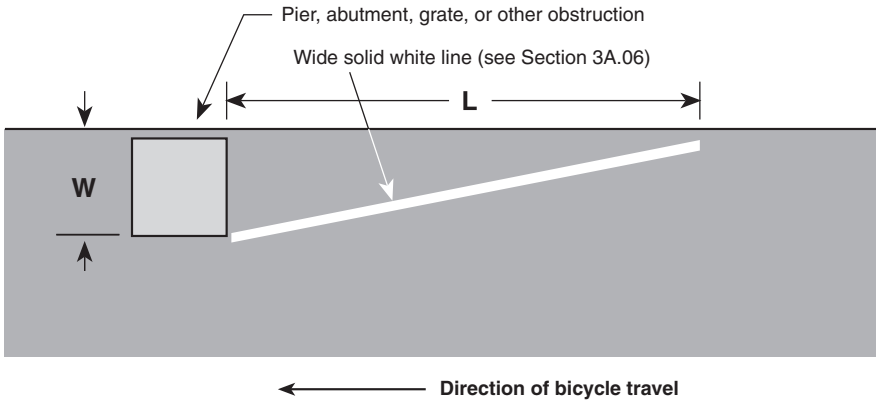
Drainage grates usually occupy portions of roadways, such as bicycle lanes, where bicycles frequently travel. Often drainage grates are poorly maintained or are of a design that can damage a bicycle wheel or in severe circumstances, cause a bicyclist to crash. Improper drainage grates create an unfriendly obstacle a cyclist must navigate around, often forcing entrance into a motor vehicle lane in severe cases. Bicycle friendly drainage grates should be installed in all new roadway projects and problem grates should be identified and replaced.

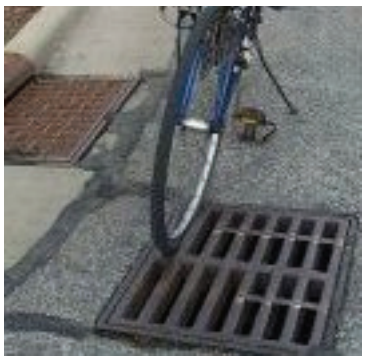
Right: Bicycle Friendly Drainage Grate Designs



**max 150 mm (6'') spacing*

Right: MUTCD example of obstruction pavement marking; if dangerous drainage grates (or other obstructions) are not to be fixed in the short term, then this pavement marking should direct cyclists away from the obstruction.





Dangerous Drainage Grate Condition; this example is dangerous due to the grate running parallel to the roadway, creating a trap for bicycle tires.

Dangerous Drainage Grate Condition; this example is dangerous due to the surrounding paving condition (when the road was resurfaced the drainage grate remained at the same height).

Bicycle-Friendly Drainage Grate

D

SHARED LANE MARKING

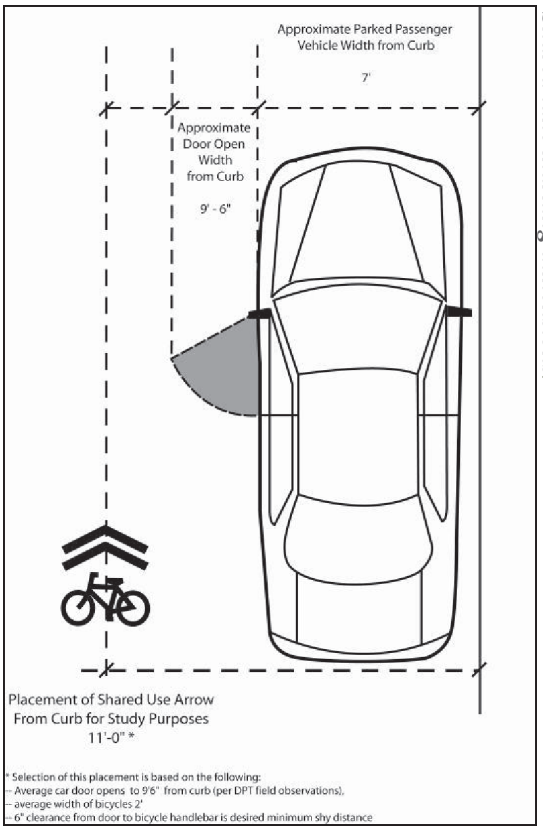
A bicycle shared lane marking (or 'sharrow') can serve a number of purposes, such as making motorists aware of bicycles potentially traveling in their lane, showing bicyclists the appropriate direction of travel, and, with proper placement, reminding bicyclists to bicycle further from parked cars to prevent "dooring" collisions. The shared lane marking stencil is used:

- Where lanes are too narrow for striping bicycle lanes
- Where the speed limit does not exceed 35 MPH
- With or without on-street parking

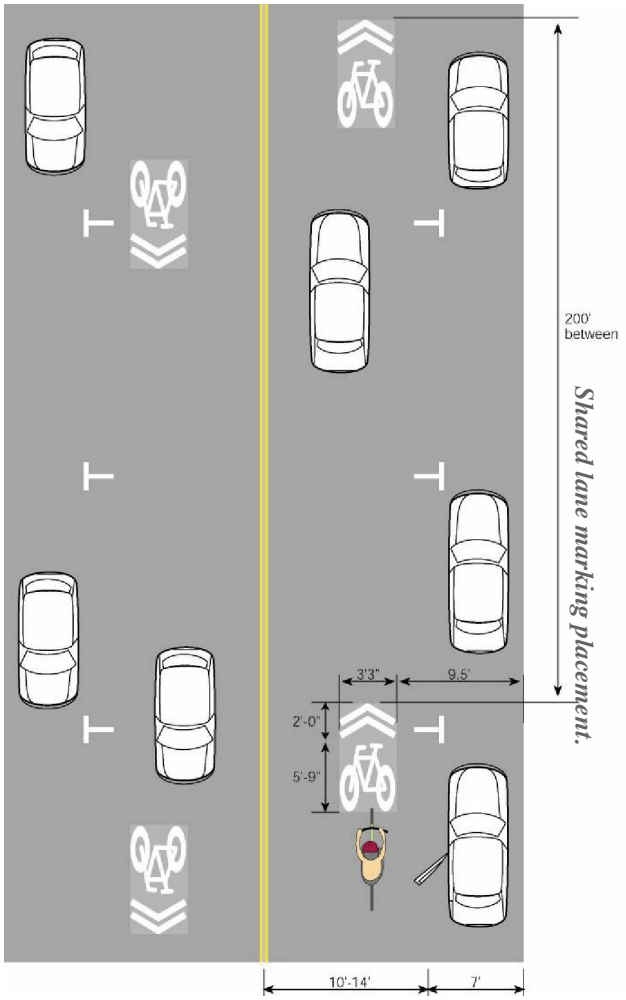
Cities such as Denver, San Francisco, Portland, and Los Angeles have effectively used this treatment for several years. As of this writing, the sharrow treatment is being considered in the 2009/2010 update of the MUTCD. However, until official action is taken by the FHWA to finalize approval and adoption of shared lane markings in the next edition of the MUTCD, the use of these markings is still considered experimental. The markings are not authorized for use except under written experimental authorization by the FHWA.

