

# **Designing Walkable Urban Thoroughfares: A Context Sensitive Approach Part 2**

**7 PDH / 7 CE Hours / 7 AIA LU/HSW**

**Institute of Transportation Engineers  
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PDH Academy

PO Box 449

Pewaukee, WI 53072

[www.pdhacademy.com](http://www.pdhacademy.com)

[pdhacademy@gmail.com](mailto:pdhacademy@gmail.com)

888-564-9098



## Designing Walkable Urban Thoroughfares Part 2 Final Exam

1. Access management addresses the basic questions of when, where and how access should be provided or denied and what legal or institutional provisions are needed to enforce these decisions. It has been shown that good access management can reduce crashes by \_\_\_\_\_ percent or more.
  - a. 60
  - b. 50
  - c. 25
  - d. 40
  
2. High levels of street connectivity improve emergency response by providing alternate routes. Measure network connectivity using metrics such as intersections per square mile. The threshold number of intersections per square mile should be somewhere around \_\_\_\_\_.
  - a. 150
  - b. 1,140
  - c. 35
  - d. 50
  
3. On lower-speed urban thoroughfares (target speeds of 35 mph or less), a range of lane widths from \_\_\_\_\_ feet on arterials and 10 to 11 feet on collectors is appropriate.
  - a. 17 to 18
  - b. 15
  - c. 8 to 9
  - d. 10 to 12
  
4. According to Table 9.1, what is the recommended width of arterial boulevards and avenues?
  - a. 4 feet
  - b. 16-18 feet
  - c. 22-24 feet
  - d. 14 feet
  
5. Parking should be prohibited within \_\_\_\_\_ of either side of fire hydrants (or per local code).

- a. 20 feet
  - b. 2 meters
  - c. 15 meters
  - d. 10 feet
6. The conversion of a wide street to a narrower one, such as the conversion of a four-lane undivided thoroughfare into a three-lane street composed of two travel lanes and a two-way left-turn lane, is also known as a \_\_\_\_\_.
- a. road diet
  - b. lane diminishment
  - c. AASHTO
  - d. transition
7. Pedestrian refuge islands should be sufficiently large to command attention. For pedestrian refuge, islands should have an area at least \_\_\_\_\_ square feet.
- a. 60
  - b. 20
  - c. 6
  - d. 120
8. According to Table 9.8, what is the minimum dimension for a bus bulb stop length (near side or far side)?
- a. 40 feet
  - b. 60 feet
  - c. 5 meters
  - d. 30 meters
9. A thoroughfare that provides water-quality treatment, retention and/or detention for some or most storm water within the right of way through use of vegetated facilities, usually swale areas, to reduce, delay and/or filter the amount of water piped directly to outfalls is known as a \_\_\_\_\_.
- a. BMP
  - b. biofiltration
  - c. mechanical filtering
  - d. green street
10. Studies conducted in the United States indicate that modern single-lane roundabouts in urban areas can result in up to a \_\_\_\_\_ percent reduction in all crashes and a 77 percent reduction in injury crashes when compared with stop-controlled intersections.
- a. 50
  - b. 61
  - c. 75
  - d. 32

## Traveled Way Design Guidelines

### Purpose

This chapter provides principles and guidance for the design of a thoroughfare's traveled way, which includes the elements between the curbs such as parking lanes, bicycle lanes, travel lanes and medians. The traveled way also includes midblock bus stops and midblock crosswalks. The guidance in this chapter is used in conjunction with the guidance for the other two thoroughfare components—the streetside (Chapter 8) and intersections (Chapter 10).

### Objectives

This chapter:

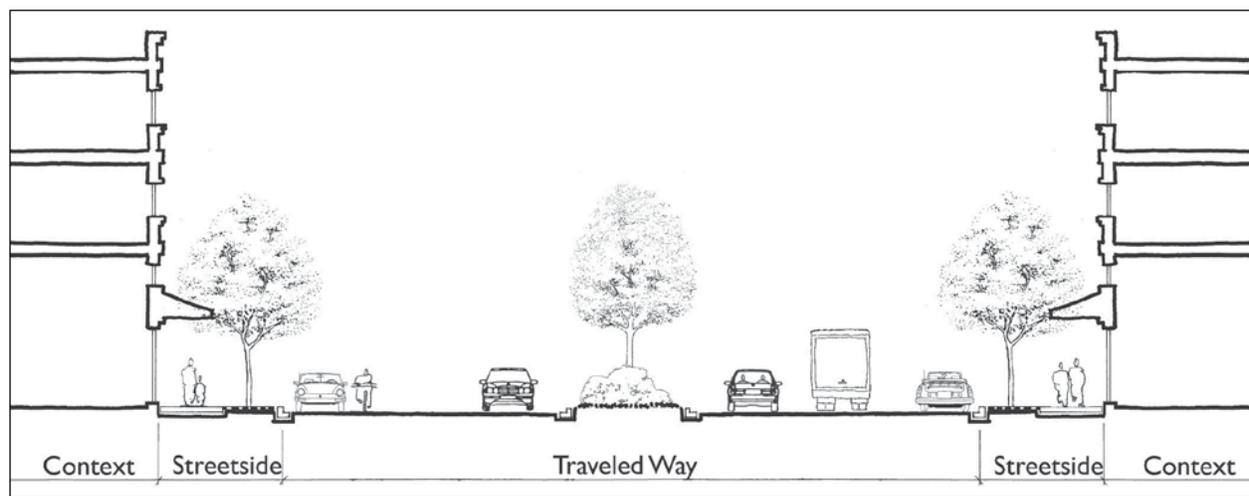
1. Introduces and defines the elements of the traveled way;
2. Presents traveled way design considerations, including key factors in determining cross-sections;
3. Describes principles for transitioning urban thoroughfares when there is a change in context, thoroughfare type, or geometric elements; and

4. Provides design guidance for the primary elements of the traveled way, which are lane width, medians, bicycle lanes, on-street parking, geometric transition design, midblock crossings, pedestrian refuge islands, transit, bus stops and stormwater management.

### Introduction

The traveled way comprises the central portion of the thoroughfare (**Figure 9.1**). It contains the design elements that allow for the movement of vehicles, transit, bicycles and freight. The traveled way is also where vehicles, via on-street parking, interface with the streetside. Many of the conflicts that occur on thoroughfares occur within the traveled way between two or more moving vehicles, moving and parking vehicles, bicyclists and vehicles, and vehicles and pedestrians crossing at midblock locations and intersections.

Fundamental principles of the design of this portion of the thoroughfare include uniform cross-section along the length of the thoroughfare and transitions designed to move vehicles laterally or change speed where cross-section elements change.



**Figure 9.1** The traveled way is the component of the thoroughfare between the curbs. Source: Community, Design + Architecture.

This report addresses the following considerations for the thoroughfare traveled way:

- Cross-section determination;
- Access management;
- Emergency vehicle operations; and
- Transition principles.

This report addresses the following guidelines for the thoroughfare traveled way:

- Lane width;
- Medians;
- Bicycle facilities;
- On-street parking and configuration;
- Transition design;
- Midblock crosswalks;
- Pedestrian refuge islands;
- Transit design;
- Bus stops in the traveled way;
- Special consideration for stormwater management; and
- Special consideration for snow removal.

## Design Considerations

### Cross-Section Determination

The following design considerations are used to determine the optimum cross section:

1. Determine context zone and identify thoroughfare type based on **Tables 4.1** (Context Zone Characteristics), **4.2** (Thoroughfare Type Descriptions), **4.3** (Relationship Between Functional Classification and Thoroughfare Type), **4.4** (Urban Thoroughfare Characteristics), **6.4** (Design Parameters for Walkable Urban Thoroughfares) and **8.1** (Recommended Streetside Zone Dimensions). This establishes the general parameters for the cross-section (such as median width, parking lane width, streetside width and function).
2. Determine the preliminary number of lanes through a combination of community objectives, thoroughfare type, long-range transportation plans and corridor-wide and network capacity analysis. Network capacity (the ability of paral-

lel routes to accommodate travel demand) should influence the number of lanes on the thoroughfare. Thoroughfare in compact mixed-use urban areas are recommended to have a maximum of six through lanes where necessary because network connectivity is limited. A maximum of four lanes is recommended for new corridors.

