

chapter

2

BICYCLING AND PEDESTRIAN ENGINEERING DESIGN VOCABULARY AND RELATED DESIGN PRINCIPLES

This chapter presents the basic vocabulary and general design principles of bicycling and pedestrian facilities in order to orient advocates regarding bicycling and pedestrian infrastructure.

MYTH

Only transportation officials can understand traffic engineering related to bicyclists and pedestrians.

REALITY

Most people can learn the basic concepts of traffic engineering, including those involving bicycling and pedestrian facilities.

NOTE

Under NYS Vehicle Code, bicycles are considered vehicles, and bicyclists are therefore subject to laws governing vehicular traffic.

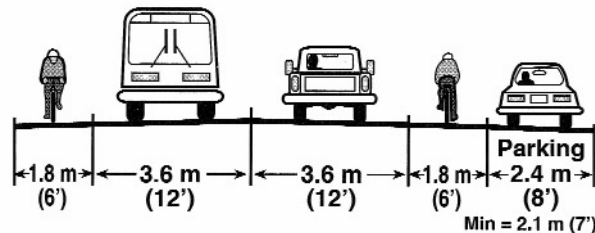
Consult the DOT website for additional explanation of laws that apply to bicyclists.
www.dot.state.ny.us/progs/bike/share.html

INTRODUCTION

Even for seasoned advocates, deciphering the terminology of the many varieties of bicycling and pedestrian facilities is difficult. Keep in mind different types of roads (e.g., highways, collectors, and residential streets) require different facilities, and urban areas tend to have a wider variety of infrastructure options than rural areas.

In addition, there is disagreement among advocates, especially regarding bicycling, about which facilities are most desirable. Some advocates feel striped, on-road bicycle lanes inhibit bicyclist safety by desensitizing motorists to the presence of bicyclists on roads without bicycle lanes. Other advocates, especially in urban areas like New York City, lobby for such bicycle lanes in the hopes of creating comprehensive transportation networks. Differences of opinion may be compounded by different goals—some advocates are primarily concerned with bicycling as a mode of transportation, others are recreational bicyclists who travel great distances on rural roads.

Differences notwithstanding, all advocates need to know basic vocabulary and engineering principles to understand different types of facilities, and their appropriateness to different road types. Chapters 3 and 4 build on this understanding by presenting some low-cost strategies for maintaining and implementing the different bicycling and pedestrian facilities appropriate to different areas.



General Bike Lane Standards

Minimum: 1.5 meters (5 feet) against curb, parking or guardrail; 1.2 meters (4 feet) open shoulder.

BASIC VOCABULARY

Bicycling Facilities

In engineering terms, there are several distinctions. A bikeway is a generic term for any road, street, path, or way which is specifically designated for bicycling travel in some manner, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes.

There are specialized terms for different types of bikeways: bicycle routes, bicycle lanes, and multi-use paths (often misunderstood to be exclusively bicycle paths).

On-Road Bicycle Routes

Bicycle routes are further differentiated into three types: shared lanes, wide outside lanes, and shoulders.

SHARED LANES (fig. 1)

Shared lanes are “standard width” travel lanes bicycles and motor vehicles share. These tend to be on residential and low-speed, low-traffic-volume streets.

WIDE OUTSIDE LANES (fig. 2)

Wide outside lanes have a width of at least 14 ft (4.2 m) to accommodate both bicyclists and motorized vehicles.

Wide outside lanes tend to be on low-speed/low-traffic-volume streets, and are most crucial in areas with severe right-of-way limitations where bicycle lanes cannot be provided. They may be installed by re-striping lanes or paving gravel shoulders. A wide lane must be between 14 ft (4.2 m) and 16 ft (4.8 m) wide to provide easy passage without allowing two cars to move in one lane. Wide lanes reduce bicycling on sidewalks and may also reduce car-door collisions, since bicyclists can ride far enough to the left of parked cars to avoid conflicts with adjacent vehicular traffic.

SHOULDER (fig. 3)

Shoulders are paved portions of the roadway to the right of the travel way. They can serve bicyclists, pedestrians and others. This type of facility is common in rural areas.

On-Road Bicycle Lanes

Bicycle lanes are designated by striping, signage, and/or pavement markings for preferential or exclusive use by bicycles (and often by other non-motorized vehicles such as motorized wheelchairs, etc).

Bicycle lanes are more easily installed on residential streets than in commercial areas, where parking is a premium.

For more information about pedestrian and bicycling facilities, see publications such as the **Manual for Uniform Traffic Control Devices (MUTCD)** from the American Association of State Highway and Transportation Officials (AASHTO).

