Figure 2-1: Many low-volume residential streets need only the most basic improvements to make them more ridable.

2. Basic Roadway Improvements

The street system provides the basic network for bicycle travel. Other elements (e.g., bike lanes and paths) supplement this system. To make most streets work for bicyclists, basic improvements may be needed. Such things as safe railroad crossings, traffic signals that work for bicyclists, and street networks that connect benefit bicyclists and make more bicycle trips possible and likely.

2.1 Roadway types

While the most basic improvements are appropriate for all categories of street, some improvements are most appropriate for certain categories. In a typical community, streets types range from quiet residential streets, to minor collector streets, to major arterials, and highways or expressways.

2.1.1 Residential streets

On quiet residential streets with little traffic and slow speeds (fig. 2-1), bicyclists and motorists can generally co-exist with little difficulty. Such streets seldom need bike lanes. Only the most basic improvements may be required, for instance:

- *bicycle-safe drainage grates*
- *proper sight distance at intersections*
- *smooth pavement and proper maintenance*

One additional factor that may need attention is connectivity. Providing bicycle linkages between residential streets and nearby commercial areas or adjacent neighborhoods can significantly improve bicycling conditions. In many communi-

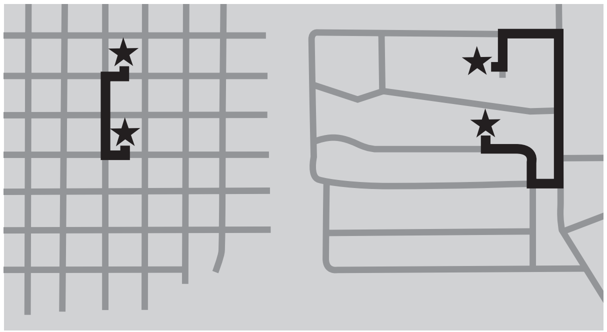


Figure 2-2: Long blocks and a lack of connectivity make trips longer and discourage bicycling for purposeful trips.

ties, newer parts of town tend to have discontinuous street networks that require bicyclists, pedestrians, and motorists to travel a long distance to get to a nearby destination (fig. 2-2) and also force bicyclists onto busier streets than necessary.

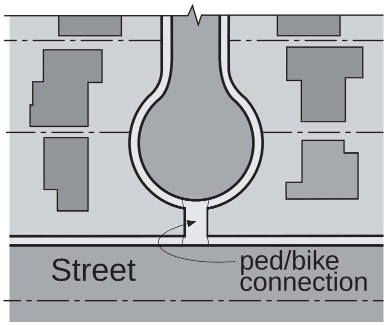


Figure 2-3: Bicycle-pedestrian connections like that shown can provide valuable short cuts. (after Mesa, AZ subdivision regulations)

Since most bicycle and pedestrian trips are short, such discontinuities can discourage bicycling and walking. Improving connections where possible can help solve this problem (fig. 2-3).

On residential streets impacted by excessive through traffic and speeding motorists — or both — traffic calming measures may be necessary. These are described in Section 2.10, but the basics include features designed to slow motorists down and those designed to divert or discourage through traffic. Also see AASHTO's *Guide for the Development of Bicycle Facilities* for information on bicycle boulevards.

Figure 2-4: Residential streets may require traffic calming measures like this traffic circle. However, designs should not endanger or discourage bicyclists.

Typical approaches include street closures, small traffic circles (fig. 2-4), chicanes, and speed humps. Traffic calming measures should be designed with bicyclists clearly in mind. In general, they should not hamper bicycling traffic and they should not create new bicycle hazards.

2.1.2 Collector streets

Collector streets typically connect local residential streets to the major roads in a community. As a result, in many areas (see the right image in fig. 2-2), the collector streets are the only ways to cross arterial streets. Even if local streets intersect the arterials, they seldom have signals to create breaks in traffic.

Therefore, in addition to the bicycle-safe grates, proper sight distance, and smooth pavement mentioned previously, other improvements should be considered for collector streets:

- *bicycle-safe railroad crossings*
- *bicycle-actuated traffic signals*
- *wide outside traffic lanes or bicycle lanes*
- *bike lanes or shoulders on bridges and underpasses*

Note: Photos are categorized by their content:

YES	*Positive example*
OK	*Special case example*
NO	*Not recommended.*

Figure 2-4: Collector streets like this one typically carry lower traffic volumes and have lower speeds than arterial streets. As a result, many bicyclists feel more comfortable using them.

The importance of collector streets for bicyclists is worth keeping in mind, particularly when considering plans for new subdivisions and commercial areas. In some communities, arterial streets are laid out on a one-mile grid, with collectors on the half mile. As a result, less-experienced bicyclists can get around without having to use busy main thoroughfares (fig. 2-4). If the pattern of collector street connectivity is broken, however, these bicyclists will find their options limited and their access restricted.

On-street parking: Most new collector streets built within urban areas are constructed with parking for both sides. However, off-street parking is plentiful in new developments, and, as a result, very little "spill-over parking" occurs on the street. This typically leaves a very wide street for bicycle and motor vehicle use (fig. 2-5). On the other hand, if a street is being used consistently for parking, there may not be enough space to provide for bicycle lanes or wide parking lanes.

Figure 2-5: In some areas with plenty of off-street parking, collectors are designed for on-street parking with extra space for bicycles. This may result in excessive width and potentially high traffic speeds.

Planners should be aware of this situation when evaluating and planning for collector streets. If additional width is built into collector streets to accommodate bicyclists and parked cars, but the street is rarely being parked on, the excessive width may result in high traffic speeds.

When transportation planners created bicycle plans for metro areas in the mid-1990's, several reported a mismatch between what bicyclists were telling them about collector street bicycling conditions and what would be expected, based upon accepted standards. Their initial analysis told them the streets were narrow and uncomfortable for bicycling. But the bicyclists told them there was plenty of space. The reason for this difference in perspective was the lack of parked cars on the streets.

If only sporadic parking is expected, new collector streets should be considered for one-side parking. Similarly, restriping existing collector streets to restrict parking to one side may improve conditions for bicyclists who have to otherwise move left around the occasional parked car.

Figure 2-6: A major suburban arterial street with 45mph speeds and high volumes. Many bicyclists would see this as a hostile bicycling environment.

2.1.3 Arterial streets

Arterial streets typically carry much of a community's traffic load, particularly for trips involving cross-town or inter-city travel. In addition, major businesses and institutions are often found along arterial streets. As a result, arterial streets are often the busiest roads around (fig. 2-6).

In a community's center, however, traffic speeds tend to be lower than in the suburbs and this may make downtown streets easier for bicycling (fig.

Figure 2-7: A downtown arterial street typically has lower traffic speeds than an arterial street in the suburbs.

2-7). Downtown, speed limits may be 25 or 30mph, while in the suburbs, arterial streets may be signed for 45 or, in some cases, 55mph.

Common improvements recommended for arterial streets include:

- *bicycle lanes, wide outside lanes, or shoulders;*
- *urban (instead of rural) highway interchange designs;*
- *shoulders or bicycle lanes on bridges and underpasses;*

2.1.4 Rural highways

Rural highways (fig. 2-8) are most useful for long-distance touring and recreational bicycling. Busy multi-lane highways are much less popular than lower volume highways and town roads, however. Interstate highways and freeways typically do not allow bicyclists.

Figure 2-8: Basic paved shoulders are often the only improvements needed to make rural roads more bicycle-friendly.

To help determine if paved shoulders are necessary for rural highways, a methodology or rating index should be used whenever traffic volumes on town and county roads increase beyond approximately 500 vehicles per day. Many counties and communities use the Wisconsin Bike Map methodology. This model rates roadways for their bicycle compatibility using traffic volumes and the width of the roadway as the two primary factors. The Bike Map methodology is available from WisDOT upon request. *[Table 2-1 in section 2.6.2 presents the concept in brief.]*

On quiet country roads, little improvement is necessary to create excellent bicycling routes (fig. 2-9). Examples include town roads and many county trunk highways. State trunk highways and some county trunk highways, however, tend to have more traffic and a higher percentage of trucks. As a result, they are often improved with the addition of paved shoulders (sec. 2.6).

Figure 2-9: Many low-volume country roads need few improvements in order to serve bicyclists well.

Rural roads near growing communities often suffer from a mismatch of design and current traffic loads. While they may have been designed for farm-to-market or rural recreational purposes, new development can overload them with suburban commute and personal business trips. These roads should get priority attention.

Also see AASHTO's *Guide for the Development of Bicycle Facilities* for information on how to retrofit bicycle facilities on existing streets and highways including strategies on how to allocate existing roadway space differently to accommodate various bicycle facilities. It includes the consideration of reducing the number of travel lanes and lane widths, as well as finding additional space by using different vehicle parking schemes.

2.2 Pavement quality

Automobile suspensions can compensate for surface roughness and potholes and their wide tires can span cracks. But most bicycles, with their relatively narrow tires and lack of suspension, have difficulty handling such hazards (fig. 2-10).

Concrete slabs or asphalt overlays with gaps parallel to the direction of travel can trap or divert a bicycle wheel and cause loss of control. Holes and bumps can cause bicyclists to swerve into the path of motor vehicle traffic. To the extent practicable, pavement surfaces should be free of irregularities.

The right lane or shoulder should generally be uniform in width. While skilled bicyclists tend to guide off the lane stripe and ride a predictable straight line, many riders move right or left depending on the width of the lane or presence of shoulders. A road which varies greatly in width encourages such unpredictable behavior.

Figure 2-10 (above): Bad pavement edges create hazards for bicyclists.

Figure 2-11 (right): Gravel from an unpaved side road is dragged up onto an otherwise adequate shoulder, reducing the amount of space available for bicycling.

On older pavements it may be necessary to fill joints, adjust utility covers or, in extreme cases, overlay the pavement to make it suitable for bicycling. See Drainage Grates (sec. 2.6) for advice on grates and utility covers.

When *new pavement overlays* are added to curbed roadway sections, the old pavement should be milled, if necessary, to allow the new asphalt to meet the gutter pan smoothly. Failure to feather the new overlay into the existing pavement can result in a hazardous longitudinal lip at the edge of the new asphalt (fig. 2-12).

Paving over a concrete gutter and then considering it usable for bicyclists is generally not satisfactory for Wisconsin climates for several reasons: (1) the joint line will probably come through the new asphalt, causing a longitudinal crack. (2) Paving to the curb may affect the drainage and lower the effective height of the curb. (3) The bicyclist will still need to shy away from the curb.

Chip sealing a road extends the life of the pavement at relatively low cost (fig. 2-13). Chip sealing can fill joints and smooth out roadway imperfections. However, when applying chip seal coats to existing streets, removal of excess gravel at the earliest possible convenience is important.

Since passing motor traffic sweeps the gravel off to the side of the road, it tends to collect in piles deep enough to cause bicyclists to crash. For this reason, bicyclists will often ride in the area cleared by motorists' tires.

Figure 2-12 (top): A rough edge created by not feathering the overlay into the curb.

Figure 2-13 (bottom): chip seal is often used to extend the life of a roadway.

Roadway patching typically follows underground utility work or it may be done to repair potholes and other problems. Pavement replacement should be flush with surrounding pavement, including the adjacent concrete gutter. If possible, longitudinal joints should be located away from the bicyclist's typical path. In addition, patches should should not fail within a year.

Figure 2-14: This drainage grate has two main problems. First, its parallel bars and slots can trap a bike wheel. Second, it's located in a likely path of a turning bicyclist.