3. Select the design and control vehicle for the thoroughfare by identifying the most common type of vehicle to accommodate without encroachment into opposing travel lanes. Chapter 7 describes the selection of a design and/or control vehicle and criteria for accepting encroachment of vehicles into opposing lanes.
4. Determine the preliminary number of turn lanes at critical intersections. Intersection design in CSS may require evaluation of trade-offs between vehicular capacity, level of service, pedestrian crossing distance and exposure to traffic.
5. Identify transit, freight and bicycle requirements for the thoroughfare and establish the appropriate widths for each design element.
6. Develop the most appropriate cross-section and compare the width to the available right of way:
  - If the cross section is wider than the right of way, identify whether right-of-way acquisition is necessary or whether design elements can be narrowed; and
  - If the cross section is narrower than the available right of way, determine which elements should be widened (such as the streetside) to utilize the available right of way.

Avoid combining minimal widths for adjacent elements, except on very low-speed facilities (25 mph maximum). For example, avoid combining minimal parking and bicycle lanes adjacent to minimum width travel lanes. Establish priorities for each mode and allocate the right-of-way width appropriately to that mode's design element. Use appropriate lane widths to accommodate the speed and design vehicle selected for the thoroughfare. Avoid maximum-width travel lanes if not warranted, as this creates overly wide thoroughfares that encourage high speeds.

### Access Management

Access management is the practice of properly locating and designing access to adjoining properties to re-

duce conflicts and improve safety while maintaining reasonable property access and traffic flow on the public street system. Effective access management includes setting access policies for streets and abutting development, linking designs to these policies, having the access policies incorporated into legislation and having the legislation upheld in the courts.

Access management addresses the basic questions of when, where and how access should be provided or denied and what legal or institutional provisions are needed to enforce these decisions. It has been shown that good access management can reduce crashes by 50 percent or more, depending on the condition and treatment used (TRB 2003). The need for rigorous access management in compact urban areas can be lessened by proper network planning, because traffic distributed to a grid of streets reduces the concentration on any one thoroughfare.

The following principles define access management techniques:

- Classify the street system by function, context and thoroughfare type;
- Establish standards or regulations for intersection spacing (see Chapter 3 for guidance);
- On streets that serve an access function (the focus of this report), minimize curb cuts in urban areas to reduce conflicts between vehicles, pedestrians and bicyclists, locate driveways and major entrances away from intersections and away from each other to minimize effects on traffic operations, minimize potential for crashes, provide for adequate storage lengths for turning vehicles and reduce conflicts with pedestrians using the streetside;
- Use curbed medians and locate median openings to manage access and minimize conflicts; and
- Use cross streets and alleys to provide access to parking and loading areas behind buildings. This topic is discussed in Chapter 3 on network planning and in Chapter 8 on street-side design.

There are a number of resources listed at the end of this chapter that provide detailed guidance on access management.

## Emergency Vehicle Operations

Urban thoroughfares are the primary conduits for emergency response vehicles, including police, fire and ambulance. Common design for thoroughfares encourages speed and capacity. This can lead to fatality- and injury-producing crashes. On the other hand, the emergency responder bears the responsibility for both response times and reasonable access to incidents within the community. A balance between these two interests must be established for the appropriate design of context sensitive thoroughfares. Both interests can work together to find response strategies that create safe and comfortable places for the non-motorist.

Emergency vehicle access and operations should always be considered in thoroughfare and site design. Local operational conditions will vary from place to place, and emergency response strategies are specific to the locale. Consequently, the practitioner should collaborate with emergency responders to learn their specific needs and response strategies and tactics used on similar streets. Asking the following questions will help in understanding issues when working with fire departments:

- What types of fire apparatus are used in responding to different emergencies that might occur on or adjacent to the thoroughfare?
- Does the type of vehicle change depending on where vehicles are responding (e.g., suburban residential versus urban core high rise)?
- In urban areas with tall buildings, how does the department deploy its ladders and how much width is needed between the vehicle and building? How much clear space is needed adjacent to the building? Do they require gaps in sidewalk furnishings to access buildings? Do they need to fully extend their vehicle's stabilizers?
- What are the characteristics of the apparatus that affect thoroughfare design (e.g., wheel turning path, overhang turning path, apparatus width)?
- In a block of attached multistory buildings, does the number of stories cause a difference in firefighting tactics that would affect the design of the adjacent street?

Fire codes may have additional guidance on emergency access requirements, such as minimum travel way clear widths and minimum space to deploy certain types of equipment, such as ladders, to reach high buildings. The following should be considered in designing networks and traveled ways to accommodate emergency vehicles:

- Many emergency responder concerns can be addressed at the network planning level. High levels of street connectivity improve emergency response by providing alternate routes, and can alleviate the need for passing stopped fire fighting vehicles. Measure network connectivity using metrics such as intersections per square mile. The threshold number of intersections per square mile should be somewhere around 150 (not including alleys). Other considerations are maximum block perimeter, existing or proposed thoroughfare connectivity and intersection types (cross, tee and so forth). A block perimeter of 1,140 feet is a reasonable length for pedestrians and emergency vehicles. Exceptions can be made, and the thoroughfare design practitioner and fire officials must come to a mutually acceptable decision based on specific local conditions.
- Alleys benefit emergency responders by creating a secondary means of approaching structure fires with smaller equipment. As secondary approaches, alleys are not primary access and need not be designed for the largest fire vehicle.
- In urban areas with tall buildings, consider no-parking zones or staging areas at the mid-block to accommodate large ladder trucks. The length and frequency of these zones should be determined with the emergency responder but should not be longer than 50 feet to minimize loss of on-street parking.
- When establishing new or reviewing existing access management configurations, care should be taken to permit direct routing capability for emergency vehicles.
- Use emergency vehicles as a design vehicle for the design of curb return radii only if the vehicle would use the roadway frequently (e.g., primary travel route from fire station to its service area). Otherwise, emergency vehicles

are generally able to encroach into opposing travel lanes. Consider using demonstration projects in the field to determine or confirm the optimal geometry for fire vehicles.

- On streets with medians or other access management features, emergency response time may be reduced by implementing mountable median curbs to allow emergency vehicles to cross (see **Figure 9.2**).
- Consider the use of bike lanes that are at least 6 feet wide on thoroughfares that have one lane in each direction and medians. This will provide the opportunity for vehicles to pull into the bike lane and allow emergency vehicles to pass them.
- Thoroughfare design in high-rise building environments may be constrained by the required distance between the building face and the centerline of ladder trucks. In many cases, this is 35 feet. However, this dimension varies and should be examined with fire officials.

### Operational Considerations

Operational and technological strategies to enhance emergency vehicle response in urbanized areas include:

1. Reducing nonrecurring congestion using techniques such as traffic incident management and information, special events traffic management, work zone management and emergency management planning; and
2. Reducing recurring congestion using techniques such as freeway and arterial management, cor-



**Figure 9.2** A mountable median allows emergency vehicles to access side streets. Source: Kimley-Horn and Associates, Inc.

ridor traffic management and travel demand management. These include techniques to improve day-to-day operations such as signal systems management, emergency vehicle preemption, access management, traveler information and intelligent transportation systems (ITS), which encompass many of the strategies listed in item 1 above.