A number of shared lane markings are recommended in this Plan, especially in the Downtown area where there is on-street parking and little room for bicycle lanes. Shared lane markings should also be considered for use on suburban roadway segments that connect bicycle lanes on either side, but do not have width for bicycle lanes.

It is recommended that shared lane markings be approached incrementally as a new facility treatment. Precedent studies and guidelines should be examined.



Shared lane marking dimensions.

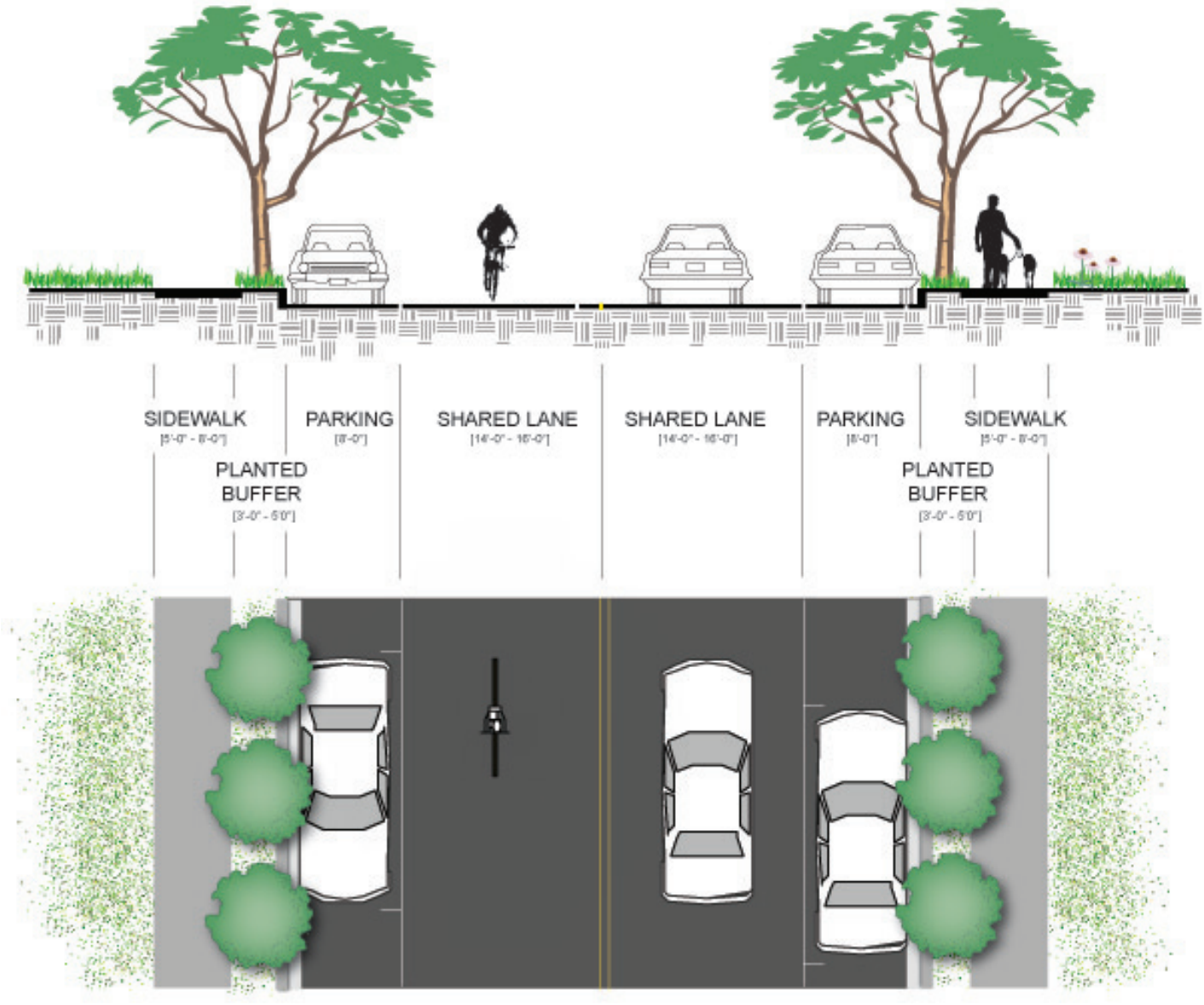


Shared lane marking placement.

Shared lane markings installed on lanes that are too narrow for striping designated bicycle lanes.

SIGNED/SHARED ROADWAY

• May either be a low volume (less than 3000 cars per day) roadway with traffic calming and signage to create a safe shared use environment, OR a higher volume roadway with wide (14') outside lanes.