Government and non-government groups have produced thorough guide books on engineering facilities, for example, see the **Transportation Alternatives Bicycle Blueprint** at www.transalt.org.



fig. 1 Shared roadway

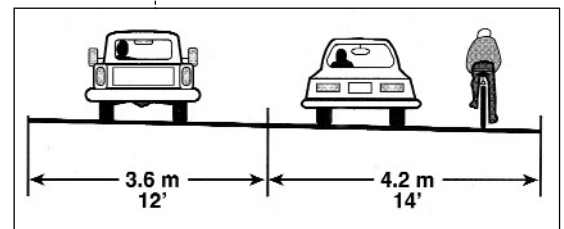


fig. 2 Wide outside lanes

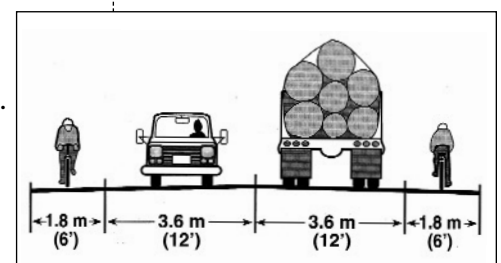


Fig. 3 Shoulder bikeway

In urban areas, bicycle lanes reduce conflict between passing motorists and bicyclists. In rural areas, pedestrian facilities can sometimes be cost-prohibitive, but are always a preferable safety measure. A paved shoulder with adequate sight-distances is a cost-effective way to accommodate the needs of both bicyclists and pedestrians. In dense and mixed-use suburban areas, pedestrian facilities can increase pedestrian volumes, reduce auto traffic, and even increase the number of transit riders [Hess 1999: 17].

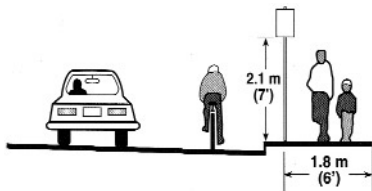


fig. 4 Sidewalk clearances

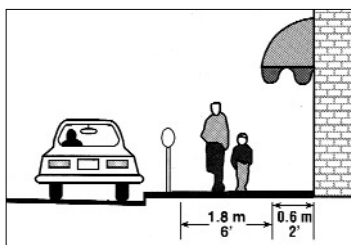


fig. 5 Sidewalk against a wall

Off-Road Multi-use paths

A multi-use path is a shared use path, physically separated from motorized vehicular traffic by an open space barrier, either within the highway right-of-way or within an independent right-of-way. Multi-use paths are intended for use by bicyclists, pedestrians and others (in-line skaters, equestrians, people in wheelchairs, strollers). Though primarily recreational, they can also afford transportation—provided they are well-designed and wide enough to separate modes (e.g., pedestrians from bicyclists) [FHWA/USDOT 1997: 87]. Narrow paths create numerous user conflicts, especially in high-traffic volume areas, and are unsafe for high-speed cycling.

Walking Facilities

Terminology for walking facilities is simpler; there are only three types of walkways: sidewalks, shoulders, and multi-use paths.

WALKWAYS

Walkways are built to standards that accommodate people in wheelchairs (which also aids elderly pedestrians and persons pushing carriages or shopping carts).

SIDEWALKS (figs. 4, 5)

Sidewalks are located along roadways, differentiated by a curb and/or planting strip with a hard, smooth surface.

Sidewalks are an essential safety requirement for pedestrians, especially along arterials and streets in and around commercial centers. Buffers such as street furniture (lights, refuse bins) or foliage (trees, bushes, planters) separate the sidewalk from the roadway. Such separation is especially beneficial to children (because of limited attention span and unpredictability) and the elderly (reduced vision and limited mobility). Buffers between sidewalks and roadways improve the quality of walking as well as safety; it is nicer to walk next to a row of trees or bushes than an open roadway. Sidewalks should have curb cuts for wheelchair accessibility. Curb cuts help all kinds of users by easing general movement [Templer 1980].

SHOULDER

In many rural areas, pedestrians use shoulders rather than sidewalks. Shoulders should be wide enough to accommodate bicycles.

MULTI-USE PATHS (fig. 6)

Multi-use paths can be used simultaneously by pedestrians, bicyclists, wheelchairs, skaters, and joggers. Paths may be unpaved or constructed with packed gravel, stone dust or asphalt grindings, and should be smooth and firm enough to meet Americans with Disabilities Act (ADA) requirements.