Finally, it should be noted that firefighters are trained in many techniques that address context sensitive streets, mainly because narrow, low-speed, pedestrian oriented streets exist in many towns and cities. Many fire departments have experience with historic networks of narrow streets. Their experience provides a basis for allowing new neighborhoods to be built on networks of relatively narrow streets. The designer should be particularly sensitive to the local fire official's experience and operational needs on urban thoroughfares.

### Transition Principles

Transitions refer to a change in thoroughfare type, context (rural to urban), right-of-way width, number of lanes, or neighborhood or district. For purposes of this report, transitions in the geometric design of thoroughfares refer to the provision of a smooth taper of appropriate length where lanes or shoulders change width, lanes diverge or merge, or lanes have been added or dropped.

In context sensitive thoroughfare design, however, transitions extend beyond geometric design requirements and reflect changes in context zone and associated levels of multimodal activity. As such, transitions can serve as a visual, operational and environmental cue of the following upcoming changes in:

- Functional emphasis from auto to pedestrian oriented;
- Thoroughfare type, particularly where functional classification and speed changes;
- Width of roadway, either a narrowing/widening of lanes or decrease/increase in number of lanes (see section on Geometric Transition Design later in this chapter); and
- Neighborhood or district, such as a transition between a commercial and residential district.

Principles for designing effective transitions include

- Using the established guidance—*Manual on Uniform Traffic Control Devices* (MUTCD), AASHTO Green Book—to properly design, mark and sign geometric transitions; and
- Designing transitions on a tangent section of roadway, avoiding areas with horizontal and vertical sight distance constraints. It is best if the entire transition length is visible to the driver.

If the purpose of the transition is to signal a change in context, neighborhood or district and/or change in speed zone, the transition principles include:

1. Providing a transition speed zone. The purpose of a transition speed zone is to avoid large reductions in the speed limit by providing two or more speed limit reductions. At a minimum, speed-reduction zones use regulatory speed limit signs. Speed limit reductions should occur on tangent sections distant from intersections. Changes in speed zones can utilize other traffic control devices such as warning signs, beacons and so forth as appropriate or can utilize appropriate traffic calming devices such as speed platforms or rumble strips where the zone is particularly short.
2. Providing visual cues to changes in context or environment. The intent of this principle is to combine regulatory speed change with traveled way or streetside features that influence driver speed. Visual cues can include streetside urban design features (landscaping, curbs, on-street parking, street light standards with banners, entry signs, thematic street furniture and so forth) and alternative pavement texture/material at intersections and crosswalks. Land uses and building style can provide visual cues as well. Progressively introducing taller buildings closer to the street affects driver perception of the change from rural or suburban to urban character. Vertical elements, such as street trees in which the vertical height is equal to or greater than the street width, may influence driver perception of the environment and indicate a change. Visual cues should culminate in a gateway at the boundary of the change in district, neighborhood, or thoroughfare. Gate-

ways (**Figure 9.3**) can be achieved with urban design features or unique intersections such as modern roundabouts.

3. Changing the overall curb to curb width of the street as appropriate for the context, thoroughfare type and traffic characteristics. This can apply to transitions where streets narrow from four to two lanes or widen from two to four lanes. Means of reducing overall street and traveled way pavement width include reducing the number of lanes, reducing lane widths, dropping through lanes as turning lanes at intersections, providing on-street parking or bicycle lanes, applying curb extensions at intersections and midblock crossings and providing a raised curbed median.

## Design Guidance

Design guidance for the traveled way elements of the thoroughfare are provided in the following sections.

## Lane Width

### Background and Purpose

Street width is necessary to support desirable design elements in appropriate contexts, such as to provide adequate space for safe lateral positioning of vehicles, on-street parking, landscaped medians and bicycle lanes. Wide streets (greater than 60 feet), however, create



**Figure 9.3** An arterial gateway into a downtown area composed of a raised intersection, public art, building orientation and attractive materials. Source: Kimley-Horn and Associates, Inc.

barriers for pedestrians and encourage higher vehicular speeds. Wide streets can reduce the level of pedestrian interchange that supports economic and community activity. Wide streets discourage crossings for transit connections. The overall width of the street affects the building height to width ratio, a vertical spatial definition that is an important visual design component of urban thoroughfares. Lane width is only one component of the overall width of the street but is often cited as the design element that most adversely affects pedestrian crossings. In fact, many factors affect pedestrian crossing safety and exposure, including the number of lanes, presence of pedestrian refuges, curb extensions, walking speed and conflicting traffic movements at intersections.

## General Principles and Considerations

General principles and considerations in the selection of lane widths include the following considerations.

- Determine the overall width of the street and the traveled way on the accumulated width of the desired design elements (e.g., parking, bicycle lanes, travel lanes and median). Prioritize design elements that constitute an ideal cross-section and eliminate lower-priority elements when designing in constrained rights of way. Reducing lane width is one means of fitting the design into the available right of way.
- Curb lane widths should be measured to the face of curb unless the gutter and catch basin

### Related Thoroughfare Design Elements

- Cross-section determination
- On street parking and configuration
- Access and speed management
- Bicycle lanes
- Bus stops
- Intersection layout
- Geometric transition
- Transit design

inlets do not accommodate bicycles and motor vehicles. However, to preserve available width for best use, inlets should be designed to safely accommodate bicycle and motor vehicle travel.

- Many fire districts require a minimum 20-foot-clear traveled way. This is usually not difficult to achieve on urban thoroughfares but could present challenges on thoroughfares that have one travel lane in each direction, on street parking and raised medians (the configuration of some four- to three-lane street conversions). In these circumstances consider adding bicycle lanes, mountable curbs on medians, median breaks, or flush cobblestone medians with periodic raised medians for plantings.
- Where adjacent lanes are unequal in width, the outside lane should be the wider lane to accommodate large vehicles and bicyclists (only where bicycle lanes are not practical), and facilitate the turning radius of large vehicles.
- While it may be advantageous to use minimum dimensions under certain circumstances, avoid combining minimum dimensions on adjacent elements to reduce street width where it could affect the safety of users. For example, avoid combining minimum-width travel lanes adjacent to a minimum-width parking/bicycle lane—a situation that reduces the separation between vehicles and bicyclists.
- When wider curb lanes are required, consider balancing the total width of the traveled way by narrowing turn lanes or medians to maintain the same overall pedestrian crossing width.
- Consider wider lanes along horizontal curves to accommodate vehicle off-tracking, based on a selected design vehicle. This measure is an alternative to increasing the curve's radius to accommodate off-tracking. The AASHTO Green Book provides guidance on widening for vehicle off-tracking.
- If a network evaluation determines that sufficient capacity exists to accommodate corridor- or areawide traffic demands, consider reducing the number of travel lanes to accommodate the desired design elements in constrained right of way. On streets with very

high turning movements, replacing through lanes (where turns are occurring from the inside through lane) with a turning lane can significantly improve traffic capacity.

- Where there is insufficient network travel lane capacity and right of way to meet thoroughfare design objectives, consider converting two parallel streets into a pair of one-way streets (couplet) to increase capacity before considering widening thoroughfares. While sometimes the subject of debate and controversy, one-way couplets have appropriate applications under the right circumstances. Strive to keep the number of lanes in each direction to three or less. This measure requires a comprehensive study of the ramifications for pedestrian and bicycle safety, transit and vehicle operations, economic issues and so forth. See the ITE *Traffic Engineering Handbook* for more on comparative advantages of one-way and two-way streets.