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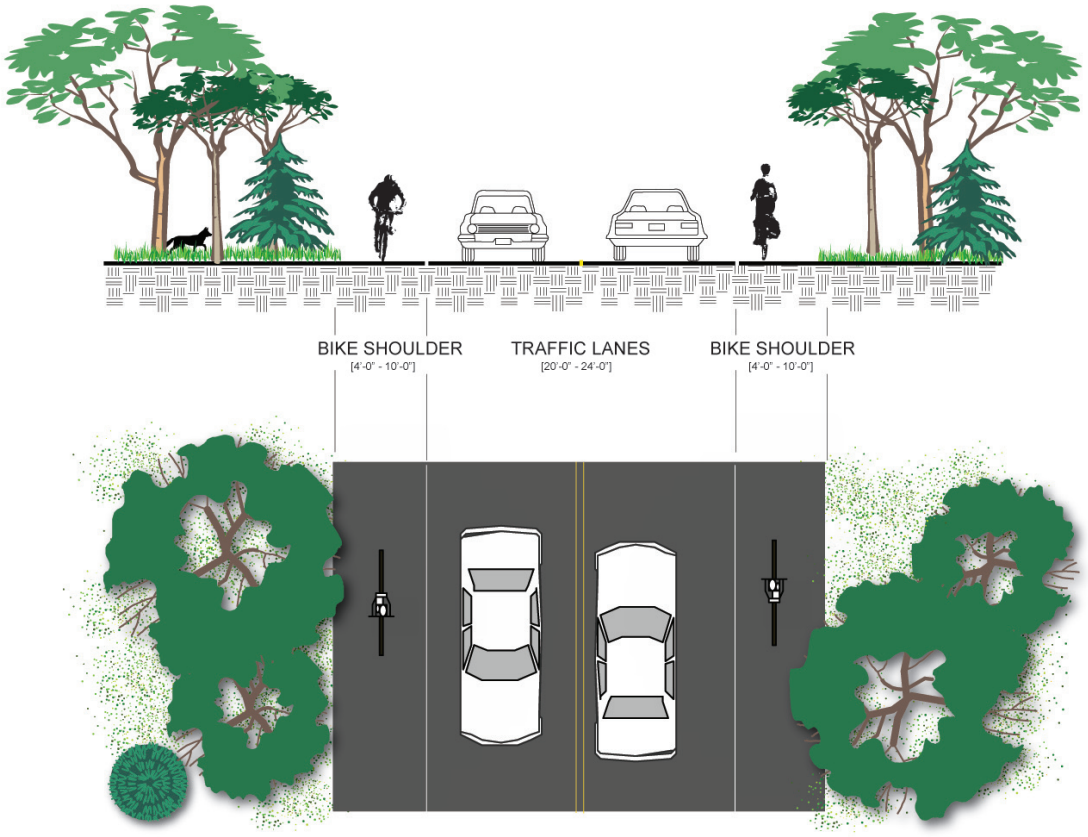
PAVED SHOULDER

Paved shoulders are the part of a roadway which is contiguous and on the same level as the regularly traveled portion of the roadway. There is no minimum width for paved shoulders, however a width of at least four feet is preferred. Ideally, paved shoulders should be include in the construction of new roadways and/or the upgrade of existing roadways, especially where there is a need to more safely accommodate bicycles.

- Most often used in rural environments, although not confined to any particular setting
- Should be delineated by a solid white line, and provided on both sides of the road
- Should be contiguous and on the same level as the regularly traveled portion of the roadway
- 4' minimum width; however for speeds higher than 40 MPH with high ADT, a shoulder width of more than 4' is recommended.
- Rumble strips should be avoided, but if used, then a width of more than 4' is needed.
- Paved shoulders should not be so wide as to be confused with a full automobile travel lane



SIDEPATH

Multi-use paths located within the roadway corridor right-of-way, or adjacent to roads, are called 'Sidepaths'. Sidepaths are most appropriate in corridors with few driveways and intersections. Bicycle routes where side paths are recommended should also have adequate on-road bicycle facilities (such as paved shoulders or bicycle lanes), so that all types of users are accommodated.

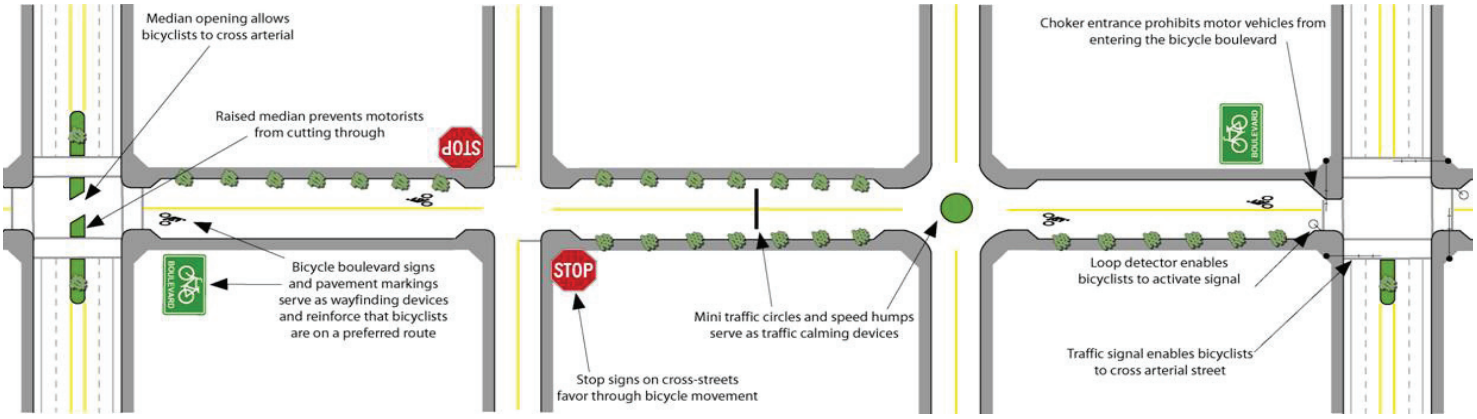
- This type of facility works best in corridors where there are limited driveway/intersection crossings and more desirable destinations along one side of the roadway, or where no roadway space is available to provide bicycle lanes.
- A !0' minimum width is necessary on sidepaths for bicyclists to pass one another safely (12' for areas expecting high use)
- A 3-5' (preferably 6') vegetated buffer between the sidepath and the roadway should be provided where possible.
- Well-designed transitions from sidepaths to on-road facilities will direct bicyclists to the correct side of the roadway (see page 288 for information on trail-roadway intersections)

D

BICYCLE BOULEVARDS

To further identify preferred routes for bicyclists, the operation of lower volume roadways may be modified to function as a through street for bicycles while maintaining local access for automobiles. Traffic calming devices reduce traffic speeds and through trips while limiting conflicts between motorists and bicyclists, as well as give priority to through bicycle movement.

Bicycle boulevards are often located on roadways that parallel a major roadway.



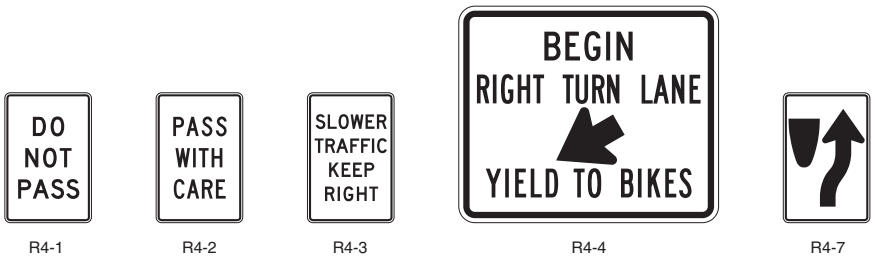
A bicycle boulevard.

Bicycle boulevard route signs and/or pavement markings can be used to direct bicyclists.