Multi-use paths are useful as short connectors or where automo-

tive traffic is undesirable or where roadway widths are limited. For example, they may be used to connect cul-de-sac neighborhood pods or can often be used in parks. The paths allow non-motorized traffic to get through without allowing automobile access. Another use is on bridges where bicyclists and pedestrians are sometimes separated from automobile traffic due to high speed narrow car lanes. Again it is often desirable to separate “wheels from heels” with good design to prevent unsafe user conflicts.

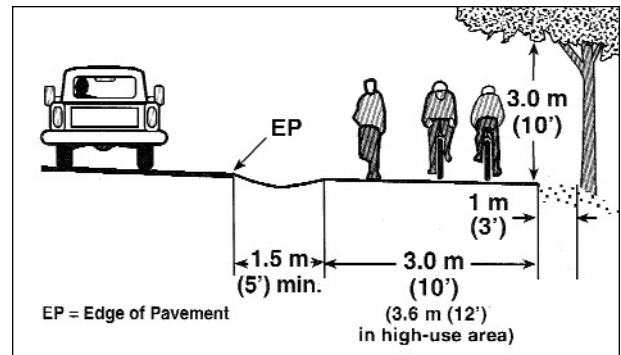


fig. 6 Multi-user path standards

DESIGN PRINCIPLES

Design principles guide the construction of bicycling and pedestrian facilities. When advocates are aware of these principles, they can better evaluate current facilities and provide effective input for the construction of new facilities.

The following is a **general** list of principles, and may have many valid exceptions.

1. Avoid conflicts between different uses. This may mean providing adequate space for each type of user, providing clear signage to alert various users to each other, or timing traffic signals to accommodate different uses. In general, facilities designed to limit conflicts between different users protect the safety of all users. For example, traffic signal timing should not impede bicyclist and pedestrian traffic. Slow and elderly people need 60 seconds to cross four lanes of car traffic.
2. Restrict free-flowing movements with compact intersections. For example, unregulated right-turn lanes often cause bicycle-car and pedestrian-car crashes.
3. Comprise intersections of as many simple right angles as possible. Skewed and multiple intersections increase the probability for conflict. (fig. 7)
4. Clearly mark all lanes. For example, on multilane roadways, mark the destination of each (left, straight through, or right) with overhead signs and/or pavement markings.
5. Construct pedestrian facilities with special attention to the needs of the elderly and children, who do the most walking and bicycling and are also the most vulnerable users on the road system. The elderly are much more vulnerable to injury, and so, not surprisingly, they have the highest pedestrian fatality rate of any age group [Zeeger 1993: 63]. The Americans with Disabilities Act (ADA) Guidelines have eased transportation for a variety of other users. As it turns out, modifications that assist people in wheelchairs—like curb cuts—also improve accessibility for the

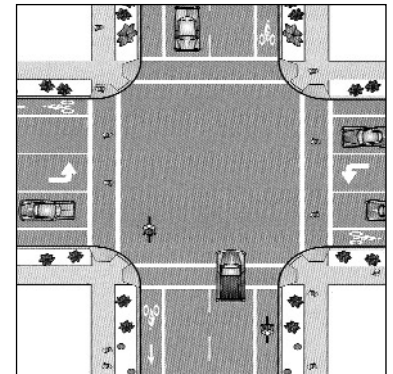


Fig. 7 Simple right angles

- elderly, people with baby carriages, shopping carts and luggage, and so on.
6. Create bikeways that are direct, logical and aligned with motor vehicle traffic. Do not route bicycling traffic with pedestrian traffic.
 7. Bicyclists and pedestrians should be visible and move predictably.
 8. Form a contiguous transportation network with striped bicycle lanes. For example, continue them right up to intersections, then resume immediately on the other side.
 9. Open all legs of an intersection to pedestrians.
 10. Allow pedestrians to travel on direct routes. If pedestrians are forced to zig-zag through intersections, jay-walking increases, which heightens risk of crashes.
 11. Do not force pedestrians to travel over an excessive expanse of uninterrupted pavement. Pedestrian refuge islands give walkers and bicyclists safe places to rest or wait for traffic signals to change [OR DOT 1995: 125].12.
 12. Do not let street furniture (such as signal poles and telephone poles) obstruct pedestrian movement or impede visibility.