## Recommended Practice

Select lane widths based on the following four key considerations:

- Target speed—on the lower-speed urban thoroughfares addressed in this report (target speeds of 35 mph or less), a range of lane widths from 10 to 12 feet on arterials and 10 to 11 feet on collectors is appropriate. On arterials with target speeds below 30 mph, widths in the lower end of the range are appropriate (10 to 11 feet). On collectors with a target speed below 30 mph, a 10-foot lane width may be appropriate unless the following design considerations or other factors warrant a wider lane. Turn lanes that are 10- to 11-foot wide are appropriate in urban areas with target speeds of 35 mph or less.
- Design vehicle—vehicles such as transit buses or large tractor-trailers require wider lanes, particularly in combination with higher design speeds if they frequently use the thoroughfare. Modern buses can be 10.5 feet wide from mirror to mirror and require a minimum 11-foot-wide lane on roadways with 30 to 35 mph target speeds. Wider curb lanes, between 13 to 15 feet

for short distances, should only be used to help buses negotiate bus stops and help trucks and buses negotiate right turns without encroaching into adjacent or opposing travel lanes.

- Right of way—balance the provision of the design elements of the thoroughfare with the available right of way. This balance can mean reducing the width of all elements or eliminating lower-priority elements.
- Width of adjacent bicycle and parking lanes—the width of adjacent bicycle and parking lanes influences the selection of lane width. If the adjacent bicycle or parking lane is narrower than recommended in this report, first consider widening the bicycle lane. If a design vehicle or target speed justifies such, provide a wider travel lane to provide better separation between lanes (**Figure 9.4**).

AASHTO highlights benefits of narrower (10 to 11 feet) travel lanes on lower-speed urban streets, including a reduction in pedestrian crossing distance, ability to provide more lanes in constrained rights of way and lower construction cost. The recommended travel lane widths in this report are also consistent with design guidelines in AASHTO's *Guide for Development of Bicycle Facilities* (1999) and the recommendations in *A Guide for Achieving Flexibility in Highway Design* (2004b).

Research on the relationship between lane width and traffic crashes found no statistically significant relationship between lane width and crash rate on arterial streets (TRB 1986).



**Figure 9.4** Bike lanes on the Embarcadero in San Francisco. This multimodal boulevard along the waterfront was formerly an elevated freeway. Source: Dan Burden, walklive.org.

## Medians

### Background and Purpose

Medians are the center portion of a street that separates opposing directions of travel. Medians vary in width and purpose and can be raised with curbs or painted and flush with the pavement. Medians on low-speed urban thoroughfares are used for access management, accommodation of turning traffic, safety, pedestrian refuge, landscaping and lighting and utilities. Based on these functions, this guidance addresses raised curbed medians with a discussion of alternate applications such as flush medians interspersed with landscaped median islands.

In addition to their operational and safety functions, well-designed and landscaped medians can serve as a focal point of the street or an identifiable gateway into a community, neighborhood, or district. Medians can be used to create tree canopies over travel lanes, offer attractive landscaping and provide space for lighting and urban design features. Wider medians can provide pedestrian refuge at long intersection crossings and midblock crossings. Medians vary in width depending on available right of way and function. Because medians increase the width of a street, the designer must weigh the benefits of a median against the increase in pedestrian crossing distance and possible decrease in available streetside widths.

Operational and safety benefits of medians include storage for turning vehicles, enforcing turn restrictions, reducing conflicts, pedestrian refuge, snow storage, reducing certain types of crashes such as head-on colli-

#### Related Thoroughfare Design Elements

- Cross-section determination
- Access management
- Pedestrian refuge islands
- Intersection layout
- Lane width
- Transit design
- Midblock crossings

sions and space for vehicles crossing the thoroughfare at unsignalized intersections. With some innovation in design, curbed medians can provide biofiltration swales to retain and improve the quality of stormwater runoff.

Flexibility in median width design revolves around the median's function, appurtenances and landscaping to be accommodated in the median and available right of way. The designer needs to consider the trade-offs between the provision of a median and other design elements, particularly in constrained rights of way.

## General Principles and Considerations

General principles and design considerations regarding medians include the following:

- Where medians are provided at intersections as refuge, they should be wide enough to accommodate groups of pedestrians, wheelchair users, bicyclists and people pushing strollers. To keep streets compact and pedestrian-scaled, median width typically should not exceed 18 feet in walkable urban environments except on ceremonial view corridors and parkways or where dual left turns are provided.
- On boulevards and wide avenues (more than 60 feet) where median dimensions need to remain continuous and left turn lanes are provided, medians should be 16–18 feet, to allow for a turn lane plus pedestrian refuge.
- Apply medians as part of a corridor access management strategy to improve safety and multimodal operational efficiency. Evaluate impacts on land access and ensure adequate locations for U-turns.

Median width may vary to accommodate a pedestrian refuge and/or turn lane. For example, designers may remove on-street parking near intersections in order to laterally shift the travel lanes to accommodate a median with a turn pocket. Where right of way is available, a continuous dimension for the median is preferred.

- Use an appropriate design vehicle for left- and U-turns when designing median width (see **Chapter 7**).
- Avoid providing overly wide medians at the expense of unreasonably narrowing the streetside. In walkable urban contexts, streetsides of appropriate width

should take higher priority than wide medians. However, the design needs to balance the safety, operational and pedestrian comfort needs of the street.

- In contrast to medians in rural areas, the width of medians at intersections in urban areas should only be as wide as necessary to provide the desired function (accommodation of longitudinal left turns, pedestrian refuge and so forth). Otherwise, the intersection loses operation efficiency and vehicles crossing the median may use the width inappropriately (side-by-side queuing, angled stopping and so forth).
- On multilane thoroughfares, medians aid pedestrians in their crossing. A median of 6 to 8 feet can be more desirable to a crossing pedestrian than the same width added to another element of the thoroughfare.
- If the median will not be landscaped, consider using alternative contrasting materials to create visual interest and an aesthetic appearance.
- Raised medians in low-speed urban contexts should be constructed with vertical curbs to provide refuge for pedestrians, access management and a place to install signs, utilities and landscaping. In snow conditions, raised medians improve delineation of the median. If emergency access is a concern, mountable curbs should be considered in special locations (where medians are carried across intersections, access managed thoroughfares near fire stations, or within 200 to 300 feet of an intersection approach that frequently experiences long queues). Mountable medians can be super-reinforced with grass-concrete pavers or concrete with added rebar.
- Narrow medians (4 feet or less) should only be used to restrict turning movements, to separate opposing directions of traffic and to provide space for traffic control devices (**Figure 9.5**). A 4-foot median may also be landscaped with shrubs.

In constrained rights of way, consider narrower medians with attractive hardscape and urban design features in lieu of planting, or provide a discontinuous median as right of way permits.

Where flush medians are desirable to maintain access to fronting property (e.g., suburban commercial

corridors), consider using textured or colored paving or stamped concrete for the median lane interspersed with raised landscaped islands to channelize turning traffic, divide opposing lanes of traffic and provide pedestrian refuge where appropriate (such as midblock and intersection crossings).

Landscaping on medians should be designed in a manner that does not obstruct sight-distance triangles.

## Recommended Practice

**Table 9.1** presents the recommended practice for median widths for various functions within low-speed thoroughfares (35 mph or less). The recommendations assume arterial and collector streets in urban contexts (C-3 to C-6) with operating speeds of 35 mph or less. Most of the guidance in this report is not applicable to flush or depressed medians or to raised medians with mountable curbs. Note that median widths are measured from face of curb to face of curb.

## Additional Guidelines

Additional guidelines regarding medians also include the following:

- At lower urban speeds (25 to 30 mph) there is no need to provide an offset between the median curb face and the travel lane;



**Figure 9.5** Narrow medians, such as on this boulevard in Chicago, should only be used to restrict turning movements, separate opposing traffic and create space for traffic control devices. Source: The Congress for the New Urbanism.