2.3 Drainage grates and utility covers

Drainage grate inlets and utility covers can be hazards for bicyclists (fig. 2-14). 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*

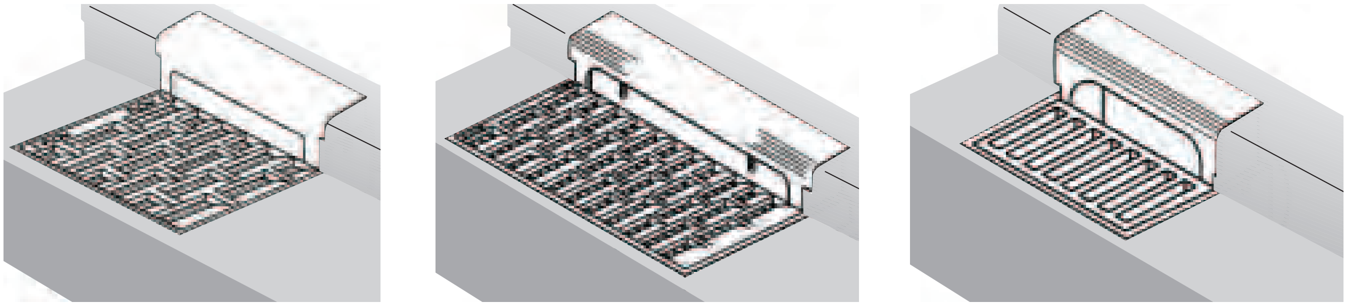


Figure 2-15:Examples of WisDOT standard bicycle-safe grates: Type A, H, and Z (left to right)

2.3.1 Grate type

The standard inlet covers used by WisDOT (fig. 2-15) are considered bicycle-safe. The inlet covers which are narrow and therefore encroach the least into a bicycle curb lane are Types "A," "H," "HM," "R," and "Z." These inlet cover types must be used for new construction/reconstruction projects and also as replacement covers for 3R improvements, providing they have the necessary hydraulic capacity.

2.3.2 Grate or utility cover location

To the extent possible, drainage grates and utility covers should be kept out of the typical bicyclists' likely path (see Fig. 2-16). In many cases, however, grates and covers are located near the right side of the roadway, where most bicyclists ride.

To reduce the potential for problems, grates should be close to the curb and should not extend farther into the roadway than is necessary; the grate should be within the gutter pan.

Where roadway space is limited, the curb may be offset at the grate location (see Fig. 2-18). Note that the total width of curb and gutter in this example from Madison does not change. The 1-ft. curb head narrows to 6-in. to allow for a Type A drain. In addition, this approach shifts the gutter pan/roadway joint line closer to the curb and farther from the bicyclist's typical path.

At intersections, the Americans with Disabilities Act. Guidance recommends placing drainage grates outside crosswalk or curb ramp locations to limit the drainage across the ramps. this also improves the safety of wheelchair users and those with visual impairments (Fig. 2-17). However, locating grates between the crosswalks would put them where turning bicyclists are likely to be closest to the curb.

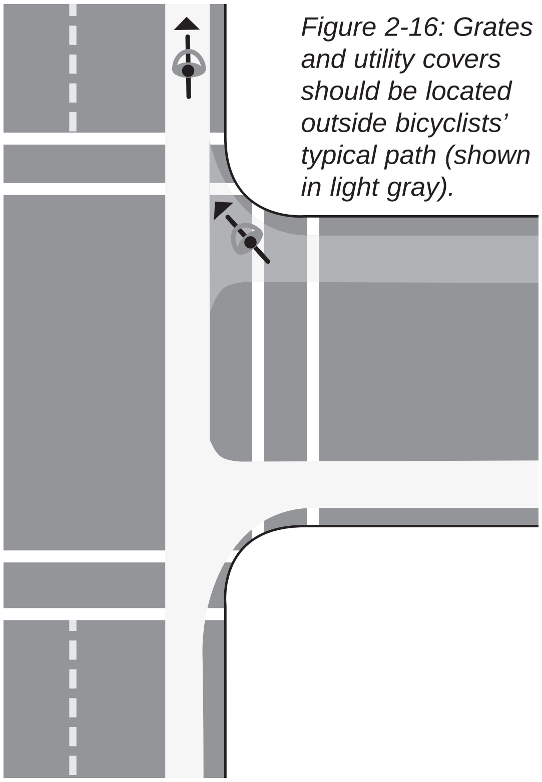


Figure 2-16: Grates and utility covers should be located outside bicyclists' typical path (shown in light gray).

If possible, grates should be located within the gutter pan just before the crosswalks. If they must be located between the crosswalks, a curb inlet should be used.

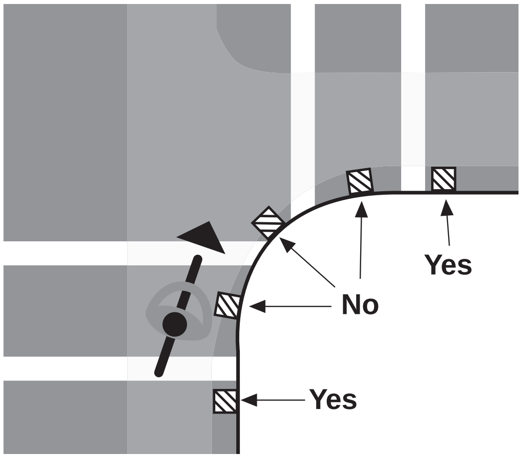


Figure 2-17 (left): Locate drainage grates before the crosswalks and corners to reduce the hazards for wheelchair users and bicyclists.

Figure 2-18 (right): Offsetting the grate into the curbface allows for the use of a 1-ft gutter pan, reduces the effective width of the grate, and moves the longitudinal joint away from the bicyclist's path.

Figure 2-19: Depressed or raised grates can be hazardous, regardless of type.

2.3.3 Grate or utility cover elevation

Whenever a roadway is resurfaced, grates and utility covers should be adjusted flush with the new surface (fig. 2-19) and should never be higher than the roadway. If the height is still below the roadway level after adjustment, the pavement should be tapered to meet (fig. 2-20), particularly if the height difference is more than 1/4 in. (6 mm)

Note: grates with bars perpendicular to the roadway must not be placed at curb cuts, as wheelchair wheels could get caught.

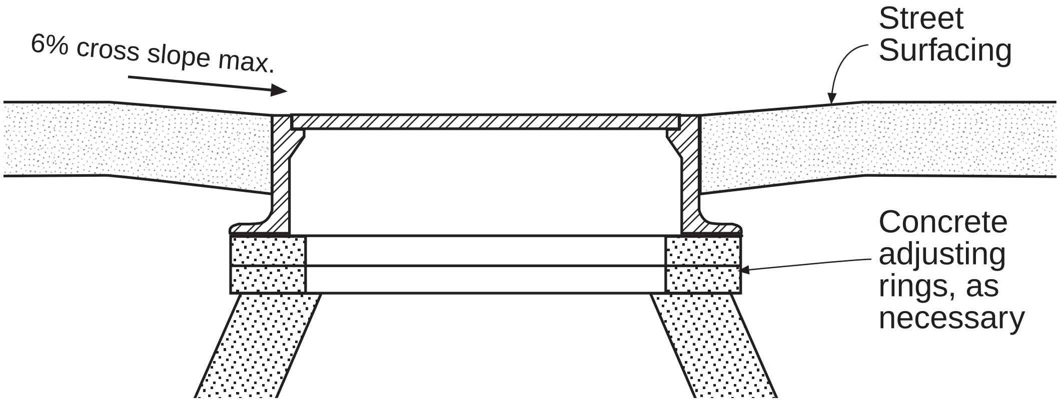


Figure 2-20: In some cases, the roadway may need to be ground to match the height of the grate or utility cover. (after Montana Public Works Standard Specifications, 1988)

2.3.4 Temporary measures

In general, temporary measures are much less satisfactory than simply replacing a dangerous drainage grate with a safe one. Field welding straps to a grate is not recommended (fig. 2-21). It can be costly and snow plows may pull the straps loose, causing a hazard. Another temporary measure — striping a hazard marker around a dangerous grate — is also generally unsatisfactory. In low-light conditions, the stripe may be hard to see and the paint may wear off quickly.

Figure 2-21: Temporary measures, like welded straps, may be more costly in the long run.

2.4 Corner sight lines

One serious concern for bicyclists is visibility at intersections (fig. 2-22). If sight lines are blocked by vegetation, fences, or other obstructions, motorists may not be able to see bicyclists, and vice versa. This is a particular concern with young bicyclists riding in neighborhoods and is a known factor in bicycle/motor vehicle crashes.

Figure 2-22: Sight obstructions can lead to bicycle-motor vehicle crashes.

Typically, at intersections of streets of different functional classifications (e.g., local vs. collector or collector vs. arterial), sight distances are considered for the driver entering from the lower classification roadway. The assumption is that such a driver would face a traffic control device (e.g., a stop sign).

For neighborhood streets, it is equally important, however, that a driver on the superior roadway be able to see — and avoid — young bicyclists approaching on the lower classification roadway. Even so, unless steep grades are a factor, young bicyclists are unlikely to approach fast enough to warrant clear sight triangles in excess of those otherwise considered necessary. To reduce sight obstruction hazards posed for both bicyclists and motorists, agencies should consider developing active sight triangle improvement programs.

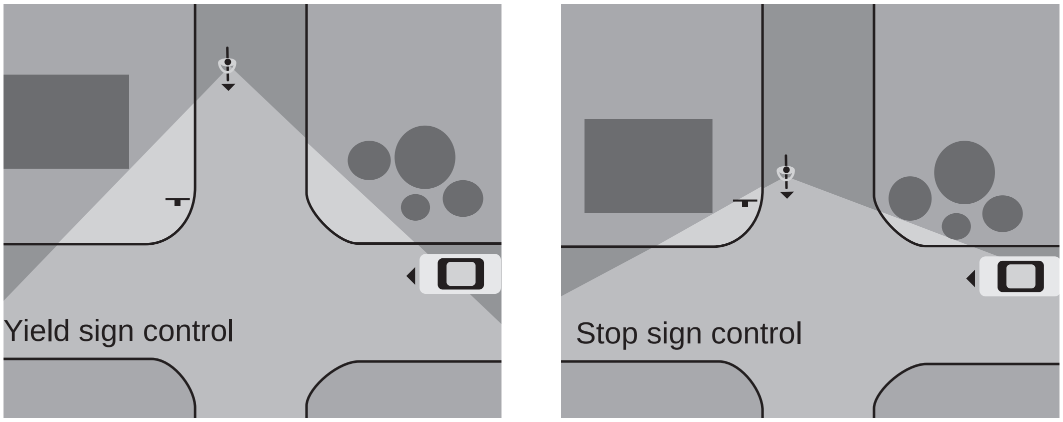


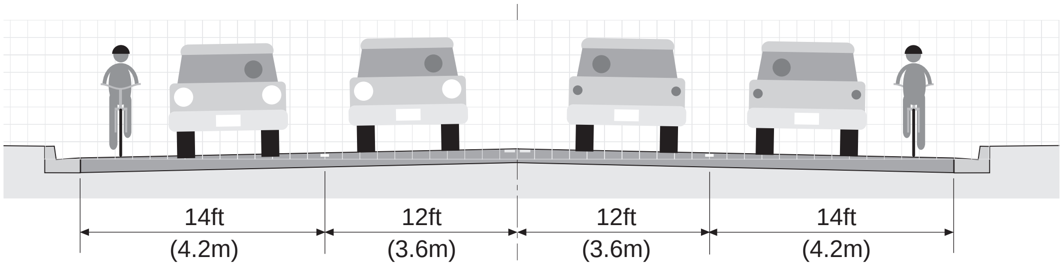
Figure 2-23: Protecting corner sight lines is an important safety task.

Figure 2-24: A wide outside lane can provide room for bicyclists and motorists to share an arterial or collector street lane.

2.5 Wide outside lanes

Where there is insufficient room to install bicycle lanes on urban and suburban arterial and collector streets, creating wide outside travel lanes can help accommodate both bicycles and motor vehicles (fig. 2-24). It is Wisconsin Department of Transportation policy to give strong consideration to bicycle lanes and wide outside travel lanes on all urban cross-section projects.

Figure 2-25: A standard "wide outside lane" configuration showing a 14ft (4.2m) outside lane and a 12ft (3.6m) inside lane.