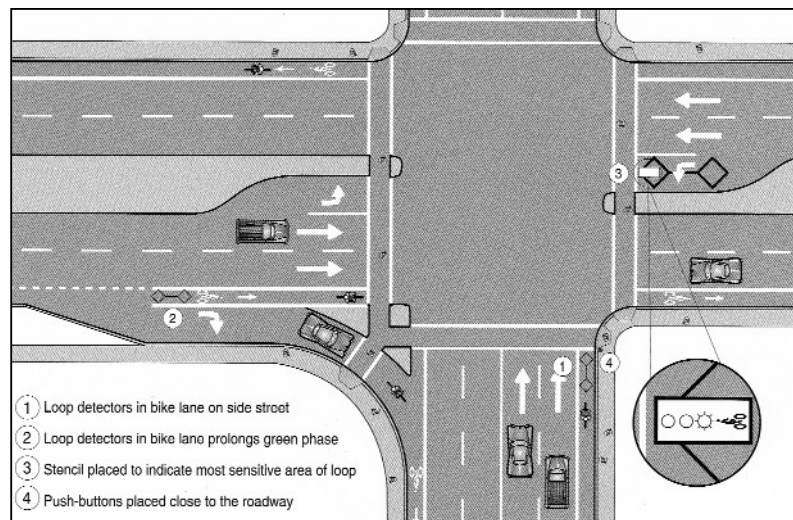


fig. 8 Good signalized intersection, sensitive to bicyclists.

NEW YORK BICYCLING COALITION
IMPROVING BICYCLING AND PEDESTRIAN SAFETY

chapter

3

MAINTENANCE ISSUES

Introduction

Spot Improvement
Programs

Recommended
Maintenance Practices

MYTH

It is prohibitively expensive to accommodate bicyclists and pedestrians on all roads.

REALITY

Many accommodation problems can be solved with regular maintenance practices.

INTRODUCTION

Maintenance is, in many cases, the simplest and least expensive way for a community to improve bicyclist and pedestrian access. Advocates may first want to consider how maintenance affects bicyclists and pedestrians, and only after look into more costly retrofits. This section presents the basics of road maintenance appropriate to such use.

In general, well-maintained roads are safer for all users. And conversely, the neglect of routine maintenance can threaten bicycling and pedestrian facilities [AASHTO 1999: 73]. Many design provisions for bicyclists and pedestrians can be installed during regular maintenance at little or no extra cost (for example, if a road is already being re-striped, the cost of including a bicycle lane is negligible). Advocates may ask to review their municipal maintenance policies to evaluate them with regard to bicyclist and pedestrian use.

Maintenance problems are, however, still subject to budget constraints and priorities. If they could, most road agencies would like to perform all the maintenance procedures listed in this chapter. Advocates can help by ensuring governments allot sufficient funds to maintenance, and assisting agencies in making tradeoffs necessitated by limited budgets.

For greater efficiency and reduced cost, neighboring jurisdictions may want to consider joint programs. A good program will establish maintenance standards and a regular schedule for inspection.

The following suggestions, drawn largely from the *Oregon Bicycle and Pedestrian Plan* (1995), incorporate many of AASHTO's recommendations from the *Guide for the Development of Bicycle Facilities*.

Spot Improvement Programs

Spot improvement programs enable problems to be brought to the attention of authorities in a quick and efficient manner. They are meant to identify such things as drainage grate replacement, bridge expansion joints, railroad crossings, intersection signal modifications that are substandard or in disrepair. Since citizens are often the first to notice facilities in need of maintenance, they are encouraged to report problems to a central contact person.

Recommended Maintenance Practices

SWEEPING

Keep the road surface free from debris and hazards. For example, sand is slippery and leaves and snow can be difficult to bicycle or walk through. Piles of debris force pedestrians and bicyclists into other parts of the roadway, where they may be less visible. Of course, debris should not be swept onto sidewalks and conversely, debris from side-

walks should not swept into the street. If it is not cost-effective to frequently remove sanding materials during icy weather, sweep high-use areas after major storms and following the winter season. This will keep storm sewers clean, reduce siltation of streams and improve water quality at points of discharge.

SURFACE REPAIRS

The quality of pavement is very important to bicyclists and pedestrians. Maintain a smooth surface, free of cracks (especially longitudinal wheel-grabbing cracks and parallel-to-traffic pavement joints), potholes, bumps by fixing physical problems regularly.

PAVEMENT OVERLAYS

Do not leave a ridge in the area where bicyclists ride (this can occur where an overlay extends partially, but not fully, to the edge of the shoulder). The drop can cause bicyclists to fall into traffic and is particularly hazardous for elderly pedestrians.

VEGETATION

Overgrown shrubs and low-hanging branches can obscure signs and people, so routinely cut vegetation back, and keep it out of walkways or bikeways. Maintain adequate clearance and sight-distances at driveways and intersections so bicyclists and pedestrians are visible to motorists. Control roots by installing root barriers during sidewalk construction to prevent the break-up of sidewalks and roadway surfaces. Require maintenance of vegetation originating from private property through local ordinances.