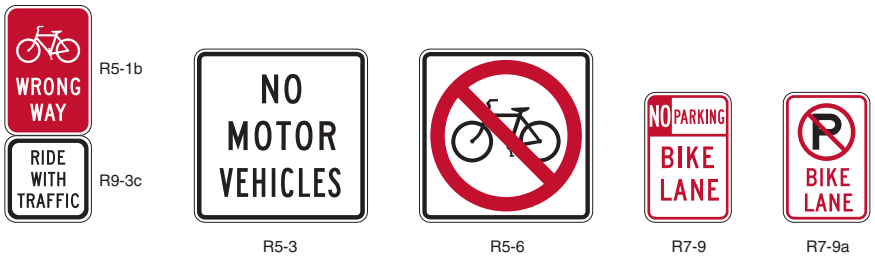
BICYCLE REGULATORY/ WARNING SIGNS

Regulatory and warning bicycle signage should conform to the Manual on Uniform Traffic Control Devices (MUTCD). The signs to the right are examples of regulatory signs for bicycle (their labels are sign reference numbers for the MUTCD).

R1-1 R1-2 R3-17 R3-17a R3-17b



R4-1 R4-2 R4-3 R4-4 R4-7



R5-1b R9-3c R5-3 R5-6 R7-9 R7-9a

SPECIAL PURPOSE SIGNAGE

The "Share the Road" sign (below), is designed to advise motorists that bicyclists are allowed to share and have the right to cycle on narrow roadways with motor vehicles. For more on the "Share the Road Initiative" go to: http://ncdot.org/transit/bicycle/safety/programs_initiatives/share.html

Innovative signage is often developed to increase bicycle awareness and improve visibility (such as 'Bikes Allowed Use of Full Lane', bottom right).

W11-1 W16-1P

Share the Road signs remind motorists that bicyclists have the right to ride on the roadway

R4-11

The "Bikes Allowed Use of Full Lane" sign is currently used on an experimental basis in several cities.

1. The Rack Element

Definition: **the rack element is the part of the bike rack that supports one bicycle.**

The rack element 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 (e.g. a mixte frame)
- Allow front-in parking: a U-lock should be able to lock the front wheel and the down tube of an upright bicycle
- Allow back-in parking: a U-lock should be able to lock the rear wheel and seat tube of the bicycle

Comb, toast, school-yard, and other wheel-bending racks that provide no support for the bicycle frame are NOT recommended.

The rack element should resist being cut or detached using common hand tools, especially those that can be concealed in a backpack. Such tools include bolt cutters, pipe cutters, wrenches, and pry bars.

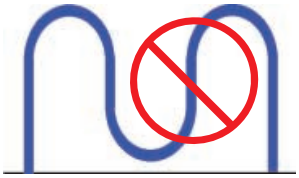
INVERTED "U"
One rack element supports two bikes.

"A"
One rack element supports two bikes.

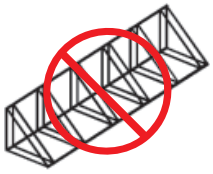
POST AND LOOP
One rack element supports two bikes.

COMB
One rack element is a vertical segment of the rack.

Not recommended

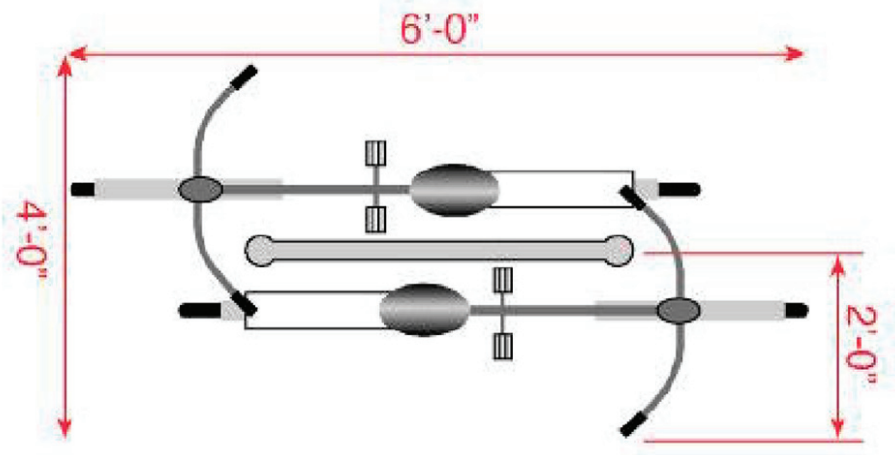


WAVE
One rack element is a vertical segment of the rack.
(see additional discussion on page 3)



TOAST
One rack element holds one wheel of a bike.

Recommended guidelines for bicycle parking from the Association of Pedestrian and Bicycle Professionals, 2002, www.apbp.org.



Custom Design

Bicycle racks that incorporate advertising can be sponsored by local merchants.

Provision of shelter from rain greatly increases usefulness of this bicycle parking facility during inclement weather.

A single inverted "U" rack can accommodate two bicycles.

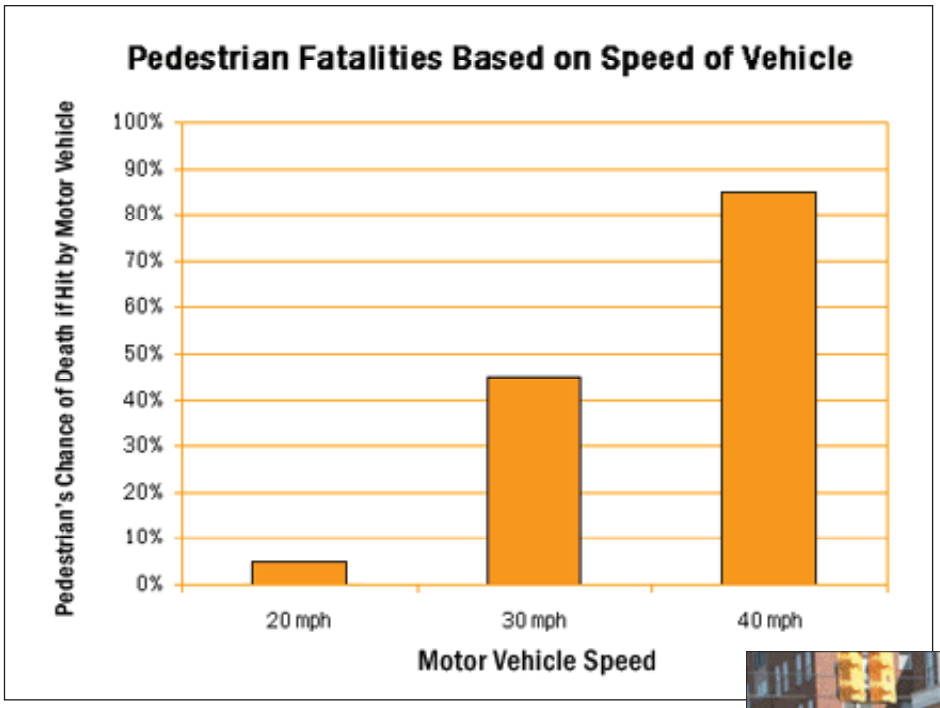
Example of a bicycle rack in Durham, NC, serving as a piece of utilitarian public art.