A useable lane width of at least 14 ft (4.2 m), not including the standard 2-ft. (0.6 m) gutter pan, is needed for a motor vehicle and bicycle to operate side by side (fig. 2-25). As an alternative, a lane width of 15 ft (4.5 m) may be used with a 1-ft. (0.3 m) gutter pan and 1 ft. curb head (see fig. 2-16). This option provides extra effective width for the bicyclist since it moves the joint line between the gutter pan and roadway closer to the curb face. In really tight right-of-way situations, a lane width of 14 ft (4.2 m) not including a narrow 1-ft. (0.3 m) gutter pan, may be acceptable.

An edge marking may be used to stripe an 11 or 12 ft (3.3 m or 3.6 m) travel lane, leaving the remainder for a 4 or 5 ft curb off-set. Such "shoulders" are similar to those provided on rural roads and highways (see Sec. 2.6), although they typically have gutters.

In some instances, widths greater than 15 ft (4.5m) can encourage the operation of two motor vehicles in one lane, although this is not a common problem in Wisconsin. This is most likely to occur near intersections with heavy turn volumes at times of maximum congestion and lowest speeds. Such conditions may reflect a need to consider modifications to the intersection. On streets with dedicated right-turn lanes, the right-most through lane should be widened.

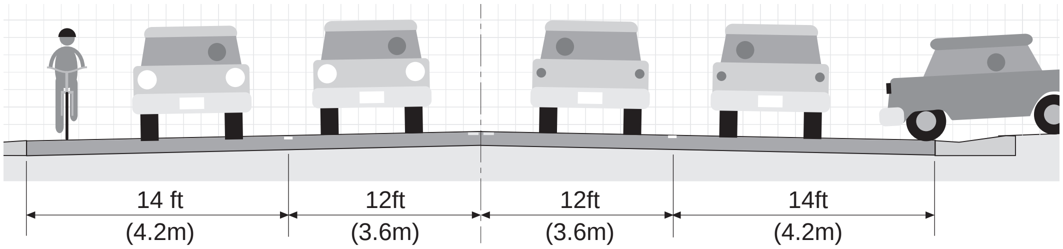


Figure 2-26: Wide outside lanes provide clearance for motorists entering driveways or cross streets or waiting to leave them.

Wide outside lanes have numerous benefits in addition to providing space for bicyclists and motorists to share. They improve roadway capacity by reducing conflicts between motorists traveling straight and those turning into or out of driveways and cross streets. And they provide space for temporary storage of snow and disabled motor vehicles.

If on-street parking is provided along with the wide outside travel lane, the parking lane should be standard width. Narrowing a parking lane to provide the space for bicyclists may or may not encourage motorists to park closer to the curb (fig. 2-27). If a standard travel lane is used, a total of 12 ft (3.6 m) of combined parking/bicycling space is highly recommended for this type of shared use.

And an opening car door may take up the extra space in the travel lane. As a result, the effective width of the outside travel lane in such cases may not be as great as the measured width.

Figure 2-27: Narrowing the parking lane by adding a white line will not necessarily create extra space for bicyclists.

Note: wide lanes are not suggested for quiet residential streets, where they are unnecessary, increase construction costs, and may increase "cut-through" traffic speeds.

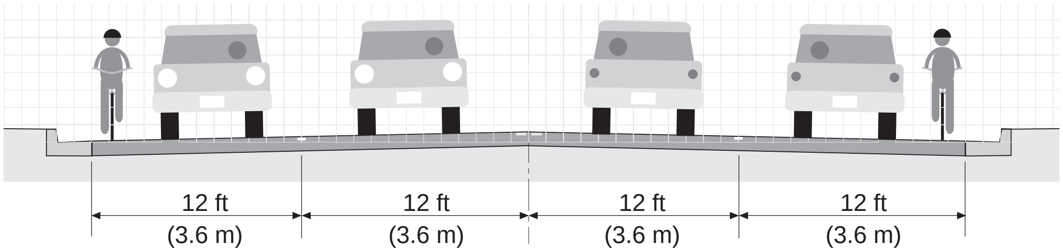
Figure 2-28: On an arterial street with narrow right-hand travel lanes, drivers will either pass bicyclists in close quarters or shift into the adjacent lane to pass.

2.5.1 Retrofitting an existing roadway

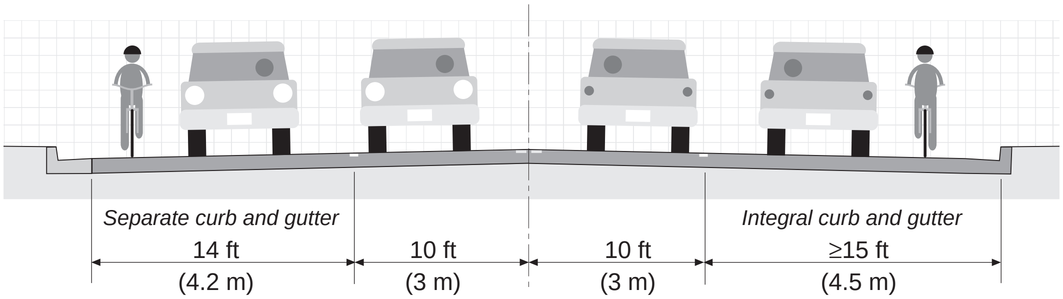
While providing wide outside lanes on new construction may be preferred, it is also possible to retrofit existing roadways by restriping. Typically, lane striping is best altered when the roadway receives a new pavement overlay. In this way, old striping patterns will not confuse motorists or bicyclists. However, where snow plows and road sanding wear away lane stripes, it may be possible to restripe to a new configuration without new paving.

Figure 2-29: One way to gain extra width in the outside lane is to shift the lane striping after a pavement overlay.

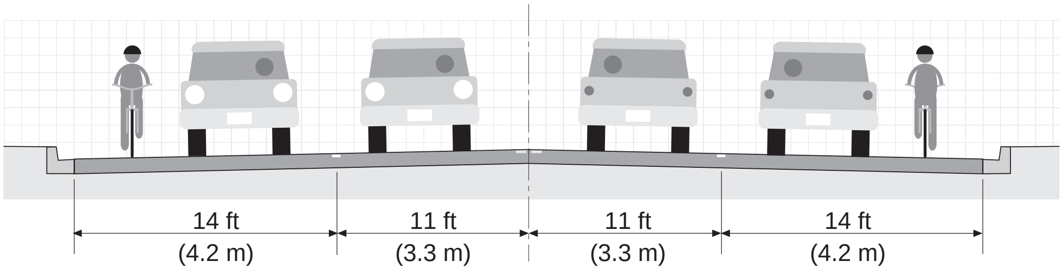
The extra width may be gained in several ways (fig. 2-29). Lane striping may be shifted to give a narrower inside lane and a 14 ft wide outside lane (fig. 2-30(b)). This should be done when the road is resurfaced or after a hard winter's sanding and plowing have erased the existing markings. On a concrete street with integral curb and gutter (fig. 2-30(b) right), there is no joint line to worry about. If curb and gutter are to be replaced, the gutter pan may be reduced to 1 ft, adding 1 ft to the curb head with an inset inlet grate (fig. 2-30(c) and 2.18). This approach provides more stability for the curb, makes it more snow plow-resistant, and makes it easier to mow adjacent grass.



(a) Standard Lanes



(b) Wide Outside Lanes



(c) Wide Outside Lanes w/1 ft Gutter

Figure 2-30: Shifting lane striping is one way to create a wider outside lane. With a concrete street with integral curb and gutter, there is no joint line that can possibly endanger bicyclists. If the curb and gutter are being replaced, extra space may be gained by reducing the gutter pan width to 1 ft.

Another approach may be to eliminate a travel lane or parking lane (fig. 2-31). Using a “road diets” approach, it may be possible to install a left turn lane or raised median and still provide sufficient capacity. On some such roadways, this approach has been used to create bicycle lanes as well.

If the roadway is scheduled for widening, planning for extra space for bicyclists should be included from the beginning. In such instances, bicycle lanes would be preferred over wide outside lanes but physical or financial constraints may govern the outcome.

Travel lanes less than 14 ft. may use shared lane markings or "bicycles may use full lane" signs, see the MUTCD for details.

Figure 2-31: Designers replaced 4 through lanes on this narrow road with 2 through lanes, a center turn lane, and space for bicyclists.

Figure 2-32: Adequate paved shoulders on rural roads provide clearance between bicyclists and passing motorists. In this particular instance, the shoulder is marked as a bike lane, since it links a state park entrance and a state trail.

2.6 Paved shoulders

On rural highways, smoothly paved shoulders are preferred by many bicyclists. Shoulders provide clearance between bicyclists and high-speed motor vehicle traffic and they reduce the “wind blast” effect of passing trucks. In addition, there are other reasons for considering shoulders.

According to *The Policy on Geometric Design of Highways and Streets (AASHTO, 2001)*, 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.*

2.6.1 Low-volume rural roads

Very-low-volume rural roads (i.e., those with ADT’s below 700) seldom require special provisions like paved shoulders for bicyclists (fig. 2-33). A motorist needing to move left to pass a bicyclist is unlikely to face oncoming traffic and may simply shift over. And bicyclists can ride far enough from the pavement edge to avoid hazards.

Figure 2-33: Very low volume rural roads seldom require paved shoulders for bicyclists.

In special cases, shoulders may be beneficial (e.g., on a town road connecting a school and a nearby rural neighborhood or a hilly low-volume highway serving truck traffic). Generally, on busier rural routes, like

State Trunk Highways, some County Trunk Highways, and connectors to important destinations, shoulders of sufficient width become critically important. In addition, paved shoulders should be seriously considered where low-volume town roads are being overtaken by new suburban development (fig. 2-34)

Figure 2-34: Paved shoulders are most helpful in developing areas. In such cases, new land uses typically lead to higher traffic levels, often rendering old rural roads inadequate and hazardous for bicyclists. Note temporary shoulders.

2.6.2 Overall shoulder width

The overall shoulder width may include a paved and an unpaved portion. While the paved portion may be suitable for bicycle use, the unpaved portion provides support for the pavement edge and may serve as an area for stopped traffic. This latter area should be stable and have a relatively smooth surface.

In general, the total shoulder width should be between 6 ft and 8 ft. (1.8 m - 2.4 m). The paved portion will be between 3 ft (0.9 m) and 8 ft (2.4 m), depending on traffic conditions (see following section). Often, the standard shoulder requirements discussed in WisDOT Facilities Development Manual (FDM) Procedure 11-15-1 will take priority.

In retrofit situations or constrained conditions, the most desirable solution may be impossible to achieve. In these cases, providing as much shoulder width as possible will benefit bicyclists. On reconstruction projects, it may be possible to re-ditch and provide adequately wide shoulders.

2.6.3 Basic recommendations

Table 2.1 provides shoulder paving requirements to accommodate bicycles on rural two-lane State Trunk Highways. Where shoulder bikeways are provided on four-lane divided expressways, the paved shoulder width should be 8 ft. (2.4 m). Where a bike route is planned or located on a County Trunk Highway or town road, the paved width, if any, should be determined by the local government, using the values in Table 2.1 (see following page).

TABLE 2.1: Rural Two-Lane State Trunk Highway Paved Shoulder Width Requirements to Accommodate Bicycles

Motor Vehicle ADT	*Bicycle ADT (or Plan inclusion)*	
	0 - 24	*≥25(1)*
Under 700	0(2)	0(2)
700 - 1500	0-3 ft (0-0.9m)(2)	4 ft (1.2 m)(3)
1501 - 3500	3 ft (0.9 m)(2)	5 & 6 ft (1.5 m)(2)(5)
≥3501(4)	4 ft(2)	5 ft (1.5 m)(2)(4)

(1) 25 bicycles per day (existing or expected) OR recommended in an adopted transportation plan.
(2) See Figure 5 of Facilities Development Manual (FDM) Procedure 11-15-1 for other shoulder paving standards not related to bicycles. For roadways that do not meet the Bicycle ADT requirement, a 3 ft. (0.9 m) shoulder is typically provided. However, for roadways with ADTs over 3500, a 4 ft. (1.2 m) paved shoulder is highly recommended.
(3) 3 ft. (0.9 m) acceptable where shoulder widths are not being widened and/or ADT is close to bottom of range.
(4) When ADTs exceed 4500, a 6ft paved shoulder is advisable.
(5) A 6 ft. paved shoulder may be highly desirable for maintenance purposes since this class calls for 6 ft. gravel shoulders. Full width shoulder paving is often preferred over leaving only 1 ft. of gravel shoulder.