SIGNS, STRIPES AND LEGENDS

Over time, bikeway and walkway signs may fall into disrepair and legends may become hard to read. Keep signs and legends—including those directed at motorists—legible.

DRAINAGE IMPROVEMENTS

Drains should not catch bicycle tires. A bicycle-safe drainage grate at the proper height improves bicyclist safety. Adjust or replace catch basins to improve drainage. Puddles that form due to poor drainage are perilous to pedestrians and bicyclists alike. When pedestrians or bicyclists have to avoid puddles, they often stray into the roadway, where motorists are not expecting them. Puddles freeze in winter, becoming even more hazardous. Drainage grates, manhole and utility covers should be flush with the pavement.

CHIP SEALING

Chip sealing is the application of a special protective wearing surface to existing pavement. Desirable as a low-cost way to fill and seal cracked and raveled surfaces of old pavement (which costs 80%-85% less than pavement overlays), it often leaves a rough and

bumpy surface undesirable for bicyclists. Further, debris from chip seals can ricochet off car tires and potentially hurt bicyclists and pedestrians.

PATCHING ACTIVITIES

Patching activities can result in loose asphalt being left on the roadway. When left on the shoulder, loose asphalt adheres to the surface and creates rough conditions for bicyclists. Avoid this by sweeping loose material off the road and shoulder immediately following patching activities.

BLADE PATCHING ACTIVITIES

The last pass of the grader sometimes leaves a rough tire track in the middle of the shoulder. Prevent this by covering the entire shoulder width, equipping road graders with smooth tires, rolling the shoulder area after the last pass of the grader, and sweeping fresh loose materials off the road before they adhere to the surface.

UTILITY CUTS

Utility cuts are the cuts in pavement made in order to make repairs or modifications to underground utilities (like power or water lines). They can leave a rough surface for bicyclists if not back-filled carefully. After cutting, finish the pavement as smooth as new. Wherever possible, make the cut in an area that will not interfere with bicycling travel. Back-filled cuts in bikeways should be flush with the

surface (humps will not get packed down by bicyclist traffic). When cutting parallel to bicycling traffic, do not leave a ridge or groove in the bicycle wheel track.

ABANDONED DRIVEWAY APPROACHES

When accesses are abandoned in urban areas, there is no point in leaving a pavement dip or warp at these locations. Fill them level with the pavement.

SNOW REMOVAL

Complete snow removal in such a way it does not interfere with bicyclist and pedestrian access. For example, do not clear snow to make room for cars by pushing it onto bicycle lanes, pavement, or

crosswalks. When these facilities are not cleared, pedestrians and bicyclists must re-route around them, forcing travel in places where drivers do not anticipate them.



Snow obstruction

NEW YORK BICYCLING COALITION
IMPROVING BICYCLING AND PEDESTRIAN SAFETY

chapter

4

TRAFFIC CALMING

Introduction

Goals, Principles and
Benefits

Traffic Control Devices and
Road Retrofits

MYTH:

The only way to improve traffic flow is to increase the speed at which vehicles move through an area.

REALITY:

Traffic calming uses a multi-modal infrastructure to improve traffic flow by decreasing vehicle speed, and boosts safety, quality of life, and local economies.

INTRODUCTION

Traffic calming techniques arise from the premise that safety and flow can be improved through measures that reduce the speed of traffic moving through a given area. The idea is somewhat counter-intuitive, and it stands in strong contrast to the conventional wisdom in traffic engineering that has prevailed in the United States for many years.

Nevertheless, traffic calming is becoming increasingly popular among transportation professionals and advocates. It improves bicyclist and pedestrian safety by reducing both the amount and speed of motor vehicle traffic [NYC DOT 1997: 53], and helps create green areas and play space on public right of ways. It also helps reduce crime. Studies show crime decreases when more people are out on the streets, creating a self-perpetuating cycle where safer, quieter streets increase bicycling and walking [Hoyle 1995: 16-18; Pinsof 1994: 11].

Traffic calming is also desirable from the standpoint of local economics. Increases in pedestrian traffic tend to lead in increased patronage of local businesses.

European, Australian, Canadian, and US studies have found pedestrian and bicyclist crashes are substantially lower on traffic-calmed streets. Injuries sustained in the crashes that do occur are less severe because vehicles are traveling at reduced speeds. Moreover, while traffic volumes remain constant, noise and air pollution decrease, along with the severity and number of injuries [Pinsof 1995: 12; Wynne 1992].