- Pave inside travel lane up to the face of the median curb unless a gutter pan is required for drainage; use 6-inch to 1-foot gutter pans unless typical flow requires more; avoid placement of catch basins in median gutters;
- Design the median nose using state, local, or AASHTO guidelines, ensuring proper end treatments to guide vehicles away from the median and pedestrian refuges;
- Design median turn lanes, tapers and transitions using state, local, or AASHTO guidelines for intersection design; and
- At intersection crossings, where the median is wide enough (see **Table 9.1**), extend the median nose beyond the crosswalk to provide an enclosed pedestrian refuge (**Figure 9.6**).

## Trees and Landscaping in Medians

In urban areas, the community may find it desirable to plant trees in raised curbed medians for aesthetic purposes. In general, the guidance in this report is consistent with AASHTO in regards to low-speed urban thoroughfares. Additional information and mitigative strategies on trees within the public right of way may be found in *A Guide for Addressing Collisions with Trees in Hazardous Locations* (TRB 2003). General guidelines for median trees include the following:



**Figure 9.6** Median nose extended beyond the crosswalk to provide an enclosed pedestrian refuge. Source: Kimley-Horn and Associates, Inc.

**Table 9.1 Recommended Median Widths on Low Speed Walkable Thoroughfares (35 mph or less)**

Thoroughfare Type	Minimum Width	Recommended Width
Median for access control		
All thoroughfare types	4 feet	6 feet <sup>1</sup>
Median for pedestrian refuge		
All thoroughfare types	6 feet	8 feet
Median for street trees and lighting		
All thoroughfare types	6 feet <sup>2</sup>	10 feet <sup>3</sup>
Median for single left-turn lane		
Collector avenues and streets	10 feet <sup>4</sup>	14 feet
Arterial boulevards and avenues	12 feet	16–18 feet
Median for dual left-turn lane		
Arterial boulevards and avenues	20 feet	22 feet
Median for transitway		
Dedicated rail or transit lanes	22 feet	22–24 feet
Added median width for platforms	10 feet for each side platform 30 feet for center platform	

<sup>1</sup> A 6-foot-wide median is the minimum width for providing a pedestrian refuge.

<sup>2</sup> Six feet (measured between curb faces) is generally considered a minimum width for proper growth of small trees less than 4 inches in diameter at maturity. A 10-foot median is recommended for larger trees.

<sup>3</sup> Wider medians to provide generous landscaping are acceptable, if desired by the community. However, avoid designing medians wider than necessary to support its desired function at intersections. This can reduce the operational efficiency of the intersections and invite undesirable behavior of crossing traffic such as side-by-side queues, angled stopping and so forth.

<sup>4</sup> A 10-foot wide median allows for a striped left-turn lane (9 to 10 feet wide) without a median nose.

- Small-caliper trees can be healthy in medians that are at least 6 feet wide, as long as a critical root area is provided. A 10-foot-wide median is recommended for larger trees. Consult an urban forester for guidance on health requirements for trees in medians. Consider the safety issues of large-caliper trees.
- Maintain a horizontal offset (minimum of 18 inches) between the trunk and median curb face and prune to maintain sight distance (**Figure 9.7**).
- Trees closer than 50 feet from the ends of medians must be regularly pruned to maintain sight distance. Trees should always be located and maintained so that the motorists' clear vision of any traffic control signs or signals will be assured at all times, retaining a vertical clearance between 2.5 feet (or 3 feet from pavement surface) and 8 feet from the top of the curb.



**Figure 9.7** Maintain a minimum 18-inch offset between the face of median tree (at maturity) and the face of curb. Source: Dan Burden, walklive.org.

### Example Landscape Setbacks from Utilities

Overhead electric—10, 15, or 20 feet, depending on tree height

Sanitary sewer main—15 feet all tree species

Water main—10, 15, or 20 feet, depending on tree size

Fire hydrant—5 feet all landscaping, 10 feet all trees

Water meter—5 feet all landscaping, 10 feet all trees

Gas lines—5, 10, or 15 feet, depending on tree size

Underground electric—5, 10, or 15 feet, depending on tree size

Street lights—10 feet all trees

Electric transformers—10 feet front access, 5 feet other sides—all landscaping

Switch cabinet—10 feet front and back access, 5 feet other sides.

Source: Gainesville, FL, *Regional Utilities Vegetation Management Tree Planting Guidelines*

- Should the community desire a continuous canopy of trees in the median, space trees between 15 and 30 feet on center, depending upon species.
- Branches that extend beyond the curb into the travel lane should be pruned to a minimum height of 13 feet above the pavement.
- Plan tree spacing and canopy height along with other elements such as light standard spacing and height, utility placement and height and traffic control devices to minimize interference and provide adequate lighting and sight lines when trees are mature. Contact local utility providers to ensure compliance with required setbacks (see sidebar for an example of setback requirements).
- When hardscape is used between median trees, structural cells (modular, preengineered cell systems designed for water management, soil and tree roots), supported reinforced panels, or other methods should be used to promote healthy roots under the hardscape.

- To maintain healthy median landscaping, an adequate watering and drainage system needs to be provided. Drought-tolerant plantings should be used when an irrigation system is not available. Provide underdraining when needed for soil conditions.

Landscaping and trees in medians are strongly encouraged in context sensitive design, not only for aesthetics but also for shade, heat island reduction and storm-water interception. The use of medians for pedestrian refuge is recommended to reduce the pedestrian barriers created by wide urban arterials and to support safe design of midblock crossings. As refuges, medians allow pedestrians to focus on crossing one direction of the street at a time, therefore reducing conflicts and decisions. At intersections, pedestrian refuges assist all pedestrians, especially the elderly, to safely cross streets (**Figure 9.8**).

Some agencies require the use of crash tested barriers when large trees are planted in narrow medians. Consult with the agency on aesthetic treatment of such barriers.

### Justification

The same rationale for medians on rural highways and conventional urban streets can be applied to context-based design of urban thoroughfares—to provide traffic safety and operational benefits by separating traffic flows, reducing conflicts and creating



**Figure 9.8** This boulevard median serves as a pedestrian refuge, a community gateway and area for landscaping. Source: Kimley-Horn and Associates, Inc.

space for turning vehicles and utilities in the center of the street. In the design of walkable urban streets, the use of medians for traffic safety and operations remains a primary objective but is expanded to emphasize the median's role as an aesthetic amenity to the street and community and to provide pedestrian refuge on wider street crossings.

## Bicycle Lanes

### Background and Purpose

Bicycle travel should be served on multimodal streets. Bicyclists vary in their level of skill and confidence, trip purpose and preference for facility types; thus, the mobility needs of bicyclists in urban contexts vary as well. Bicycle facilities should encompass a system of interconnected routes, paths and on-street bicycle lanes that provide for safe and efficient bicycle travel. This report focuses only on the provision of bicycle lanes on major thoroughfares— streets that are designated as arterials or collectors. Refer to AASHTO's *Guide for the Development of Bicycle Facilities* for planning and design guidance for other types of bicycle facilities.

Not all urban thoroughfares will include bicycle lanes. However, except for freeways and streets where bicycling is specifically prohibited, bicyclists are permitted to use any street for travel, even if bicycle lanes are not provided. The design of bicycle lanes on major urban thoroughfares is typically



**Figure 9.9** A bike lane adjacent to parallel parking on an avenue. Source: Kimley-Horn and Associates, Inc.

coordinated with a community's or region's master bicycle plan to ensure overall connectivity and the selection of the best streets for implementation of bicycle lanes. However, absence of a designation in a bicycle plan does not exclude the practitioner from providing bicycle lanes if the need exists. The width of the street and the speed and volume of adjacent traffic are the most critical factors in providing safe bicycle lanes. If adequate facilities cannot be provided, then the safety of both the bicyclist and driver is compromised. In urban areas the practitioner is faced with two conditions in designing bicycle lanes: adjacent to curb or adjacent to on-street parking (**Figure 9.9**). This section addresses these conditions.