While Table 2.1 provides general guidance, more detailed analysis should be considered when preparing a bicycle plan or where specific roadway conditions are more complicated than normal. To this end, the Department has produced several reports that should be of assistance:

Resources for Planning Rural Bicycle Routes

The WisDOT report *Planning for Rural Bicycle Routes* (Van Valkenburg, 1993) provides a methodology for evaluating the most important characteristics of rural roadways for bicyclists (i.e., traffic volume, percent of truck traffic, percent of no-passing zones, and paved width). Designers and planners are encouraged to use this report as a basic reference for evaluating the need for bicycle improvements on rural highways.

In addition, the forthcoming WisDOT *Guide to Rural Bicycle Facilities Planning* will provide an overview and approach for developing bicycle plans for small communities and rural areas. In this report, readers will find a step-by-step process to the planning process.

For more information, contact Tom Huber at <thomas.huber@dot.state.wi.us>

On almost all state highway projects involving reconditioning or reconstruction, paved shoulders will be part of the project. Planners and engineers need to consider the width of the paved shoulder by examining the two columns of Table 2.1. The first column represents highways with a low bicycle count and anticipated low bicycle usage, even after the shoulder paving improvement.

The second column indicates a moderate level of current or anticipated bike use (25 cyclists or more per day during peak periods). This column should be used under the following situations:

- *A bicycle transportation plan (e.g., the Wisconsin Bicycle Transportation Plan, county bicycle transportation plans, or regional bicycle transportation plans) identifies a highway segment as needing wider paved shoulders;*
- *A bicycle use survey has determined there are 25 bicyclists per day using the highway;*
- *Likely bicycle traffic generators (e.g., schools, businesses, subdivisions, parks, etc.) have been built or expected to be built along the stretch of highway;*
- *A highway project stretches between the built-up area of a village or city and an intersecting town or county road. In most cases, bicycle travel will be heaviest between the city/village limits and the nearest town or county road. Paving wider shoulders (using column 2) for just this segment provides a safer means for bicyclists to access the town and/or county road system.*

2.6.4 Guardrails and slopes

If a guardrail is provided adjacent to the shoulder, there should be between 6 ft. (1.8 m) and 8 ft. (2.4 m) between the guardrail and the travel lane (fig. 2-35). The width of the paved shoulder should be determined based on Table 2.1 or FDM Procedure 11-15-1. If wider paved shoulders are being used, paving the entire shoulder should be considered, especially if the guardrail is only 6 ft. (1.8 m) from the travel lane. Where width is constrained by topography or other factors (fig. 2-35, lower image), there should be as much paved width between the travel lane and the guardrail as practicable. In new construction, a guardrail may not be necessary if a 4:1 cross slope is provided next to the edge of the shoulder.

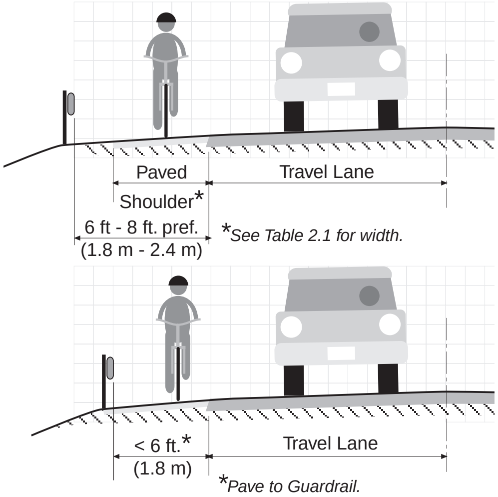


Figure 2-35: Guardrails should be offset from the travel lane by 6 ft to 8 ft (1.8 m - 2.4 m). The width of the paved shoulder should be determined by consulting Table 2.1.

2.6.5 Grades

If funding is limited, adding or improving shoulders on uphill sections first will decrease conflicts between fast motor vehicle traffic and slower bicyclists. This includes providing paved shoulders next to uphill auxiliary lanes (climbing lanes). On the downhill side, bicycles may travel almost as fast as motor vehicles, making extra space less important.

2.6.6 Pavement design and loading

Shoulders should be smoothly paved and have adequate strength and stability to support occasional motor vehicle tire loads under all weather conditions without rutting or other surface variations. The thickness of shoulder paving should be based on usual design considerations appropriate for each situation, although full-depth pavement is recommended.

2.6.7 Joints between travel lanes and shoulders

Where it is necessary to add paved shoulders to existing roadways for bicycle use, the area where bicyclists will be riding should be kept free of joint lines. If a wider shoulder (i.e., 8 ft.) is being provided, the joint line will not likely be a serious problem. However, if a narrow shoulder is being added, it is desirable to provide a minimum of 4 ft. (1.2 m) of clear width without a longitudinal joint line.

2.6.8 Unpaved driveways

At unpaved highway or driveway crossings, the highway or driveway should be paved a minimum of 15 ft. (4.5m) from the edge of the traveled way on either side of the crossing to reduce the amount of gravel being scattered along the shoulder by motor vehicles (fig. 2-36). If the unpaved highway or driveway approaches the shoulder on a descending grade, gravel will tend to scatter farther than normal. As a result, the pavement should be extended accordingly.

Figure 2-36: Paving into gravel driveways or side roads, or in this case a stone-surfaced state trail, can help keep debris from covering the paved shoulder.

2.6.9 Rumble strips

Two types of rumble strips (shoulder-style rumble strips and perpendicular-style rumble strips) are used on rural roadways.

Shoulder rumble strips are not suitable as a riding surface and present a potential hazard to bicyclists (fig. 2-37). In Wisconsin, they are commonly used on freeways and expressways, and sometimes on two-lane roadways because of their effectiveness in reducing run-off the road crashes on high-speed roadways. The WisDOT FDM provides more information on rumble strips policies and designs standards.

Figure 2-37: Continuous shoulder rumble strips provide an unsafe surface for bicycling. Gaps every 40-60 ft. that are 12 ft. long should be provided for bicyclists to safely move between the shoulder and travel lane as necessary to avoid debris, make turns, pass, etc.

Shoulder rumble strips should not be used if they are being proposed for the purpose of improving safety for bicyclists; their presence is more likely to cause a hazard for bicyclists than it is to enhance a "physical separation" between motorists and bicyclists. Furthermore, rumble strips should not be used unless there is at least a clear shoulder pathway available to bicyclists of 4 ft. (1.2 m) wide (or 5 ft. (1.5 m) wide if there is an obstruction such as a curb or guardrail) to the right of the rumble strip for bicycle use. (See FDM S.D.D. 13A10)

Perpendicular-style rumble strips (FDM S.D.D. 13A8 and 13A9) are more common on 2-lane roadways and are found on state, county, and town road sys-tems. If they are required at intersection approaches, they should not continue across the paved shoulder. If a paved shoulder is not present, the right-most 18 in. to 3 ft. (0.45 m -0.9 m) of pavement should be left untreated so bicyclists may pass safely.

Fig. 2-38: An old unused diagonal railroad crossing. The flangeway can catch and turn a bicyclist's front wheel, especially when wet, and the roughness can also cause a tumble.

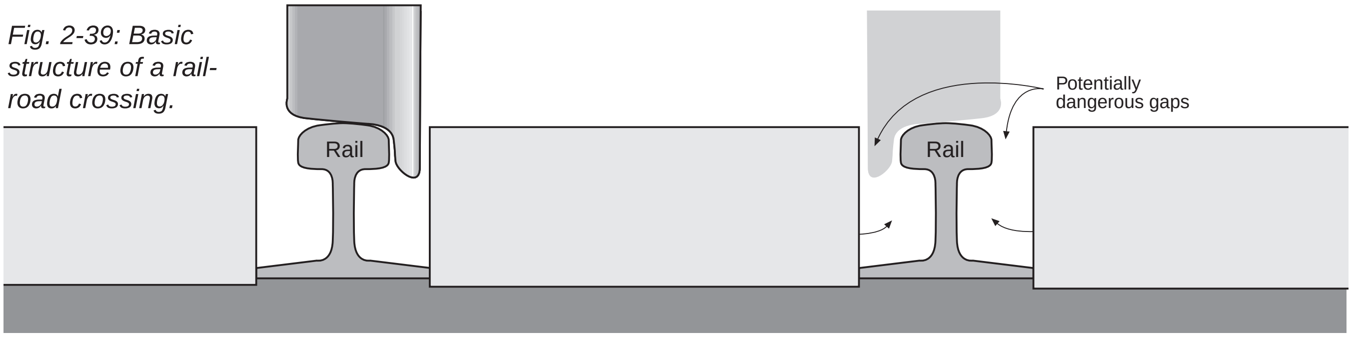
2.7 Railroad crossings

Special care should be taken wherever a roadway or path crosses railroad tracks at grade. Numerous bicycle crashes have resulted from dangerous crossings. The most important crossing features for bicyclists are (1) the crossing angle and the presence of a gap on either side of the track's rail; and (2) the crossing's smoothness. Problems with both of these features are illustrated in figure 2-38.

2.7.1 Crossing angles and gaps

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 is 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. However, if the crossing angle is less than approximately 60 degrees, remedial action should be considered.

Fig. 2-39: Basic structure of a railroad crossing.



Since the gap between the side of the rail and the roadway surface is a primary source of the problem (fig. 2-39), the width of the gap should be minimized. For the gap on the outside of the rail (called the “field flangeway”), this problem can often be solved relatively easily. Fillers made of rubber or polymer are manufactured by several companies, primarily to keep water and debris out, and these can eliminate the outside gap almost entirely.

But such is not the case for the gap on the inside of the rails (fig. 2-40). This gap, called the “gauge flangeway,” must be kept open, since it is where the train wheel’s “flange” must travel. (Flanges on the inside of the train wheels keep the train on the tracks.)

To allow for this flange, Federal regulations require public crossings to have at least a 2.5 in. gauge flangeway. On some crossings, the required gap is 4 in. Currently, there is no way around this regulation. Fillers for gauge flangeways are designed to this requirement and provide space for the wheel’s flange (fig. 2-41).

While some commercially-available products fill the gauge flangeway gap completely, these may only be used in low-speed applications. Such an application might be a low-speed track in (or entering) a freight yard or manufacturing plant (fig. 2-42). At higher speeds, the filler will not compress and can derail the train.

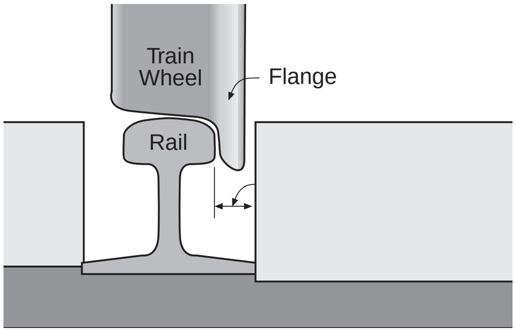


Fig. 2-40: Federal regulations require the gauge flangeway to be a minimum of 2.5in. wide to allow for the train wheel flange.

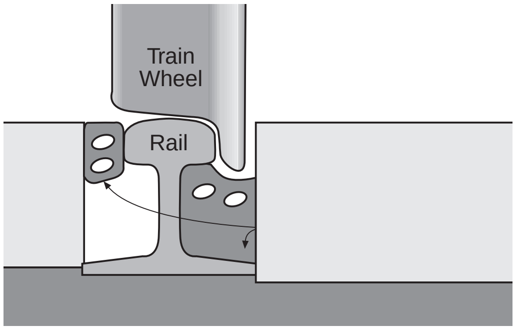


Fig. 2-41: Fillers can completely eliminate the field flangeway gap but must allow for the train wheel in the gauge flangeway.