D.21 TRAFFIC CALMING TREATMENTS

Traffic calming is a procedure in which the arrangement of the street and its elements encourages slower traffic to ensure safe speeds. Typically, compliance with traffic control devices are optional but with the use of physical and visual cues that traffic calming introduces, drivers are force to respond to the calming procedures.

Research on effective traffic calming in the U.S. suggests that traffic calming can effectively reduce the speed of vehicular traffic, decrease the number of automobile accidents, and contribute to noise reduction. Research also supports that the use of multiple traffic calming procedures will exponentially reduce the number of crashes.

The following pages describe typical traffic calming measure.



Above: Graph from Killing Speed and Saving Lives, U.K. Department of Transportation, London, 1987.

Right: Example of multi-modal intersection with traffic calming elements.

The curb extension makes motorist reduce speeds for turning and provides street parking.

CURB EXTENSIONS (BULB OUTS)

A curb extension (also known as a bulb out) is the additional sidewalk space allocated along the street as a traffic calming measure. By extending the curb, the street becomes more narrow to vehicular traffic thus slowing down traffic speeds. The curb extension also reduces the crossing distance for a pedestrian decreasing the time of a pedestrian in the street. The extension also improves the visibility of both motorist and pedestrians.

Curb extensions also prevent motorists from parking vehicles too close to crosswalks and curb ramps leaving the space open for pedestrian movement. Motor vehicles, parked too close to corners, present a threat to pedestrian safety, since they block sight lines, obscure visibility of pedestrians and other vehicles, and make turning particularly difficult for emergency vehicles and trucks.

Extensions to the curb are only recommended where parking exists. Curb extensions must not intervene with the adjacent drive lanes, bicycle lanes, or roadway shoulders. The turning needs of larger vehicles, such as school buses, need to be considered in curb extension design as well.

The curb extension narrows the width of the street and can be used in combination with crosswalk markings.

CHOKERS

Chokers are a design tool used to widen sidewalks or planting beds along vehicular corridors to decrease the width of the travel lane. By narrowing the street, effectively reducing the travel lanes by half of a lane wide, the choker forces motorist to yield to each other and slow down. In order for this to function effectively, the width of the travel lane cannot be wide enough for two cars to pass. Sixteen feet is typically effective (and will permit emergency vehicles to pass unimpeded).

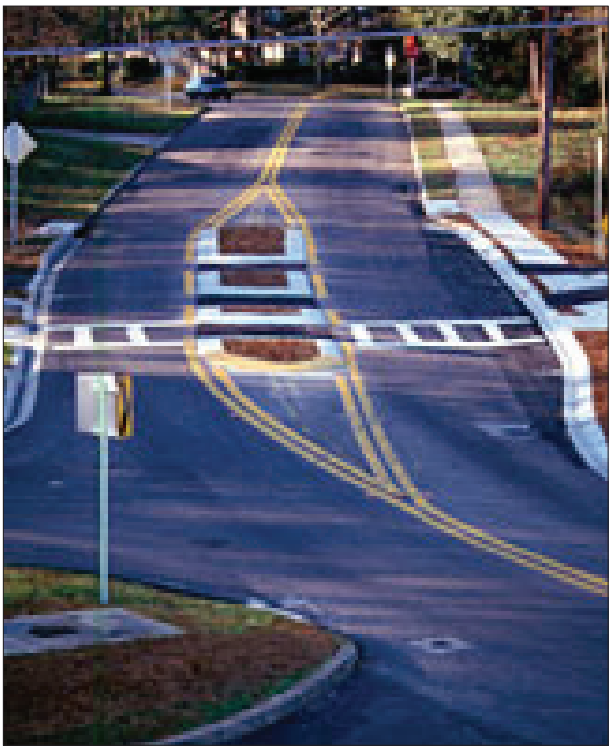
Chokers can be created by bringing both curbs in, or they can be done by more dramatically widening one side at a midblock location. They can also be used at intersections, creating a gateway effect when entering a street.

The choker produces a narrow passage for vehicular traffic.

This choker narrows the street from two lanes to one. Traffic is forced to slow down and, in some cases, wait for an approaching vehicle to pass before proceeding.

D

CROSSING ISLANDS (CENTER ISLANDS, PEDESTRIAN ISLANDS, MEDIAN SLOW POINTS)



Crossing islands allow pedestrians to be concerned with one direction of traffic at a time. The roadway markings in the design shown here also help make motorists aware that a pedestrian may be crossing.

Crossing islands are pedestrian refuge areas raised to curb height typically located in the center of street, intersections or midblock crossways. Center crossing islands protect pedestrians from vehicles and subsequently allow users to watch one direction of traffic at a time.

Where midblock or intersection crosswalks are installed at uncontrolled locations (i.e., where no traffic signals or stop signs exist), crossing islands should be considered as a supplement to the crosswalk. They are also appropriate at signalized crossings. If there is enough width, center crossing islands and curb extensions can be used together to create a highly improved pedestrian crossing.

Curb extensions may be built in conjunction with center crossing islands where there is street parking. Care should be taken to maintain bicycle access. Bicycle lanes must not be eliminated or squeezed in order to create the curb extensions or islands.

Crossing islands may be added to the middle of a street when the street is very wide.

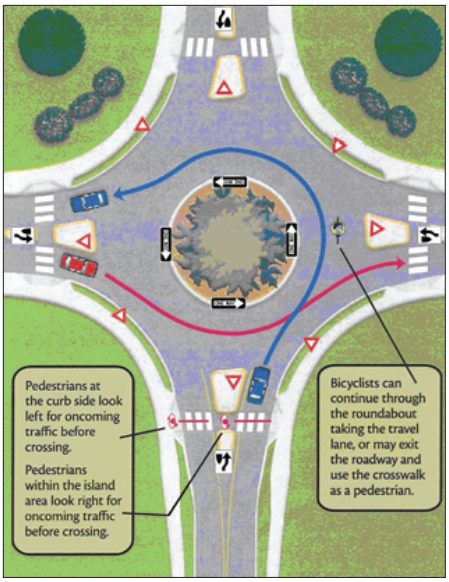
Crossing island allows pedestrians to stop before completely crossing a road.