#### Related Thoroughfare Design Elements

- Cross-section determination
- Lane width
- Bicycle lane treatment at intersections
- On-street parking and configuration
- Transit design
- Modern roundabouts
- Curb extensions

### General Principles and Considerations

Implementation of bicycle lanes can meet many community objectives, including accessibility, connectivity between destinations, youth mobility and increased system capacity. General principles and considerations regarding bicycle lanes include the following:

- Bicycle lanes are not required on every street. It is desirable to provide bicycle lanes on major thoroughfares with target speeds of 30 mph or more and on streets with high traffic volumes and speeds less than 30 mph.

- Availability of parallel bicycle facilities does not eliminate the need to have a bicycle lane on thoroughfares. Bicyclists need to access properties along corridors, and they often benefit from traffic signals and other controls found on urban thoroughfares.
- The decision to place bicycle lanes on major urban thoroughfares should be based upon a number of factors, including:
  - Interconnectivity between other bicycle facilities and direct connections between origins and destinations, including transit access points; and
  - Ability to provide a continuous facility and overcome barriers such as topography, rivers, railroads, freeways and so forth.
- As published in *Selecting Roadway Design Treatments to Accommodate Bicyclists* (FHWA, 1994), a “design bicyclist” refers to the skill level of the bicyclist and, along with the factors described above, affects decisions on implementation of bicycle lanes. The three types of bicyclists, each of which has different needs, are (1) advanced or experienced bicyclists (require facilities for directness and speed and are comfortable riding in traffic and shared lanes), (2) basic or casual bicyclists (require comfortable and direct routes on lower-speed and lower-volume thoroughfares and prefer separated and delineated bicycle facilities), and (3) children (require adult supervision and typically only travel on separated paths or very low-volume and low-speed residential streets).
- Walkable urban thoroughfares should at least meet the needs of type 2, the basic or casual bicyclists.
- When considering additional operating space in urban areas, it is a constant challenge to balance competing needs on multimodal thoroughfares. Nowhere is this more evident than in providing bicycle facilities. As stated in the Chapter 9 section on lane width, avoid combining minimum dimensions to implement all of the desirable design elements, particularly on designated bicycle routes.
- It is often more prudent to provide the recommended or maximum dimensions for bicycle

facilities, curb lanes and parking lanes and to eliminate other design elements to maximize bicyclist safety. For example it may be desirable to convert a four-lane undivided street to a three-lane street with left-turn lanes to provide bicycle lanes rather than narrowing all of the other design elements to retain four lanes.

- Designated bicycle facilities adjacent to head-in angled parking are discouraged because of the lack of visibility between bicyclists and drivers backing out of spaces. Converting from angled to parallel parking provides width for bicycle lanes.
- Where possible on one-way streets, angled parking can be implemented on the left side of the street while the bicycle lane remains adjacent to parallel parking on the right side of the street. Some communities use reverse (back-in) angled parking, which improves driver visibility of bicyclists (**Figure 9.10**).
- Bicycle travel on sidewalks should be discouraged, even if the sidewalk width meets the width requirements of a shared multi-use path. Bicycles on sidewalks travel at higher speeds than pedestrians, creating the potential for serious injury. Bicyclists might collide with obstacles on sidewalks including street furniture, sign posts and so forth. Additionally, drivers do not expect bicyclists on sidewalks, creating conflicts at intersections and driveways. Con-



**Figure 9.10** Reverse (back-in) angled parking improves driver visibility of bicyclists. Source: Dan Burden, walklive.org.

**Table 9.2 Recommended Practice for Bicycle Lanes on Walkable Urban Thoroughfares**

	Minimum Width	Recommended Width
Bicycle lane width—combined with on-street parking lane		
All thoroughfare types	13 feet	13 feet
Bicycle lane width—no on-street parking		
All thoroughfare types	5 feet <sup>1</sup>	6 feet

Table notes:

<sup>1</sup> Requires a minimum 3-foot rideable surface outside of gutter pan. If no gutter pan is present, the minimum width is 5 feet. Bicycle routes without marked lanes are acceptable for low-volume thoroughfares with target speeds of 25 mph or less.

venient alternatives will limit the attractiveness of sidewalk riding. While on-street facilities designed to the guidelines above are preferred, alternative routes on parallel streets or a separated off-street multi-use path may be a better choice in some situations.

The design of bicycle lanes in urban areas is well documented. Refer to the *Manual on Uniform Traffic Control Devices* (FHWA 2009) and *Guide for the Development of Bicycle Facilities* (AASHTO 1999). For alternative ways to accommodate bicyclists refer to *Innovative Bicycle Treatments* (ITE 2002).

## Recommended Practice

**Table 9.2** presents the recommended practice for bicycle facilities on thoroughfares. The recommendations assume arterial and collector streets in urban contexts with target speeds of 35 mph or less.

## Justification

Urban thoroughfares within the bicycle network should provide bicycle lanes, particularly where the width of shared lanes is prohibitive or undesirable. The type and experience level of bicycle riders and the volume of bicyclists is a consideration in determin-

ing the need for bicycle lanes. Where bicycle lanes are needed and right of way is constrained, the designer needs to understand the trade-offs between adding bicycle lanes and eliminating or reducing the width of other thoroughfare design elements.

## On-Street Parking Configuration and Width

### Background and Purpose

The presence and availability of on-street parking serves several critical needs on urban thoroughfares: to meet parking needs of adjacent uses, protect pedestrians from moving traffic and increase activity on the street. Usually, on-street parking cannot by itself meet all of the parking demand created by adjacent land uses and typically will supplement the off-street parking supply. On-street parking provides the following benefits:

- Supports local economic activity of merchants by providing proximate access to local uses, as well as visitor needs in residential areas;
- Increases pedestrian comfort by providing a buffer between pedestrians and moving traffic helping reduce vehicle splash, noise and fumes;
- Slows traffic, making pedestrian crossing safer;

- Enables drivers and their passengers to become pedestrians conveniently and safely;
  - Provides an indication to the motorist that desired operating speeds are reduced and that they are entering a low or moderate travel speed area;
  - Provides the shortest accessible route to a street fronting building entrance for pedestrians who have disabilities;
  - Increases pedestrian activity on the street since people will walk between their parking space and destination, providing more exposure to ground floor retail and increasing opportunities for social interactions;
  - Supports local economic activity by increasing the visibility of storefronts and signs to motorists parking on street;
  - Reduces development costs for small business by decreasing on-site parking needs, particularly in urban infill development on small lots;
  - Requires less land per space than off-street parking and is thereby an efficient and cost-effective way to provide parking; and
  - Provides space for on-street loading and unloading of trucks, increasing the economic activity of the street and supporting commercial retail uses.
- A reduction in traffic capacity and increased friction in the flow of traffic;
  - Conflicts with the provision of bicycle lanes and increased hazards to bicyclists;
  - Use of thoroughfare width that could be used for other functions (e.g., wider streetsides);
  - Visual obstructions for pedestrians crossing intersections, vehicles moving along the thoroughfare and vehicles exiting driveways;
  - The need for, and administration of, parking enforcement; and
  - An increase in crashes.

On-street parking can result in a 3 to 30 percent decrease in the capacity of the adjacent travel lane, depending on the number of lanes and frequency of parking maneuvers. The designer needs to balance traffic capacity and local access needs when deciding where and when to permit on-street parking. There are methods for minimizing the impact of parking maneuvers on traffic flow. For example, see MUTCD (Figure 3B–17, referenced in Section 3B.18) showing a parallel parking configuration that allows vehicles to drive forward into the parking space.