There is a caveat, however, from the point of view of transportation professionals. Traffic calming comes at a cost, which may accrue to motorists, or those depending on motorists (such as merchants). Like everything else, the value of the technique is using it in certain situations, sufficiently evaluating the design trade-offs to produce the best results. Transportation professionals are likely to find advocates who remember this perspective more thoughtful, reasonable, and empathetic.

The first part of this chapter builds on the design principles discussed in Chapter 2 to present a general picture of traffic calming and its benefits. The second part of the chapter presents traffic calming strategies used to retrofit roads to accommodate bicyclists and pedestrians.

TRAFFIC CALMING

The goal of traffic calming is to create transportation networks conducive to multiple modes of transportation. The New York State Department of Transportation defines *traffic calming* as: “the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users” [ITE State of the Practice, 1999].

Because wide and straight roads project an image to motorists of the street as “their turf,” traffic calming uses techniques to either actually reduce the area of the roadway available to motorized traffic, or to create the perception of reduced space. Either way, the result of traffic calming is more hospitable streets for bicyclists and pedestrians. Landscaping, for example, can be used to enhance residents’ *sense of place* [Hoyle 1995: 16-18]. Streets with landscaping and narrowed lanes have a relaxed, pedestrian feel and communicate a message to the driver: “Beware, this is shared space.”

The rest of this chapter gives an overview of traffic calming principles, benefits, and traffic control devices used in retrofitting roads according to traffic calming tenets. There is a wide variety of traffic calming literature available. See www.trafficcalming.org for the state of the art. See also Walkable Communities, Inc. at www.walkable.org, or the National Center for Biking and Walking at www.bikefed.org.

There is a wide variety of traffic calming literature available.

www.trafficcalming.org

Walkable Communities, Inc.
www.walkable.org

National Center for Biking and Walking
www.bikefed.org

General Traffic Calming Principles

- Street design allows drivers to drive at, but no more than, speed limit. (*fig. 1*)
- Street design allows local access, but discourages through traffic.
- Street design increases pedestrian traffic through commercial areas, often by allowing “mixed-use zoning.”
- Street design and traffic management devices are compatible with the neighborhood character.
- Street design and traffic control devices are easy to maintain.
- Landscape design improves safety for pedestrians and bicyclists.
- Design or redesign changes the psychological feel of the street. Rather than physically narrowing the street or travel lanes, modifications make the roadway appear narrower than it is. This can be accomplished by putting buildings closer to the roadway edge, or by adding tall trees as close as traffic safety allows. (*fig. 2*)

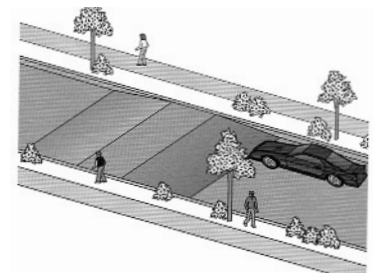


fig. 1 Speed hump allows drivers to drive at the speed limit.

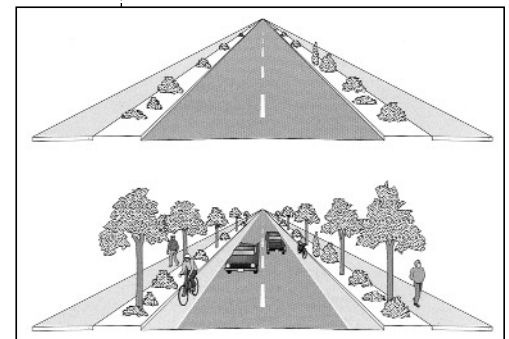
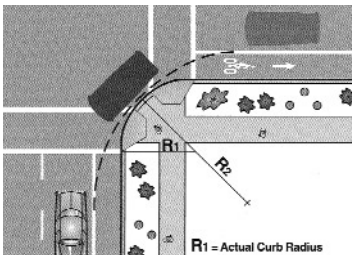
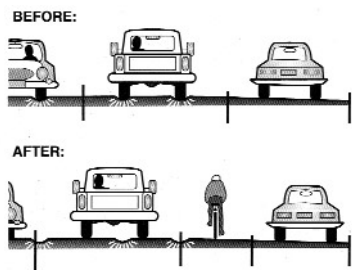