CHICANE

A chicane is a traffic method used to narrow and/or turn the roadway with the use of divergent paths and shifting parking lanes. When motorists are prevented from driving in a direct linear fashion, their speeds are normally reduced. Using chicanes is a successful way to force motorist to shift travel lanes and restrict direct forward movement. Shifts can be created by moving street parking from one side to the other or by building landscaped islands that gradually cause the motorist to maneuver the obstacles in order to continue progression.

A chicane on a one-lane road.

This chicane narrows the street to fewer lanes and requires traffic to move slowly.



Movement within a roundabout.

A traffic mini-circle helps reduce vehicle speeds, but still allows cars and emergency vehicles to pass through the intersection with little difficulty.

MINI CIRCLES (ROUNDABOUTS)

Mini-circles are traffic islands raised to curb height, located at the center of an intersection. The design of a mini-circle is intended to force motorists to reduce speed in order to turn in a circular motion. Drivers making left turns are directed to go on the far side of the circle prior to making the turn. Drivers going straight must go around the circle before proceeding. And drivers going right must yield to traffic that is in the mini-circle.

The center portion of the mini-circle is usually landscaped with various plant materials that allow motorists and pedestrians clear sights to all sides of the intersection. In locations where landscaping is not feasible, traffic circles can be enhanced through specific pavement materials.

Mini-circles are designed to slow traffic but because they do not have the capability of controlling right turns at the intersection, pedestrians and cyclists do encounter potential risk. In order to compensate for this risk, right curb radii should complement this treatment to discourage high speed right turn maneuvers. Large vehicles (i.e. delivery and fire trucks) can be accommodated with a roll-curb on the mini-circle.

Cyclist and pedestrian needs can also be accommodated by moving crosswalks away from the mini-circle to a mid-block crossing or next intersection.

Roundabouts (and other circular intersection types) allow for landscaping, monuments, and other aesthetic uses within the central island.

Vehicles entering the roundabout give way to vehicles in the roundabout.

SPEED HUMPS

Speed humps are 3”-4” raised mounds that extend the width of the street to deter motorists from excessive speeds. Speed humps should not be confused with the speed “bump” that is often found in mall parking lots. Generally, speed humps are 12’ to 14’ in length and span the width of the road. The length and height of the speed humps determine the speed at which traffic will travel over the devices. Shorter lengths and greater heights slow cars most drastically.

The traditional 12’ hump has a design speed of 15 to 20 mph, a 14’ hump a few miles per hour higher, and a 22’ table has a design speed of 25 to 30 mph. The longer humps are much gentler for larger vehicles.

A warning sign notifies motorists before humps. Humps generally have pavement markings to enhance visibility and a taper edge near the curb to allow a gap for drainage.

Speed humps are used on streets to reduce speed, causing motorists to slow down.

D

RAISED INTERSECTION

A raised intersection is a speed table that spans the area of the entire intersection. Each side of the intersection has a ramp for the vehicle approach, which elevates the entire intersection to the level of the sidewalk. They can be built with a variety of materials, including asphalt, concrete, stamped concrete, or pavers. The crosswalks on each approach are also elevated as part of the treatment to enable pedestrians to cross the road at the same level as the sidewalk, eliminating the need for curb ramps. Use detectable warnings to mark the boundary between the sidewalk and the street.

A raised intersection slows all vehicular movements through the intersection and improves pedestrian crossings in all directions.

The raised intersection above enhances the pedestrian environment at the urban crossings.

Raised intersections, like the one above, reduce vehicle speeds at busy intersections.

RAISED PEDESTRIAN CROSSING

A raised pedestrian crossing is also a speed table, with a flat portion the width of a crosswalk, usually 10’ to 15’. Raised intersections and crosswalks encourage motorists to yield to the vehicular ramp and elevated pedestrians.

A raised pedestrian crossing provides a continuous route for the pedestrian at the same level as the sidewalk. Pavement markings may be used on the slope to make the crossing visible to motorists.

The raised crosswalk helps reduce vehicle speeds and the measures tend to have a predictable speed reduction solution.

SPEED TABLE

A speed table is a broad portion of a speed hump, used as a pedestrian crossing. The speed table can either be parabolic, making it more like a speed hump, or trapezoidal, which creates the flat table like surface. Speed tables can be used in combination with curb extensions where street parking exists.

The speed table (above) causes less of a delay than humps and are typically preferred by fire departments over speed humps.

The speed table design (above) allows cars to pass without slowing as significantly as with speed humps.

D

GATEWAYS

A gateway is a physical landmark that indicates a change in environment from a higher speed major roadway to a minor road (lower speed district). Gateways can include different traffic calming techniques such as of street narrowing, medians, signing, archways, roundabouts, or other identifiable features. Gateways reveal to motorist that an area of slower speeds has been reached. This can help achieve the goal of meeting expectations and preparing motorists for a different driving environment. Gateways are only an introduction and slower speeds are not likely to be maintained unless the entire area has been redesigned or other traffic-calming features are used.

Gateways produce an expectation for motorists to drive more slowly and watch for pedestrians when entering a commercial, business, or residential district from a higher speed roadway.

Creative gateways help establish a unique image for an area.

LANDSCAPING

Landscaping along the corridor can work as a buffer to separate pedestrians from vehicles, reduce the visual width of the roadway (which encourages slower speeds), and provide an aesthetic appeal to the street. This can include a variety of trees, bushes, and/or flowerpots, which can be planted in the buffer area between the sidewalk or walkway and the street.

Choosing appropriate plants, providing adequate space for maturation, and preparing the ground can help ensure that the plants survive with minimal maintenance and don't buckle the sidewalks as they mature. The following guidelines should be considered: plants should be adapted to the local climate and fit the character of the surrounding area—they should survive without protection or intensive irrigation; and the plant's growth patterns should not obscure signs or pedestrians' and motorists' views of each other.

The landscaping enhances the street environment.

The landscaping on this street calms traffic by creating a visual narrowing of the roadway.

Landscaping with low shrubs, ground cover, and mature trees that are properly pruned can add shade, color, and visual interest to a street.