## General Principles and Considerations

General principles and considerations regarding on-street parking include the following:

- On-street parking should be located based on the characteristics of the thoroughfare type, needs of the adjacent land uses and applicable local policies and plans for parking management.
- On-street parking should be primarily parallel parking on higher-volume urban arterial boulevards and avenues. Angled parking may be used on low-speed and low-volume collector avenues and streets with ground floor commercial uses, primarily those serving as main streets (see **Figure 9.11** and the Chapter 6 section on special thoroughfare types).
- On-street parking should be prohibited on streets with speeds greater than 35 mph due

### Related Thoroughfare Design Elements

- Lane width
- Curb extensions
- Bicycle lanes
- Cross-section determination

### Trade-Offs

While this report supports on-street parking as an inherent element of walkable, compact, mixed-use urban areas and a component of the economic health of urban businesses, the practitioner designing walkable streets should always consider the trade-offs of integrating on-street parking. These include:

to potential hazards associated with maneuvering in and out of spaces.

- Width of the parking space is dependent on the context zone, thoroughfare type and the anticipated frequency of parking turnover.
- Conform to local and PROWAG accessibility requirements and provide appropriate number of accessible spaces.
- Use metered parking, or a similarly appropriate technology, to enforce parking time limits that provide reasonable short-term parking for retail customers and visitors while discouraging long-term parking.
- In developing and redeveloping areas, provide the amount of on-street parking for planned, rather than existing, land use densities. If more parking is needed, consider public or shared parking structures or integrate the design of parking facilities with adjacent land uses.

## Recommended Practice

The preferred width of a parallel on-street parking lane is 8 feet wide on commercial thoroughfares (all types) or where there is an anticipated high turnover of parking and 7 feet wide on residential thoroughfares. These dimensions are inclusive of the gutter pan and applicable to all context zones (C-3 through C-6).



**Figure 9.11** Angled parking on a retail-oriented main street in Hayward, CA. Source: Kimley-Horn and Associates, Inc.

On low-volume, low-speed avenues and streets in commercial main street areas, where sufficient curb-to-curb width is available, angled parking may be appropriate. Angled parking should have the dimensions shown in **Table 9.3** for a variety of different angles. Head-in angled parking can create sight distance problems associated with vehicles backing out of parking spaces. The use of reverse (back-in) angled parking can be used to overcome sight distance concerns and is considered safer for bicyclists traveling adjacent to angled parking (**Figure 9.12**).

**Table 9.3 Minimum Dimensions for Head-In Angled On-Street Parking\***

Angle	Stall Width	Stall Depth (Perpendicular to Curb)	Min. Width of Adjacent Lane	Curb Overhang
45°	8.5–9.0 feet	17 feet 8 inches	12 feet 8 inches	1 foot 9 inches
50°	8.5–9.0 feet	18 feet 3 inches	13 feet 3 inches	1 foot 11 inches
55°	8.5–9.0 feet	18 feet 8 inches	13 feet 8 inches	2 feet 1 inches
60°	8.5–9.0 feet	19 feet 0 inches	14 feet 6 inches	2 feet 2 inches
65°	8.5–9.0 feet	19 feet 2 inches	15 feet 5 inches	2 feet 3 inches
70°	8.5–9.0 feet	19 feet 3 inches	16 feet 6 inches	2 feet 4 inches
90°	8.5–9.0 feet	18 feet 0 inches	24 feet 0 inches	2 feet 6 inches

Source: *Dimensions of Parking*, 4th Edition, Urban Land Institute

Notes:

Typical design vehicle dimensions: 6 feet 7 inches by 17 feet 0 inches. Use 9.0 feet wide stall in commercial areas with moderate to high parking turnover.

\*For back-in angled parking, reduce curb overhang by one foot.



**Figure 9.12** Reverse (back-in) angled parking improves driver visibility. Source: Dan Burden, walklive.org.

## Additional Guidelines

Additional guidelines regarding on-street parking include the following:

- Where traffic capacity needs to be balanced with on-street parking, consider using the curb lane for parking during off-peak periods and for traffic during peak periods. It is important to consider the trade-offs of this strategy. It requires consistent daily enforcement and immediate towing of violators. Removal of parking will impact the walkability of the streetside by removing the parking buffer. This strategy should be used when traffic congestion causes significant impacts to adjacent residential neighborhoods or in conditions with poorly connected networks and limited alternative routes.
- Angled parking should be allowed in C-4 and C-5 context zones where operating speeds are 25 mph or less and where the community finds the delay produced by parking maneuvers acceptable. Where practical or on bicycle routes, back-in diagonal parking is preferable to front-in parking. Consider the trade-offs associated with different angles of parking; lower-angle parking results in fewer parking spaces, while higher-angle parking requires a wider adjacent travel lane to keep vehicles exiting parking spaces from backing into the opposing travel lane.
- For parallel parking provide a minimum 1.5-foot wide operational offset between the face of curb and edge of potential obstructions

such as trees and poles. This will allow the unobstructed opening of car doors.

- Parking should be prohibited within 10 feet of either side of fire hydrants (or per local code), at least 20 feet from nearside of midblock crosswalks (those without curb extensions) and at least 20 feet from the curb return of intersections (30 feet from an approach to a signalized intersection) unless curb extensions are provided (see Chapter 10).
- At bus stops, intersections and various mid-block locations, extend curbs by 6 feet into the parking lane to improve pedestrian visibility and to provide additional space for street furniture and landscaping (see Chapter 10 section on curb extensions).
- Reverse (back-in) angled parking requires a wider edge zone in the streetside due to the longer overhang at the rear of most vehicles. This extra width can be compensated by the narrower travel lane needed adjacent to parking for maneuvering and less depth for the parking stall since the longer overhang is over the curb.

## Justification

The recommendations in this report are based on the principles presented in the AASHTO Green Book and pedestrian facilities guide. The Green Book states that the “designer should consider on-street parking so that the proposed street or highway improvement will be compatible with the land use ... the type of on-street parking should depend on the specific function and width of the street, the adjacent land use, traffic volume, as well as existing and anticipated traffic operations.”

## Geometric Transition Design

### Background and Purpose

Transitions refer to a change in the width or speed of a thoroughfare or the need to laterally shift vehicles. In terms of geometric design, transitions refer to the provision of an adequate taper where lanes shift or narrow, shoulders widen, lanes diverge or merge and where deceleration lanes are provided. Geometric transitions are usually required when there is a change in the thoroughfare type and associated change in width, particularly

where functional classification and speed changes and where a change in the width of roadway, either a narrowing or widening of lanes, or a decrease or increase in number of lanes is introduced. Refer to the section transition principles earlier in this chapter for guidance on nongeometric transitions.