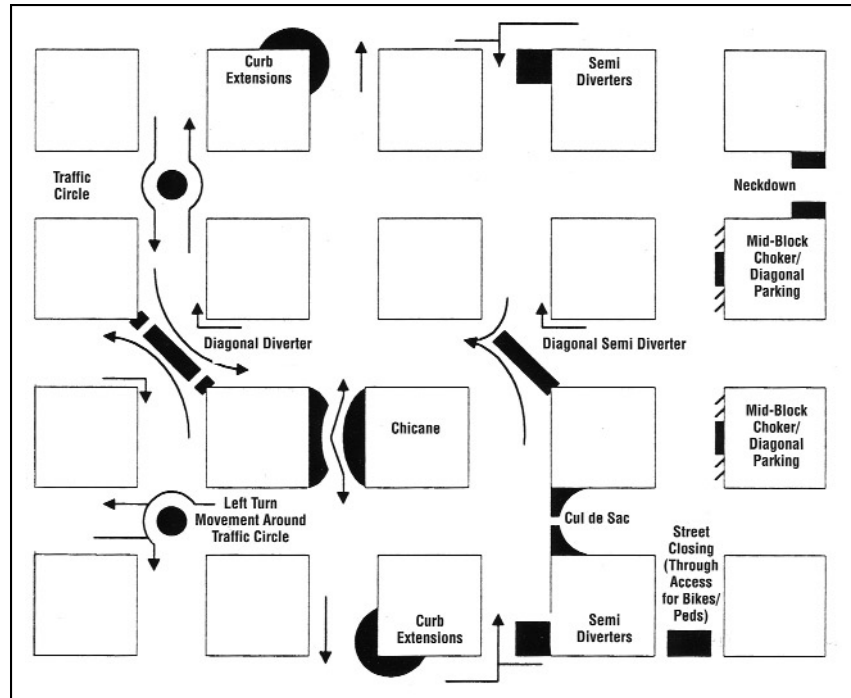
fig. 2 Trees and colored bike lanes make a roadway appear narrower.



Effective radius at intersections is increased with bike lanes.



Motor vehicles no longer drive in wheel ruts after restriping.



An example of traffic calming practices

- High-speed traffic is kept on appropriate roads and out of residential neighborhoods.
- Street modifications do not simply shift traffic problems from one part of the city to another.

Benefits of Traffic Calming

- Expanded route choice. Traditional town planning techniques (such as grid street patterns, on-street parking, narrower streets, smaller turning radii, and alleys rather than driveways) allow expanded route choice.
- Reduced exposure of bicyclists and pedestrians to intersecting traffic.
- Trips made by walking, cycling, or public transportation can be substituted for trips normally made by car.
- Increased mobility for children and the elderly through walking and cycling, resulting in less chauffeuring.
- Mixed zoning allows businesses to locate closer to residential areas.
- Increased levels of localized employment.
- Improved attractiveness of local shopping centers and facilitation of public festivals and entertainment [Hoyle 1995: 16-18; Lerner-Lam 1992; Pinsof 1995: 12].
- Enhanced safety. Travel lanes are offset from curbs, lanes are better defined, and parking is removed or reduced. Adding bicycle

lanes improves sight distance and increases turning radii at intersections and driveways.

- Lowered maintenance costs. Narrow streets have lower construction and maintenance costs. Re-striping can help extend pavement life, as traffic is no longer driving in the same well-worn ruts [OR DOT 1995: 81-85].

Traffic Control Devices and Road Retrofits for Traffic Calming Projects

This is only a cursory review of possible control devices for traffic calming projects. Again, for more information, visit the websites listed above.

STOP SIGNS/YIELD SIGNS

Bicyclists are more inconvenienced than drivers by unnecessary stopping, so yield signs and other traffic calming measures are preferable to stop signs.

COLORING OR TEXTURING

Make pedestrian crossings and bicycle lanes a different color from vehicular roadway. Drivers see only the travel lanes as available road space. Low-cost methods include:

- Paving travel lanes with concrete and bicycle lanes with asphalt, or the reverse.
- Slurry sealing or chip-sealing the roadway and not the bicycle lanes.
- Incorporating dyes into concrete or asphalt.

CHICANES (fig. 3)

Chicanes create a curved path for vehicles on a previously straight roadway. The roadway width remains adequate for two cars to pass, but the interruption causes vehicles to slow down.

PEDESTRIAN REFUGE ISLANDS (fig. 4)

Pedestrian refuge islands (or safety islands) are pavement markings or raised islands between opposing traffic lanes within an intersection. They are particularly helpful to those who have difficulty crossing a wide street without stopping. Elderly pedestrians, for example, are over-represented in crashes when crossing wide streets of four or more lanes.