Fig. 2-42: This rubberized crossing includes both gauge and field flangeway fillers that eliminate the gaps entirely. This combination may only be used where train speeds are very low.

Fig. 2-43: A flared approach provides a safer angle for bicyclists crossing a diagonal railroad track.

While the flangeway problem on diagonal crossings may be partially solved with fillers, in general such solutions can only address the field flangeway part of the problem. At the same time, smooth installations using concrete and/or rubber can reduce the hazard by making the crossing more level and uniform (see Sec. 2.7.2). Where right-of-way allows, another approach is to flair the roadway, bike lane, or path to allow for a more perpendicular approach (fig. 2-43 and 2-45). In terms of the geometrics of such a flair, there is no simple template for all applications. The appropriate crossing details will vary depending upon (1) the angle of track crossing; and (2) the width of the facility. If the set of tracks create an acute angle to the road and bike lanes are not provided, it is especially important to provide for a wide enough area on the opposite side of the tracks to allow bicyclists to gradually reestablish themselves in the travel lane.

Fig. 2-44: Warning sign W11-59.3 (similar to that shown) may be used where the hazard cannot be completely eliminated.

> *The objective of the design should be to provide bicyclists with adequate width and distance to travel across the tracks at no less than a 60 degree angle to the tracks.*

In some cases, a separate path may be necessary to provide an adequate approach angle. It is also important to take into account sign and signal location design and installation when widening the approach.

Where hazards to bicyclists cannot be avoided, appropriate signs, consistent with the MUTCD, should be installed to warn bicyclists of the danger (fig. 2-44). However, signage is no substitute for improving a crossing's safety.

2.7.2 Crossing smoothness

Regardless of angle, some crossings can damage bicycle wheels and cause a crash. This is most often the result of unevenness and poor conditions. Asphalt often deteriorates, especially near the rails, and a ridge buildup may form. Timber crossings wear down rapidly and are slippery when wet. Regular maintenance can help but to truly solve these problems, replacing the crossings with models with longer life and a more stable surface is best.

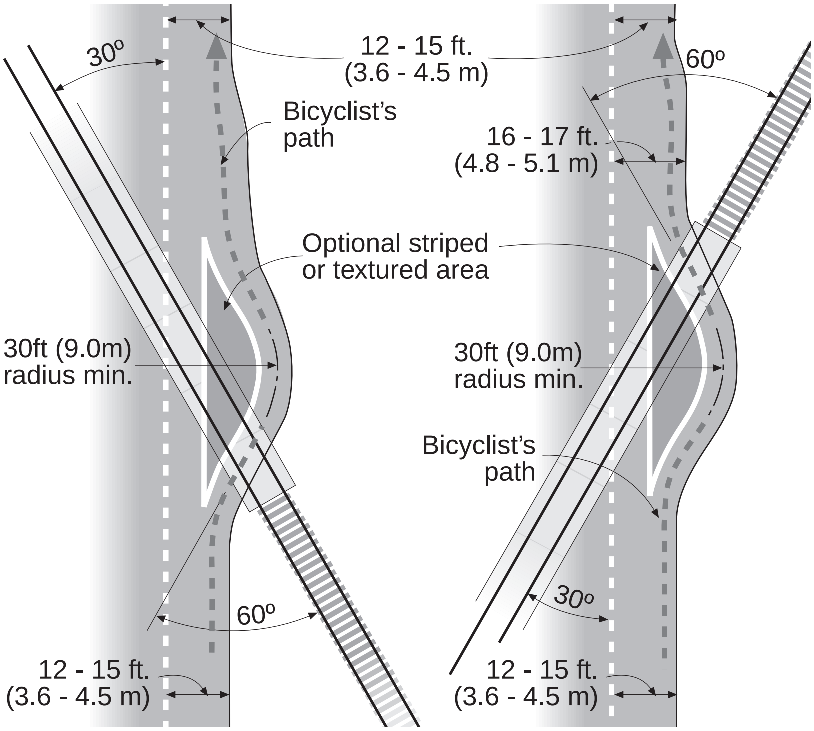


Fig. 2-45: Sample crossing designs . (after Oregon DOT State Plan)

There are two primary crossing types to consider: concrete and rubber. Concrete performs well under wet conditions and, when laid with precision, provides a smooth ride. It also has a long life under heavy traffic. Rubberized crossings also provide a durable, smooth crossing, though they may not last as long as concrete and may become slippery when wet. Either is superior to the more common timber or asphalt crossings. In addition, newer combination concrete/rubber designs can provide the benefits of each type.

2.7.3 Railroad/path or walkway crossings

With path/railroad crossings, the Americans with Disabilities Act is an important factor. The path surface must be level and flush with the rail top at the outer edge and between the rails, except for a maximum 2-1/2 inch gap on the inner edge of each rail to permit safe passage of the train's wheel flanges.

Figure 2-46: Traffic signal systems should be designed with bicyclists in mind. Note bicycle pavement marking for signal loop detector in through lane.

2.8 Traffic signals

There are several primary bicycle-related problems with traffic signal installations. First, many demand-actuated signal systems (those that change when traffic is detected) were not designed, installed, or maintained to detect bicycles. As a result, bicyclists may find it impossible to get a green light.

In addition, minimum green time may be inadequate at wider crossings for bicyclists to clear the intersection. As a result, bicyclists can be caught in an intersection during the change from green to red. According to national crash studies, approximately 3 percent of reported non-fatal car/bike crashes involved a bicyclist caught in a signalized intersection during a phase change. These crashes typically happen while the bicyclist crosses a multi-lane road.

2.8.1 Bicycle detection

Many traffic signals in urban areas are activated by wire detector loops buried in the roadway. An electrical current passes through the wires, setting up an electromagnetic field. When a large mass of metal (e.g., a car) passes over the loop, it interferes with the field and causes a signal to be sent to the controller box, which then changes the traffic light.

Typically, the loop is placed behind the stop line at an intersection; each through or left turn lane will have one. Often, “advance” loops are placed some distance before the intersection; these loops tell the system that a vehicle is coming and it starts the process of changing the signals.

If new loops are added to an existing roadway, the pavement cut lines left over after installation can tell bicyclists where to place their bicycles to have the best chance for detection. Many bicyclists know this trick and

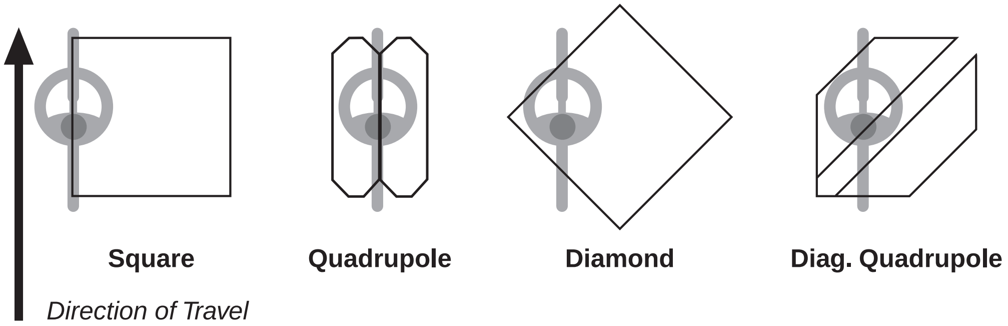


Fig. 2-47: Diagrams of various detector loop types. The lines show the locations of the wires buried under the pavement. The gray bicycle shows a preferred location for the bicycle.

use it often. However, once an asphalt overlay is added to the roadway, bicyclists can no longer identify the loop's location. As a result, they will have a harder time getting detected. This problem may be addressed through the use of pavement markings (see Sec. 2.8.2).

In general, standard *rectangular* or *square* loops are relatively insensitive to bicycles unless the bicyclist stops right over the wires. For this reason, the edge of such a loop should be identified with a pavement marking. The sensitivity may, in some cases, be adjusted to detect a bicycle without picking up motor vehicles in adjacent lanes.

Some types of detector loops have shown greater ability to detect bicycles (fig. 2-47). The *quadrupole* loop is relatively sensitive over the center wires and somewhat less sensitive over the outer wires. As a result, this loop is often used in bicycle lanes. The *diagonal quadrupole* is somewhat similar but is rotated 45 degrees to the side. This loop is relatively sensitive over its entire width and is often used on shared-use roadways or shared-use paths. Both the quadrupole and the diagonal quadrupole have been hooked up to counting equipment and used to count bicycles.

The *diamond* loop has been used with success in Wisconsin. Since bicyclists tend to ride close to the right side of the roadway, the right "point" of the diamond should be located within 6-12 in. (0.15m - 0.3m) of the edge of pavement or the gutter pan joint. A modification (fig. 2-48) of this design is also used to cover a broader area. This *extended diamond* can cover two traffic lanes.

Figure 2-48 (below): The extended diamond loop can be used over two traffic lanes.

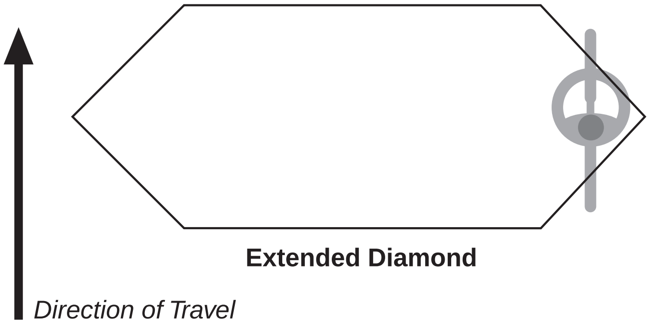
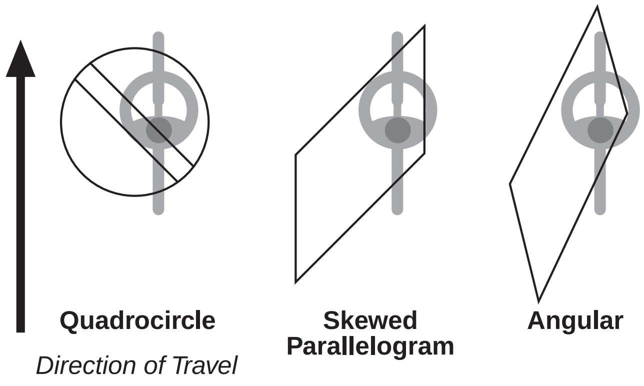


Figure 2-49 (bottom): Other loops, including these designs, have shown promise in detecting bicycles.



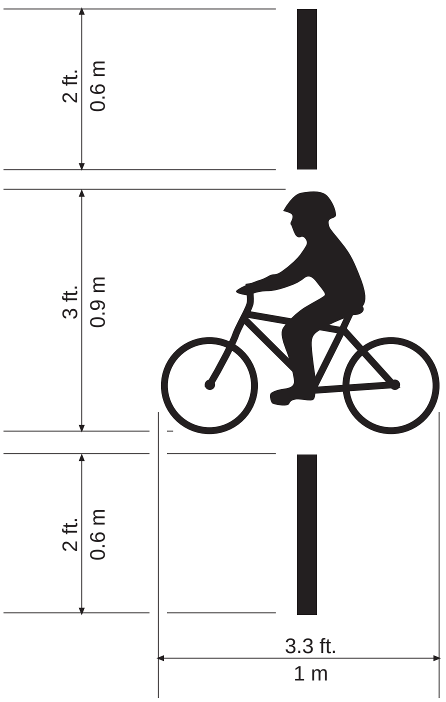
Other designs in use include the *quadrocircle*, the *skewed parallelogram* and the *angular* loop (fig. 2-49). These have also shown promise in detecting bicycles while working well for other traffic.