D

PAVING MATERIALS

Paving materials are important to the function and look of a street, both in the road and on the sidewalk. Paving materials can also increase crosswalk visibility and act as a physical traffic calming device when using paved brick or cobblestone. Textured crosswalks should be marked with reflective lines since these types of crosswalks are not as visible, especially at night or on rainy days.

Smooth travel surfaces are best for all pedestrians. The pedestrian path material should be firm, planar, and slip-resistant. Concrete is the preferred walking surface. A different look can be achieved by using stamped concrete or concrete pavers, which are available in a variety of colors and shapes. Colored paving can often enhance the function of portions of the roadway, such as a colored bicycle lane. This can create the perception of street narrowing, in addition to enhancing the travel facility for bicyclists.

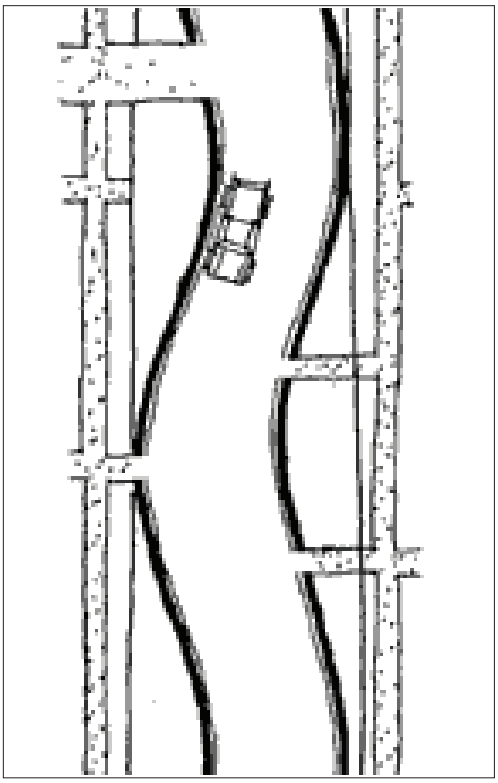
Brick or cobblestone streets help slow traffic and create a feeling that the street is not a highway or fast-moving arterial.

This paving creates an aesthetic enhancement to the street.

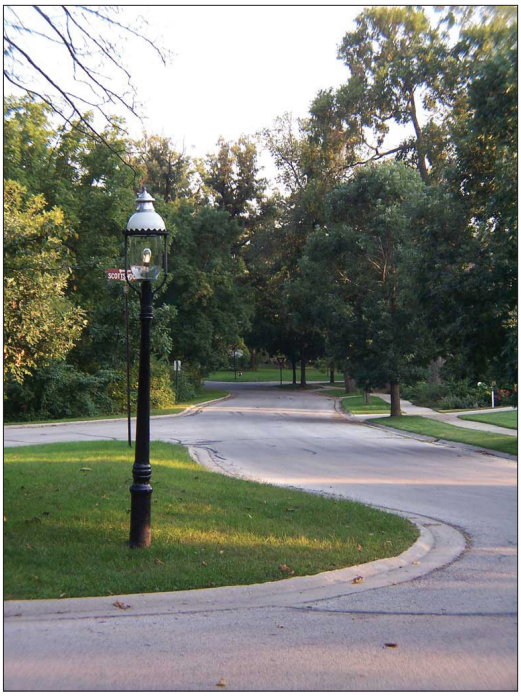
SERPENTINE DESIGN

Serpentine roadway design is when a street is aligned in a wave fashion to shift traffic left and right with the use of built-in visual enhancements. This allows movement but forces vehicles to reduce speed. The opportunities for significant landscaping can be used to create a park-like atmosphere.

Such designs are usually implemented with construction of a new neighborhood street or during reconstruction of an existing street corridor. This type of design can be more expensive than other traffic-calming options and needs to be coordinated with driveway access.



The serpentine design changes the entire look of a street to send a message to drivers that the road is not for fast driving.



The serpentine street is a curving roadway that helps slow traffic through the use of curbs and landscaping.

The opportunities for significant landscaping can be used to create a park-like atmosphere.

D

WOONERF

A woonerf ("Street for living") is a Dutch term for a common space created to be shared by pedestrians, bicyclists, and low-speed motor vehicles.

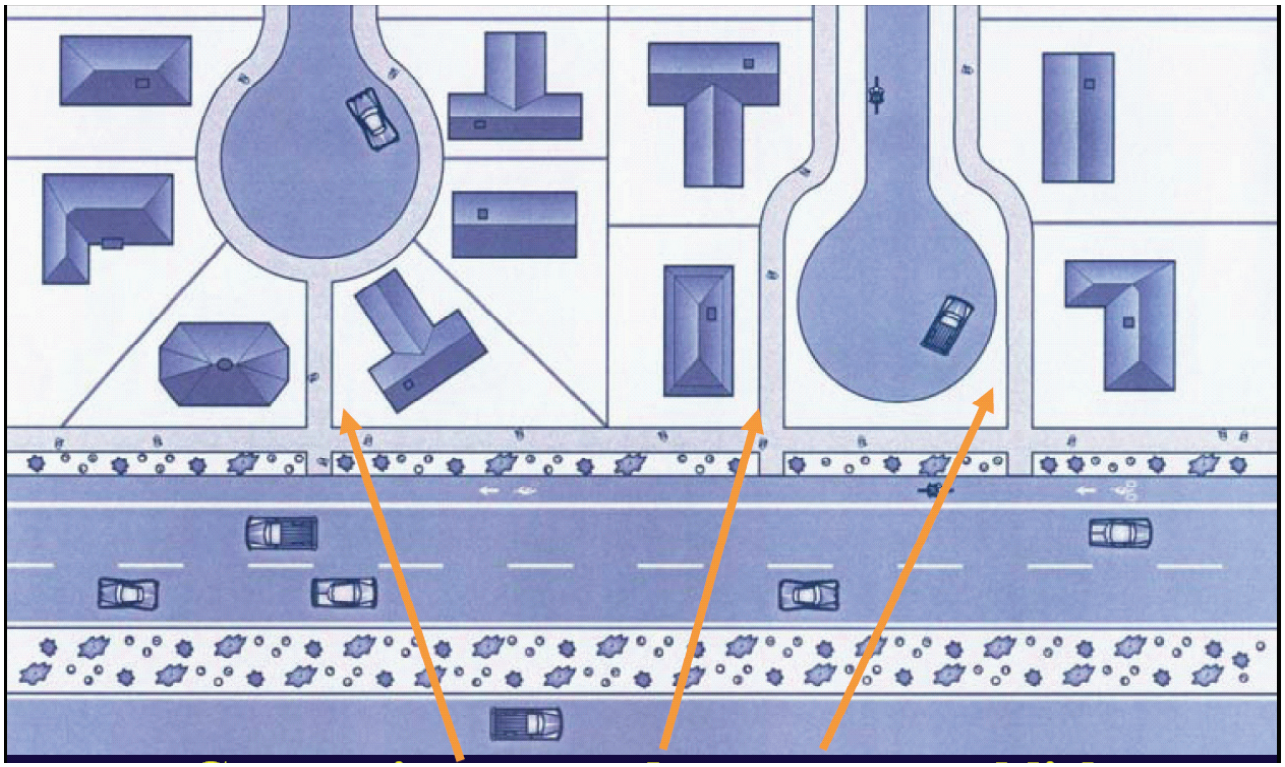
They are typically narrow streets without curbs and sidewalks. Vehicles are slowed by placing trees, planters, parking areas, and other obstacles in the street. Motorists become the intruders and must travel at very low speeds below 10 mph. This makes a street available for public use that is essentially only intended for local residents. A woonerf identification sign is placed at each street entrance.