PEDESTRIAN MALLS

Pedestrian malls not only improve pedestrian safety but are an economic benefit to small business. Closing streets to car traffic (either completely or during certain hours of the day) increase the foot traffic past stores and may increase customers for local busi-

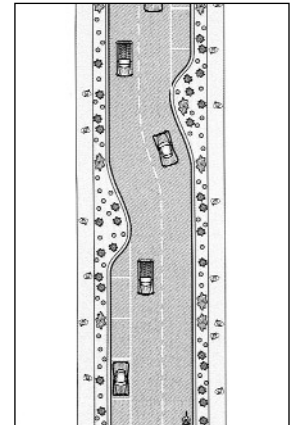


fig. 3 Chicane created through alternate parking

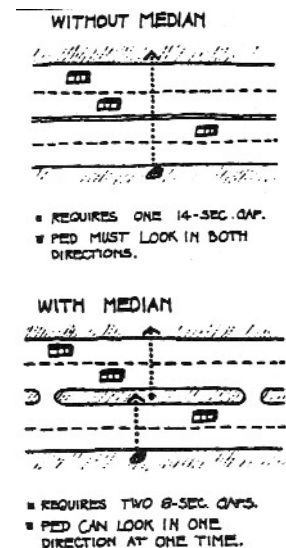


fig. 4 Pedestrian refuge islands.

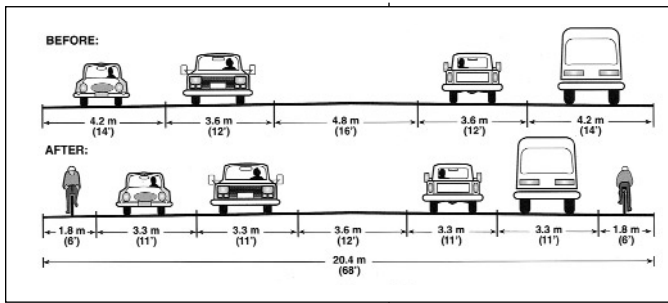


fig. 5 Reduced travel lane widths.

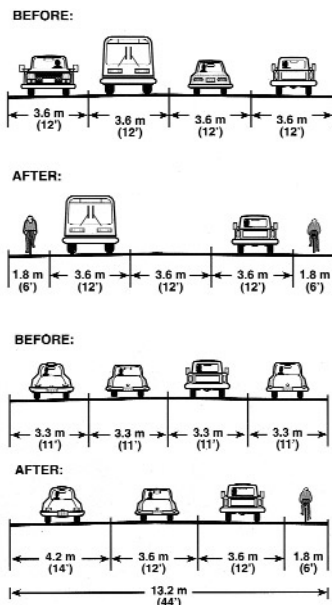


fig. 6 Reduced number of travel lanes from four to two, with center turning lane (top) and from four to three on a one-way street (bottom).

nesses. Pedestrian malls are often developed during revitalization efforts in a downtown area, with the added benefit of substantially increasing safety for younger and older pedestrians. They also increase economic activity because merchants tend to locate where there is a high volume of pedestrian traffic. Pedestrian malls can be made more attractive with the provision of seating areas.

REDUCED TRAVEL LANE WIDTHS (fig. 5)

The need for full-width travel lanes decreases with speed. This is significant because narrowing lanes helps make room for bicycle lanes. Additionally, creating dedicated left-turn lanes with the “left-over” space makes vehicular traffic more predictable.

Up to 25 MPH (40km/h): Travel lanes may be reduced to 10 or 10.5 ft (3 or 3.2 m).

30 to 40 MPH (50 to 65 km/h): 11 ft (3.3 m) travel lanes and 12 ft (3.6 m) center turn lanes may be acceptable.

45 MPH (70 km/h) or greater: Try to maintain a 12 ft (3.6 m) outside travel lane and a 14 ft (4.2 m) center turn lane if there are high truck volumes.

REDUCED NUMBER OF TRAVEL LANES (fig. 6)

On two-way streets with four travel lanes and a significant number of left-turn movements, re-striping for a center turn lane, two travel lanes, and two bicycle lanes often improves traffic flow.

One-way couplets, many of which were originally two-way streets, can result in an excessive number of travel lanes in one direction. In many cases, the road can be reduced by one lane.

REMOVING ALL PARKING

Safety and capacity of a roadway may be increased by removing all parking. However, this is usually not feasible in dense, commercial or residential urban areas. Problems may be avoided by taking a survey of on- and off-street parking used by area businesses and residences and removing parking on the side less reliant on on-street parking (usually the side with fewer residences or businesses, or the side with residences rather than businesses in mixed-use neighborhoods).

REMOVING SOME PARKING

It may not always be desirable to remove all parking: on-street parking can promote traffic calming efforts by serving as a buffer between cars and other traffic [OR DOT 1995: 12-14]. Some parking removal however, may be desirable. This can be accomplished in several ways.