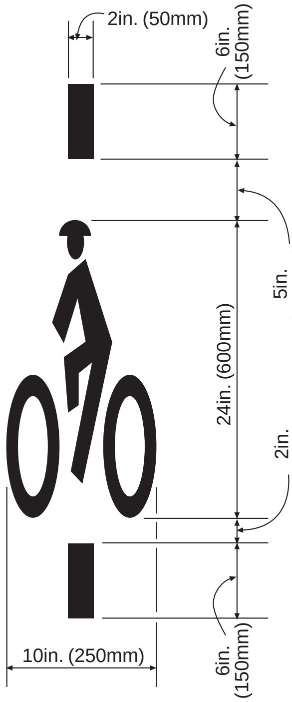
Detectors for traffic-actuated signals should be installed where bicyclists are likely to travel. This includes the right side of through travel lanes and the center of bicycle lanes, as well as left-turn lanes and shoulders.
In addition to loop detectors, other technologies — for example, video, microwave, and infrared systems — have been used successfully in detecting bicycles.

In some situations, the use of pedestrian- or bicyclist-actuated buttons may be an acceptable alternative to the use of detectors provided they do not require bicyclists to dismount or make unsafe leaning movements. However, actuated buttons should not be considered a substitute for detectors, particularly where right turn only lanes exist.

Figure 2-50 (left) Madison's pavement marking for loop detectors.

Figure 2-51 (right): Suggested pavement marking in the 1999 AASHTO Guide for the Development of Bicycle Facilities.





2.8.2 Signal loop markings

As suggested in Section 2.8.1, detector loops typically vary in sensitivity across their width. Further, they are seldom installed across the entire lane. For these reasons, pavement markings are often used to identify the most sensitive location for detection.

Currently, there is no standard marking in the *Manual on Uniform Traffic Control Devices*. However, figure 2-50 and figure 2-52 show the marking used in Madison; figure 2-51 shows the marking suggested in the AASHTO *Guide for the Development of Bicycle Facilities (1999)*.

Installing bicycle sensitive detectors will do more than helping bicyclists safely cross signalized intersections. By installing such detectors and marking the most sensitive locations, agencies can reinforce the principle that bicycles are vehicles and their use is a lawful and encouraged form of transportation

Figure 2-52: Close-up of Madison-style loop detector pavement marking.

2.8.3 Signal timing

As a general principle, bicycles should be considered in the timing of all traffic signal cycles. Normally, a bicyclist can cross an intersection under the same signal phasing arrangement as motor vehicles. On multi-lane street crossings, special consideration should be given to ensure short clearance intervals are not used. An all-red clearance interval is often used and benefits bicyclists who need the extra time.

With wider and wider intersection designs, the traffic engineer must pay close attention to crossing times. The desire to keep lanes full width and to add more turn lanes must be weighed against alternatives that provide protective channeling, reduced crossing width, or other designs. For these reasons, geometric designers and operations staff must work closely to create supportive bicycle crossings.

To check the clearance interval, a bicyclist's speed of 10mph (16 km/h) and a perception/reaction/braking time of 2.5 seconds should be used.

2.8.4 Programmed visibility heads

Where programmed visibility signal heads are used, they should be checked to ensure they are visible to bicyclists who are properly positioned on the road. Systems should be designed to permit the bicyclist to detect any change in traffic signals.

Figure 2-53: Bicyclists using the shoulder of a highway bridge. Note lack of debris and smooth pavement, aspects that bicyclists appreciate.

2.9 Structures

Structures like bridges and underpasses almost always provide critical links for bicycle travel (fig. 2-53). Since they are often expensive to build or modify, structures tend to be replaced less often than connecting sections of roadway. As a result, aging structures typically form bottlenecks on the overall system. Yet, they often provide the only ways past major barriers and typically connect, in some fashion, with networks of local

Figure 2-54: Lane striping was shifted to the left on this 4-lane downtown bridge to give 15-foot outside lanes and 11-ft. inside lanes.

roads on either end. For these reasons, improving a structure — or considering bicyclists' needs when building a new one or renovating an existing one — can provide significant benefits for bicycle users for years to come.

Structures are most often associated with bridges over rivers. However, hundreds of bridges in Wisconsin are necessary to carry traffic over other highways and railroad tracks. Bicycle accommodations are important for all of these crossings whether such accommodation is provided on a road going under another highway or railroad tracks, or on a bridge over a highway or tracks.

Properly accommodating bicyclists over and under freeways is especially important since crossings are limited because of the high costs associated with these bridges. Because of the limited spacing of these crossing points for cyclists on freeways, traffic is typically heavy, thus making it that much more critical to provide additional space for bicyclists. While bridges often have some of the highest traffic counts in a community, this is not a good reason for not accommodating bicyclists on that bridge.

Bicyclists' needs should be considered on a routine basis and on all structures (except those on highways where bicyclists are prohibited). The federal law supporting bicycle accommodations on bridges dates back to 1990 and is provided below.

Federal Law Supports Accommodating Bicyclists on Bridges

Title 23 U.S.C. §217: Bicycle Transportation and Pedestrian Walkways

(e) Bridges. – In any case where a highway bridge deck being replaced or rehabilitated with Federal financial participation is located on a highway on which bicycles are permitted to operate at each end of such bridge, and the Secretary determines that the safe accommodation of bicycles can be provided at reasonable cost* as part of such replacement or rehabilitation, then such bridge shall be so replaced or rehabilitated as to provide such safe accommodations.

** "Reasonable cost" was later defined by FHWA as to not exceed 20% of the larger project cost.*

2.9.1 Bridges

Improving a bridge for bicycle use involves analyzing four major areas of concern: (1) width constraints; (2) static obstructions; (3) surface problems; and (4) approaches.

Figure 2-55: A suburban bridge with 5-ft shoulder for bicycles, as well as a sidewalk.

Bridge deck width: Several options are available for accommodating bicyclists on bridges or on roads that cross under bridges. In urban and suburban areas, a 5-ft striped area (unmarked or marked as bike lanes) should be included in the basic design (fig. 2-55 and 2-56 top). At a minimum, a 4-ft striped area (not marked as a bike lane) should be provided. Alternatively, wide outside lanes can be provided as a minimum form of accommodation as long as there is at least 14 ft. of usable space in the outside lane (fig. 2-54 and fig. 2-56 bottom). Typically this translates to at least 15.5 ft. from the curb face of a sidewalk on a bridge. Sixteen feet is commonly used and should be used whenever the outside lane is next to a parapet or concrete barrier (fig. 2-56 middle).

There is an exception to the above guidelines. On low-speed urban bridges, generally with a projected traffic of less than 2,000 ADT, it is often acceptable to accommodate bicyclists in a standard travel lane.

In rural areas, speed and traffic volumes become bigger factors. On rural roadways, shoulders should be common features on all new bridges except low-volume structures. See Figures 1 through 4 of FDM 11-15-1 for the appropriate widths. Generally for all

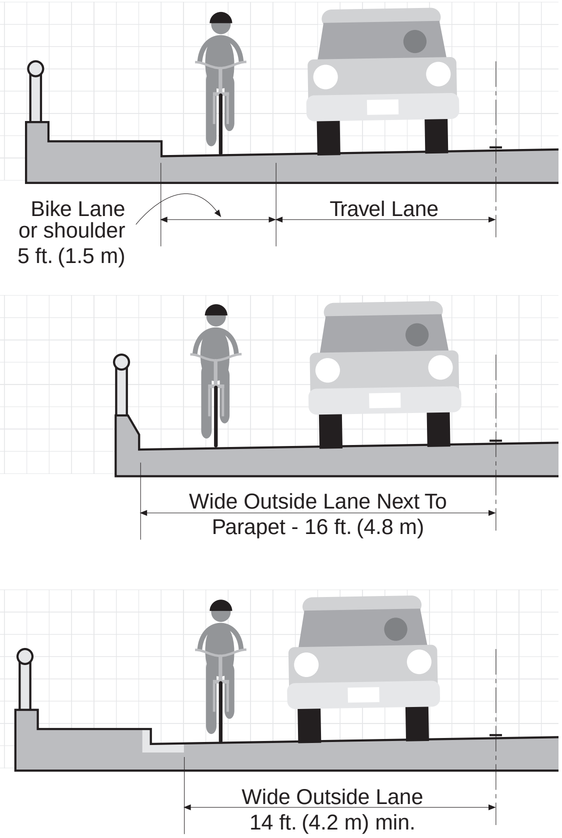


Figure 2-56: Recommended widths for different structure situations.

county and state highway bridges with ADTs in excess of 750, the minimum width of shoulder areas is five feet. For state, county and town road bridges with ADTs of less than 750, bicyclists will often be sharing the travel lanes, but, since traffic is so low, bicyclists will seldom encounter auto traffic on the bridge. Minimum offsets (shy distances) from bridge parapets or sidewalks to the travel lanes on these bridges is either 2 or 3-ft.. (See section 4-16-3 for a discussion of attached bicycle/pedestrian paths on highway bridges).

Figure 2-57: This bridge has a 54 in. railing that protects bicyclists from going over the top and into the river. Although a low-probability event, the consequences would be severe.

Static obstructions: Bicycle-safe bridge railings should be used on bridges specifically designed to carry bicycle traffic, and on bridges where specific protection of bicyclists is deemed necessary. On highway bridges that have full-width shoulders and are not marked or signed as bikeways, the standard 32 in. (0.8 m) parapet/railing can be used.

On bridges that are signed or marked as bikeways and bicyclists are operating right next to the railing (no sidewalk, for example), a 42 in. (1 m) railing/parapet should be used as the minimum height, while 54 in. (1.35 m) is the preferred height. The higher railing/parapet height is especially important and should be used on long bridges, high bridges, and bridges having high bicyclist volumes.

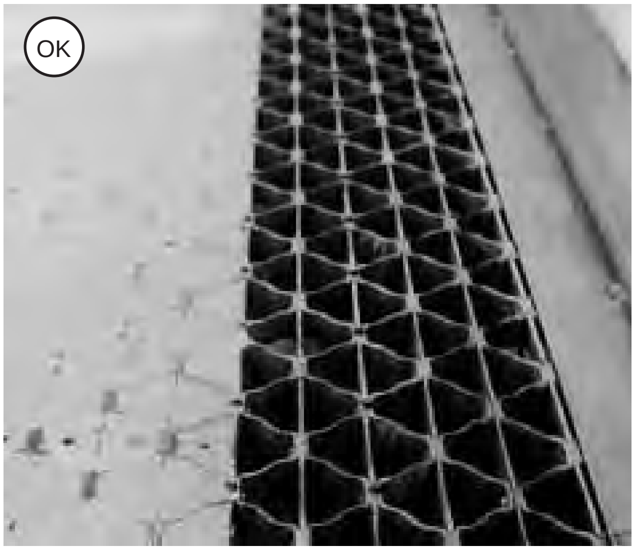
Lower railings (i.e., standard heights) may be adequate for town road bridges which have low bicycle and motor vehicle volumes or on those bridges with sidewalks next to the railing.

In cases where existing railings are lower than desired, consideration should be given to retrofitting an additional bicycle railing to the top, bringing the total height to 42 or 54 inches. This is particularly useful on relatively narrow bridges, where bicyclists may be riding closer to the railing than otherwise.

Guardrails on bridge approaches should be designed with the needs of bicyclists in mind. As a general rule, a roadside barrier should be placed as far from the traveled way as conditions permit.

Surface conditions: On all bridge decks, special care should be taken to ensure that smooth bicycle-safe expansion joints are used. In cases where joints are uneven, skid-resistant steel plates may be attached to one side of the joint. Another option is to provide a rubberized joint filler or cover.

Figure 2-58: Lightweight concrete was used to fill the voids in this steel bridge deck.



The bridge deck itself should not pose a hazard for bicyclists. Steel decking on draw bridges or swing bridges can cause steering difficulties for bicyclists. In general, such bridges should not be designated as bicycle facilities without determining the deck's effect on bicycle handling.