Consideration must be given to provide access by fire trucks, sanitation vehicles and other service vehicles if needed.

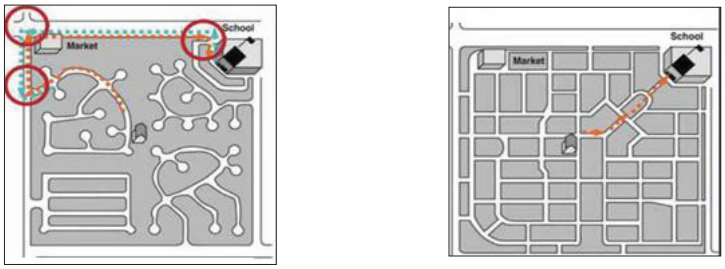
Motorists, cyclists, and pedestrians share the space on this woonerf or living street.

D.22 LAND USE AND PEDESTRIAN TRAVEL

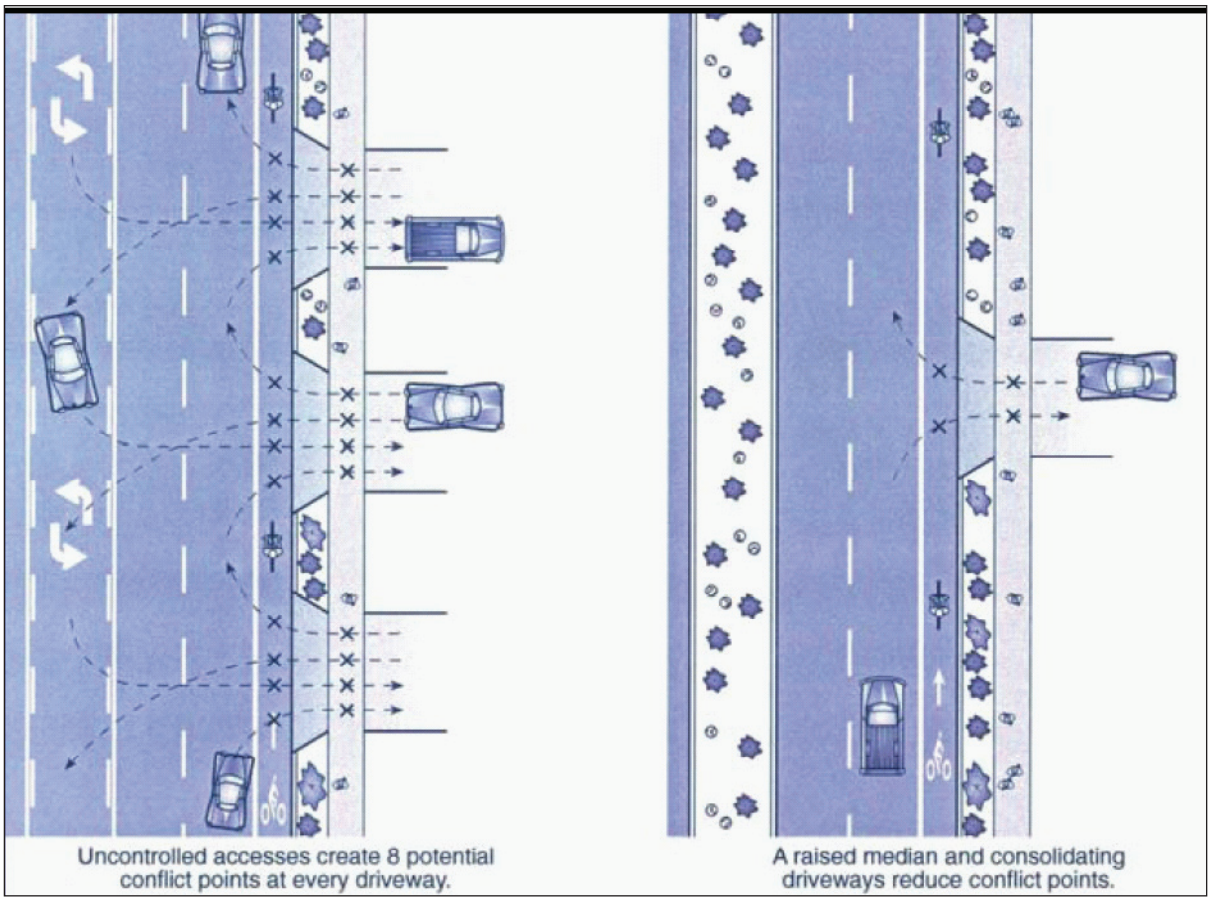
The land use and development environment plays a major role in the walkability of an area. The following are brief examples of the importance of connectivity, not only along corridors and across roadways, but also between neighborhoods and into commercial sites.



The above example shows the effectiveness of connecting a traditional cul-de-sac neighborhood to a collector or arterial road.



The above example communicates the difference between a connected street and pedestrian network (on right) versus separated cul-de-sac neighborhoods. A person living in the scenario to the right will have a longer trip to school and will likely be forced to travel by automobile. A person living in the scenario could walk to school safely and easily. This scenario, used consistently, would significantly reduce traffic.



Driveway access management is a key issue throughout the United States. A high number of driveway accesses and/or wide driveway accesses create more conflict points between motorists, bicyclists, and pedestrians. Every effort should be made to retrofit and build new development with the goal of achieving the scenario to the right.

Pedestrian connectivity is critical not only between destinations but within destinations. The example shown above shows an excellent commercial area with clear pedestrian pathways of travel.