One option is to fill the voids in the steel deck with lightweight concrete (Fig. 2-58); to save money and weight, this treatment can be limited to the right sides near the edge of the roadway. If this approach is used, it is advisable to providing warning signs that direct bicyclists toward the treated surface.

The accumulation of roadside debris may cause problems for bicyclists, forcing them to ride farther out from the right edge than many would prefer (fig. 2-59). Regular maintenance, particularly in the right half of the outside lane and on any paved shoulders is important.

Figure 2-59: On this bridge, debris collects in the narrow striped shoulder; as a result of the surface conditions and the shoulder's width, motorists must change lanes to pass safely.

Bridge approaches: Bicycle provisions, whether bicycle lanes, paved shoulders, or wide outside lanes, should be provided for the approaches to bridges and, preferably, should continue 1000 ft (300 m) on either side of major bridges to ensure a safe transition. If on- or off-ramps or intersections are present, shoulders or wide outside lanes should continue at least as far as the ramps or intersections.

On lower-speed bridges and ramps, a bicycle lane crossing is similar to that used for turn lanes and a striping pattern should be used (see Sec. 3-7). If a wide outside lane is used, the extra width should be added to the right-most through lane (fig. 2-60).

Figure 2-60: At the end of a bridge with wide outside lanes, the extra width should continue in the through lane rather than the right turn lane.

On high-speed bridges and ramps, shoulder striping should not cross over the ramp, but should follow the ramp; another shoulder stripe should pick up on the far side of the ramp. On high-speed bridges and ramps, especially those with ramp AADTs over 800, it may be desirable for the bicycle lane to leave via the off-ramp and, if necessary, re-enter via the next available on-ramp.

2.9.2 Interchanges

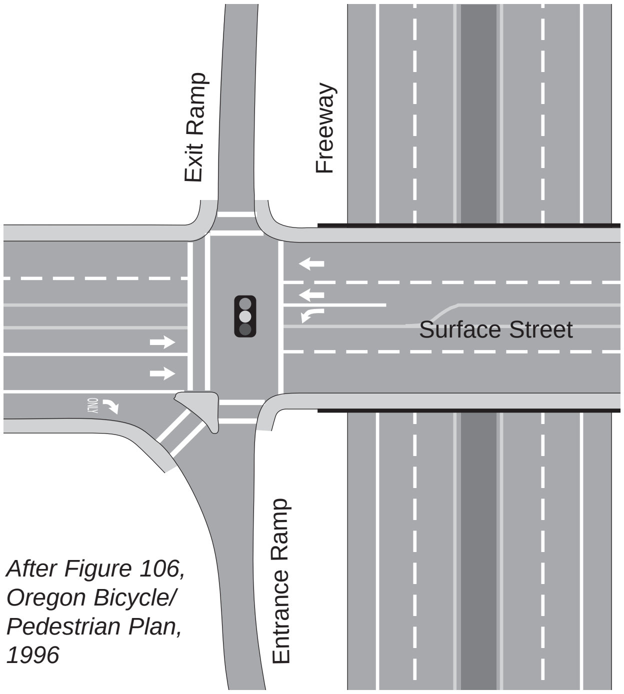
Freeways present formidable barriers to bicycle circulation. Non-interchange crossings of freeways almost always provide a better level of service and safety to bicyclists and pedestrians (fig. 2-61). Unfortunately, because of the expense involved in bridging across freeways, few non-interchange crossings are constructed in suburban and urban areas.

Figure 2-61: The non-interchange crossing provides a lower-volume and easier freeway crossing for bicyclists than the interchange.

When planning or reconstructing freeways, providing more non-interchange crossings can improve conditions for bicyclists by eliminating ramps where conflicts often occur. Additional non-interchange crossings will also let local auto traffic avoid interchanges, making it easier for bicyclists (and motorists) using the interchanges. Although there will be more stress for bicyclists traveling through interchanges, bicycle accommodations should still be provided.

There are ways to improve the level of service for bicyclists through interchanges by:

Figure 2-62: Urban-style interchange with right-angle intersections and, controlled movements.



After Figure 106, Oregon Bicycle/ Pedestrian Plan, 1996

- *Avoiding designs that encourage free-flow motor vehicle movement (fig. 2-62 instead of 2-63).*
- *Freeway ramps should connect to local streets at or near a right angle with stop control or signals at the intersection.*
- *Where large trucks must be accommodated, using compound curves for the intersection of the ramp and local street to reduce the speed of intersecting traffic.*
- *Provide good visibility of bicyclists at ramp intersection with local roads*

AASHTO provides guidance on the issue of ramp design. In its *Policy on Geometric Design of Highway and Streets* (2001), it states that interchanges should be studied for the most fitting arrangement of structures and ramps and accommodation of bicycle and pedestrians.

It goes on to say that where a ramp joins a major crossroad or street, forming an intersection at grade, the governing design speed for this portion of the ramp near the intersection should be predicated on near-minimum turning conditions as given in the chapter on intersections and not based on tables for establishing design speeds for ramps.

Figure 2-63: An interchange appropriate for a rural location but not a suburban or developing area.

In rural areas (fig. 2-63), not as much consideration needs to be made of interchange design since traffic volumes and bicycle use is typically much lower than in urban areas. Furthermore, bicyclists found in these areas are usually more experienced. Nevertheless, shoulder widths leading up to the interchange should continue through the interchange consistent with the bridge widths found in Figures 1 through 4 of FDM 11-15-1.

Also see AASHTO's *Guide to Bicycle Facilities, 4th edition*, and an ITE Proposed Recommended Practice: *Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges* for more information on interchange recommendations.

Figure 2-64: A residential street traffic circle slows traffic at intersections and reduces the frequency of intersection crashes.

2.10 Traffic Calming

The term "traffic calming" typically refers to environmental changes that (1) divert through motor vehicle traffic or (2) slow motor vehicle traffic. Traffic calming has a long history in places like Europe and Australia. Yet, over the last 20 years, the traffic calming field has also grown enormously in the United States.

These techniques have been tried in many communities (fig. 2-64) and the experience has been collected in numerous manuals, courses, and articles. The purpose of this section is not to provide detailed design guidance; rather it is to introduce the topic and discuss how typical calming measures can be designed to enhance neighborhood bicycling. If some traffic calming measures are done inappropriately, they may create problems and hazards for bicyclists. Similarly, without close cooperation with maintenance departments and emergency services to assure safe access, calming designs may cause more problems than they solve.

Traffic calming measures have been used most commonly on residential streets, often at the request of residents concerned with safety and quality of life. In some communities, traffic calming techniques have also been used on collector or arterial streets, often to slow traffic in such places as neighborhood business districts or downtowns.

Successful traffic calming measures are seldom applied at one single location or on one street. The best approach involves developing a community-wide program and process for implementing networks of improvements. The idea is to look at a neighborhood as a whole and develop a neighborhood-wide traffic control plan. In this way, neighborhood traffic problems will not simply be shifted from one street to the next.

Figure 2-65: A street closure keeps major street traffic from diverting onto this residential street. The short path (foreground, left) connects the neighborhood with a signalized crossing and the school beyond.

2.10.1 Traffic diversion approaches

Traffic calming measures of this type typically discourage through motor vehicle traffic with street closures or diverters (fig. 2-65 and 2-66). Such installations are often used in neighborhoods impacted by cut-through traffic avoiding busy arterial streets. In addition, the physical improvements are supplemented by proper regulatory and warning signage.

Figure 2-66: This mid-block street closure is part of a "bicycle boulevard," a through route for bikes that avoids an adjacent busy arterial street.

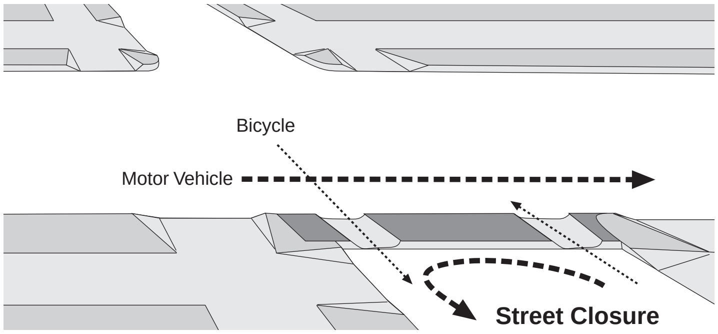


Fig. 2-67 (above).

Street closures block motor vehicle traffic entirely. While not as common as less severe treatments, they are occasionally used where cut-through traffic creates significant problems. As shown in Figure 2-66, they are sometimes installed at mid-block. If street closures are used, channels to allow bicycles through should be included (fig. 2-67).

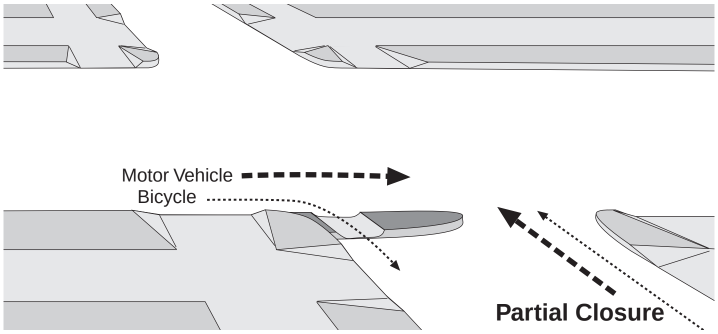


Fig. 2-68 (above).

Partial street closures are generally placed at intersections and prohibit one direction of motor vehicle. Bicyclists are allowed to ride past in either direction or may be provided with a channel as shown in Figure 2-68. The barrier may be supplemented with “Do Not Enter” regulatory signs and “Except Bikes” subplates.

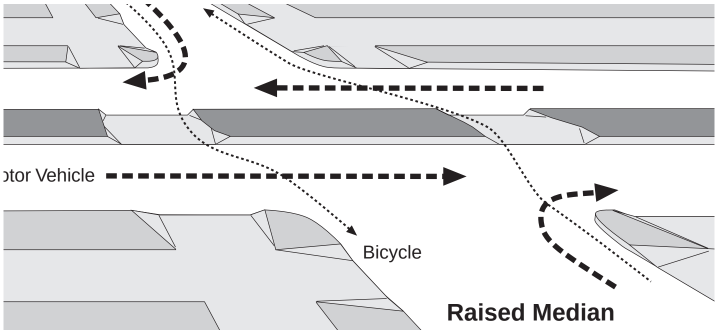


Fig. 2-69 (above).

Raised medians are often used on major streets to eliminate left turns into local streets and cross traffic from those streets (fig. 2-69, 2-70). If curb ramps or cuts are provided at the crosswalks, bicyclists and wheelchair users can get through. This design can also provide median refuges to help pedestrians and bicyclists cross busy multi-lane streets.

Figure 2-70: A raised median stops motor vehicle cross traffic and left turns. Curb ramps and cuts provide bicycle and pedestrian access.

Diverters are diagonal barriers placed at intersections to force all motorists to turn right or left (fig. 2-71). Unlike street closures, motorists do not have to turn around, however. Channels for bicyclists must be carefully designed to the geometrics of the intersection. In addition, each channel should be designed to safely work for both crossing directions.

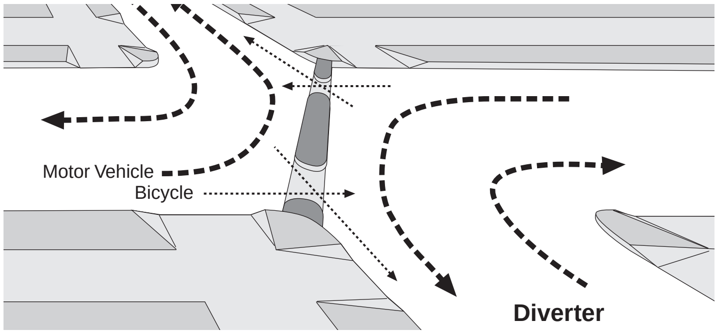


Fig. 2-71 (above).

Partial diverters only block particular movements. They typically force motorists to turn right rather than going straight or turning left (fig. 2-72). Depending on the geometrics, designers may provide a channel for bicyclists or they may widen the crosswalk to accommodate bike traffic with a slight diversion to the right.

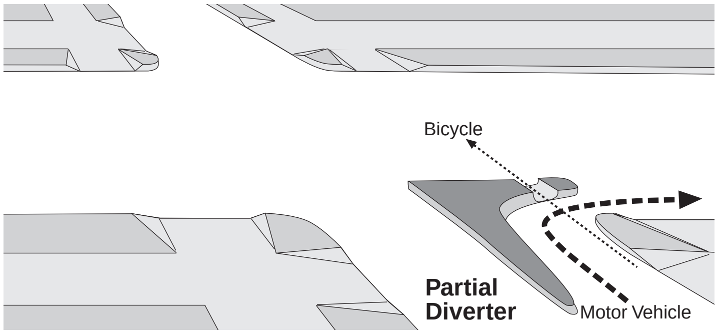


Fig. 2-72 (above).

2.10.2 Measures for slowing traffic

Other traffic calming measures allow motor vehicle traffic to proceed straight but are designed to slow traffic. While these are unlikely to reduce traffic volume on a residential street, they tend to reduce traffic speeds.

Residential street traffic circles are relatively small raised islands (fig. 2-73) located in the middle of an intersection. These force motorists to slow and divert to the right to pass around the circle. The size and shape is determined by specifics of the intersection. Since bicycles are relatively narrow, they can usually pass straight through.

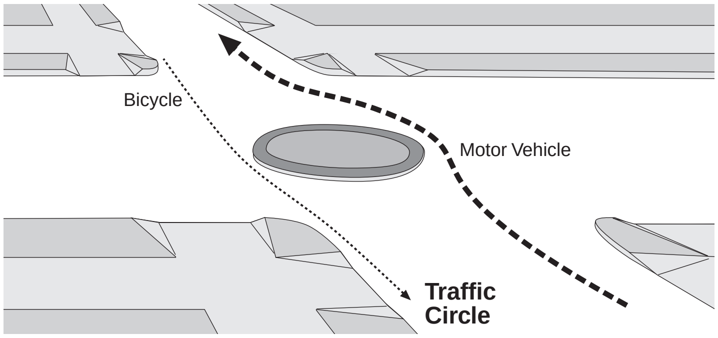


Fig. 2-73 (above).

Speed humps or speed tables are sections of raised roadway surface, typically 8 to 12 ft long (2.4 m to 3.6 m), that force motorists to slow down (fig. 2-74). These should not be confused with speed bumps, which are typically less than 3 ft. (1m) long and are found in parking lots or mobile home parks. [Speed bumps can catch a bicyclist's pedal or severely jar a front wheel and cause a crash.] Design speeds should be no less than 15mph.

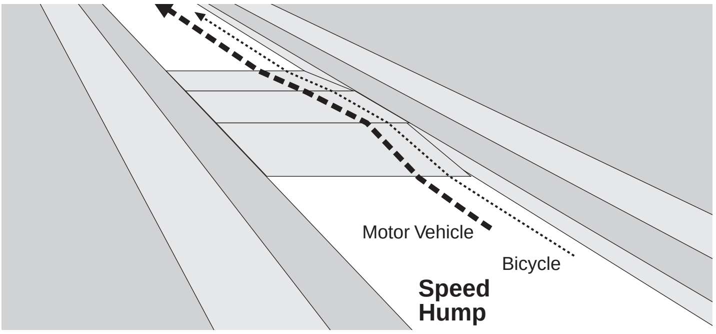


Fig. 2-74 (above).

Figure 2-75: A chicane forces traffic to divert left and then right.

Chicanes are staggered obstacles (e.g., expanded sidewalk areas, planters, street furniture, or parking bays) designed to shift the traffic stream side-to-side (fig. 2-75). The extent to which motorists slow depends on the design speed of the device, how close the obstacles are to each other, and how far to the left motorists must shift.

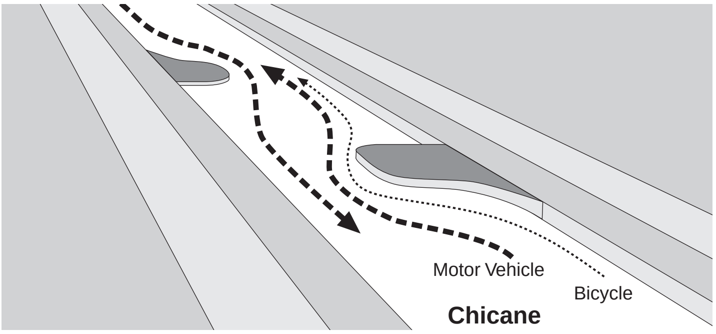


Fig. 2-76 (above).

Since bicyclists must divert the same as motorists through chicanes (fig. 2-76), the most successful designs use design speeds compatible with typical bicycle speed. They also work best on level terrain, where bicyclists can maintain a relatively uniform speed in both directions. In some cases, a channel can be provided outside the confines of the chicane.

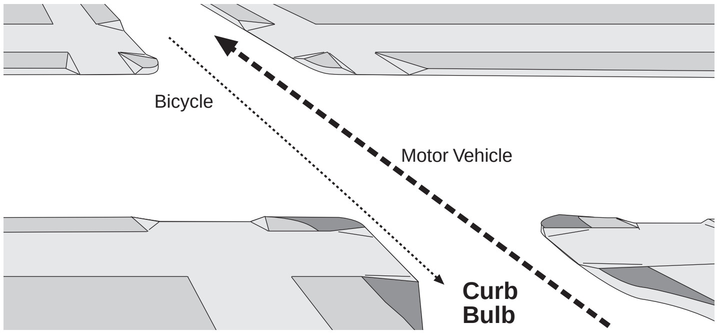


Fig. 2-77 (above).

Curb bulbs are sidewalk extensions that narrow the road and reduce crossing distances while increasing pedestrian visibility (fig. 2-77). They are often used in downtown shopping districts. The width of the extension should match the width of on-street parking and should not impinge upon bicycle lanes or the bicycle travel way (e.g., wide curb lanes).

Figure 2-78: A squeeze point with a speed hump narrows motor vehicles lanes but includes bicycle bypasses to the outside. This example also includes a speed hump. As with any traffic calming measure, they must be designed to work with maintenance and emergency vehicles.

Chokers or squeeze points narrow the street over a short distance to a single lane (fig. 2-78, 2-79). As a result, motorists must slow down and, occasionally, negotiate with on-coming traffic. Bicyclists are often provided channels to the outside so that they may avoid the squeeze point.

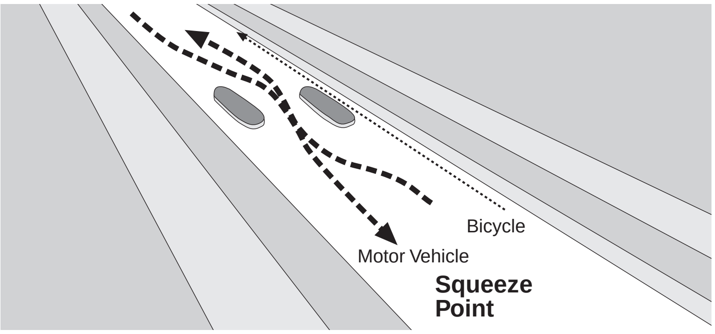


Fig. 2-79 (above).

Wo*onerf* is a Dutch term meaning "living yard." It denotes a street design strategy in which motorized and non-motorized traffic are integrated on one level (fig. 2-80). Design features like perpendicular parking, play structures, plantings, and trees are purposefully placed to reduce traffic speeds and alert motorists to the fact they do not have priority over other traffic. These areas are primarily intended to serve the needs of residents of all ages. Bicyclists traveling through the woonerf do so at very slow speeds.

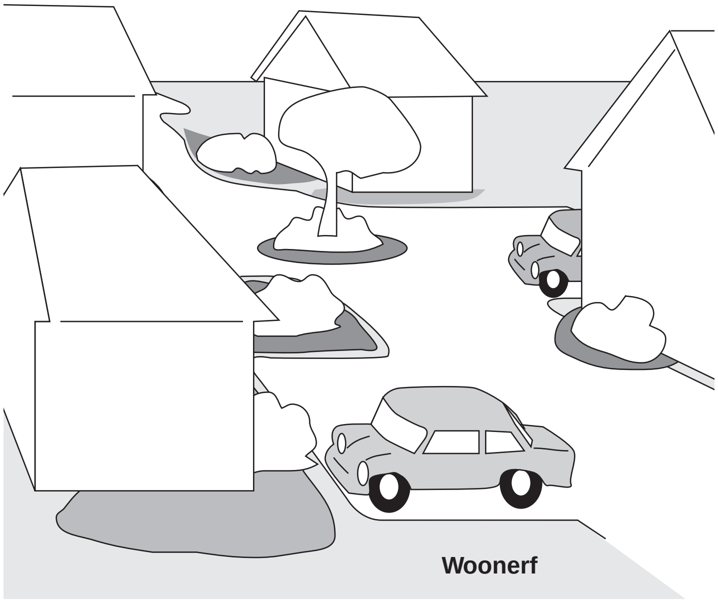


Fig. 2-80 (above).

These are only a few of the traffic calming measures used today. Whichever approach a designer chooses, the facility should consider the needs of bicyclists.

Figure 2-81: In rural areas, a particular bike route may have low traffic volumes, provide a direct route, or help bicyclists safely overcome a barrier.

2.11 Bicycle Route Designation

There are dozens of communities and counties in Wisconsin that have signed shared roadways as bicycle routes. These signed routes indicate a preference for bicyclists for one or more of the following reasons:

- *The route provides continuity to other bicycle facilities such as bike lanes and shared paths;*
- *The road is a common route for bicyclists because of its directness or land uses it serves;*
- *There is a need to assist bicyclists between two points with wayfinding devices because of the complexity of a particular route;*
- *In rural areas, the route is preferred for bicycling due to low volumes of motor vehicle traffic, directness, or its ability to help bicyclists safely overcome an upcoming barrier;*
- *The route runs parallel to a major roadway which has not yet been treated with wide curb lanes, bike lanes, or paved shoulders.*

Bike route signs may also be used on streets with bike lanes, as well as on shared use paths. This is especially important for wayfinding purposes if a single bikeway transitions from one type to another throughout a community. For example, if a particular segment of a community's bikeway consists of a shared use path, then continues to a set of bike lanes, then finishes as a shared roadway, it may be advantageous to use bike route signs to tie in all 3 bikeway types together and aid bicyclists in finding their way. Bike route signs should always be accompanied with supplemental plaques that indicate the route’s end point and/or its name (fig. 2-82). Showing mileage to a particular destination is also recommended.

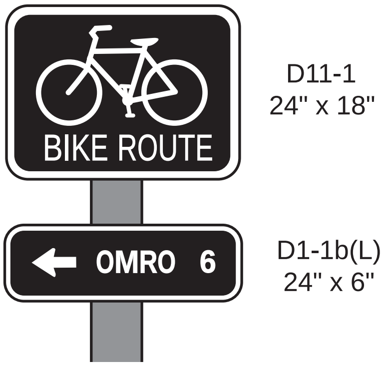


Figure 2-82: Standard D11-1 Bike Route and D1-1b signs.

There are examples in Wisconsin where bike route signage has been inappropriately used and does not support a real purpose. The following criteria should be considered prior to signing a route:

- *The route provides through and direct travel from one destination to another;*
- *The route connects discontinuous segments of shared use paths, bike lanes, and/or bike routes;*
- *An effort has been made, if necessary, to adjust traffic control devices to give greater priority to bicyclists on the route, as opposed to other parallel streets. This could include placement of bicycle-sensitive loop detectors where bicyclists stop at signals.*