## Recommended Practice

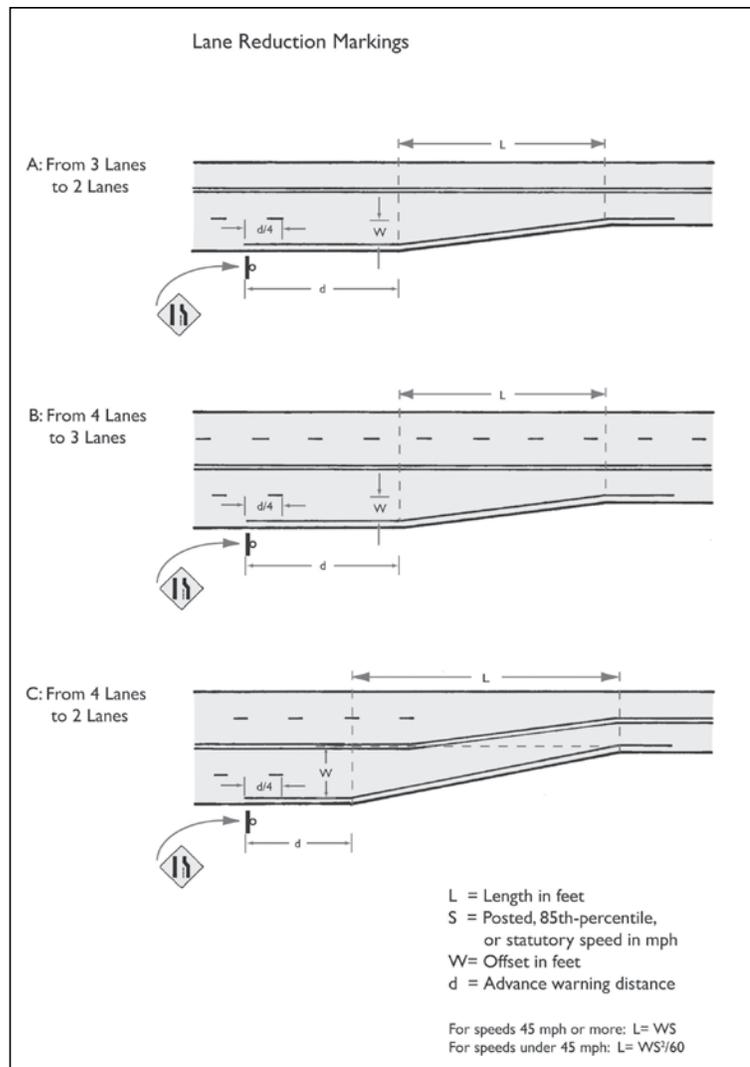
For changes in roadway width and space designing a geometric transition such as a lateral shift, lane addition or drop, lane or shoulder narrowing and so forth, use the established guidance in the MUTCD, where the length of the transition taper is computed by the following equation:

- $L = WS^2/60$  (for speeds less than 45 mph)

where L equals the length of the transition taper (feet), W equals the width of the lateral shift or offset (feet) and S equals the 85th percentile operating speed in mph or posted speed in mph (whichever is higher) or the target speed in new construction projects (Figure 9.13).

## Additional Guidelines

- Transitions should be accompanied by appropriate warning signs (refer to MUTCD).
- Transitions should occur on a tangent section of roadway, avoiding areas with horizontal and vertical sight distance constraints.
- Ensure the entire transition length is visible to the driver.
- The transition design described above is unnecessary when roadways widen or lanes are added. In these cases, a transition taper of 10 to 1 is sufficient. Speed-change lanes at intersections (transitions to left- or right-turn lanes) usually require a shorter taper and deceleration distance. AASHTO recommends 100 feet for single-turn lanes and 150 feet for dual-turn lanes.



**Figure 9.13** Typical transition design and markings. Source: Community, Design + Architecture, adapted from the *Manual on Uniform Traffic Control Devices* (FHWA).

## Four-Lane to Three-Lane Conversions (Road Diets)

A road diet is the conversion of a wide street to a narrower one, such as the conversion of a four-lane undivided thoroughfare into a three-lane street composed of two travel lanes and a two-way left-turn lane. This conversion provides additional space to accommodate other desirable features such as bike lanes, wider street-sides, pedestrian refuge, landscaping, or on-street parking. Case studies demonstrate that road diets reduce conflicts at intersections, reduce accidents and have minimal effects on traffic capacity and diversion on thoroughfares under 20,000 vehicles per day.

Three-lane roadways can improve emergency response by allowing emergency vehicles to bypass congestion by using the two-way left-turn lane. They create opportunities for pedestrian refuges at midblock and intersection crossings and eliminate the common “multiple threat” hazards pedestrians experience crossing four-lane roads. Other benefits include easier egress from driveways (improved sight distance), smaller curb return radius by increasing the effective radius of the road, improvements for transit (allows curbside stops outside of travel lane) and buffers street tree branches from closely passing trucks. Road diets can improve the flow of traffic and reduce travel speeds, particularly when used in conjunction with roundabouts (see Chapter 10 section on modern roundabouts). **Figure 9.14** shows a street before and after a road diet.

Converting four-lane roads to three lanes and adding a raised median and on-street parking may result in the thoroughfare failing to meet local fire districts minimum clear travelway requirements. See discussion on emergency vehicle operations earlier in this chapter.

For more detailed information, design guidance and case studies, refer to *Road Diet Handbook: Setting Trends for Livable Streets*, Second Edition (Parsons Brinkerhoff, Rosales, 2007).

## Midblock Crossings

### Background and Purpose

Midblock crossings provide convenient locations for pedestrians to cross urban thoroughfares in areas with infrequent intersection crossings or where the nearest intersection crossing creates substantial out-of-direction travel. When the spacing of intersection crossings is far apart or when the pedestrian destination is directly across the street, pedestrians will cross where necessary to get to their destination directly and conveniently, exposing themselves to traffic where drivers might not expect them. Midblock crossings, therefore, respond to pedestrian behavior. Properly designed and visible midblock crosswalks, signals and warning signs warn drivers of potential pedestrians, protect crossing pedestrians and encourage walking in high-activity areas.

### Related Thoroughfare Design Elements

- On-street parking
- Pedestrian refuge islands
- Medians
- Curb extensions
- Bicycle lanes

## General Principles and Considerations

Installing midblock crosswalks can help channel pedestrians to the safest midblock location, provide visual cues to allow approaching motorists to anticipate pedestrian activity and unexpected stopped vehicles and provide pedestrians with reasonable opportunities to cross during heavy traffic periods when there are few natural gaps in the approaching traffic streams (**Figure 9.15**). General principles and considerations regarding midblock crossings include the following:

- Appropriate stopping sight distance is a critical part of the design of midblock crossings. Refer to AASHTO’s *Policy on Geometric Design of Streets and Highways* (2004) for guidance in determining sight distance.
- The practitioner should always evaluate a number of factors before installing midblock crosswalks, including proximity to other crossing points, sight distance, vehicle speed, crash records, illumination, traffic volumes, pedestrian volumes and nearby pedestrian generators.
- In the urban environment, pedestrians should not be expected to make excessive or inconvenient diversions in their travel path to cross at an intersection. On the other hand, because midblock crossings are not generally expected by motorists, they should be used only where truly needed and appropriately signed, marked and illuminated.
- Midblock crossings should be identifiable to pedestrians with vision impairments. Where there is a signal, a locator tone at the pedestrian detector might be sufficient. A tactile strip across the width of the sidewalk at the curblines and



**Figure 9.14** Before and after illustration of a road diet. Source: Claire Vlach, Bottomley Design & Planning.

at pedestrian refuge islands needs to be used so that visually impaired pedestrians are alerted to the presence of the crossing.

- For a crosswalk to exist at a midblock location, it must be a marked crosswalk and have high visibility to drivers who may not anticipate a midblock crossing. Midblock crosswalks should be marked with a higher-visibility crosswalk marking such as longitudinal or diagonal lines or should be constructed with a high-contrast alternative pavement.
- When an unsignalized midblock crosswalk is installed, warning signs should be placed for both directions of traffic. A pedestrian warning sign with an “AHEAD” notice or a distance plaque should be placed in advance of the crossing, and a pedestrian warning sign with a downward diagonal arrow plaque should be placed at the crossing location. On multilane facilities, an advanced stop bar should be considered.

## Recommended Practice

The recommended practice for midblock crossings on urban thoroughfares is shown in **Table 9.4**. Examples are provided in **Figures 9.16 through 9.19**.

## Justification

Street life and activity entering and leaving buildings are often oriented toward midblock locations rather than intersections. Pedestrian convenience is related to walking distance as well as safety in crossing the roadway. Well-designed midblock crosswalks are highly visible to motorists, bicyclists and pedestrians; reduce walking distance; and contribute to pedestrian convenience.



**Figure 9.15** Midblock crosswalks provide opportunities to cross streets with long distances between intersection crossings. Source: Claire Vlach, Bottomley Design & Planning.

**Table 9.4 Recommended Practice for Midblock Crossings**

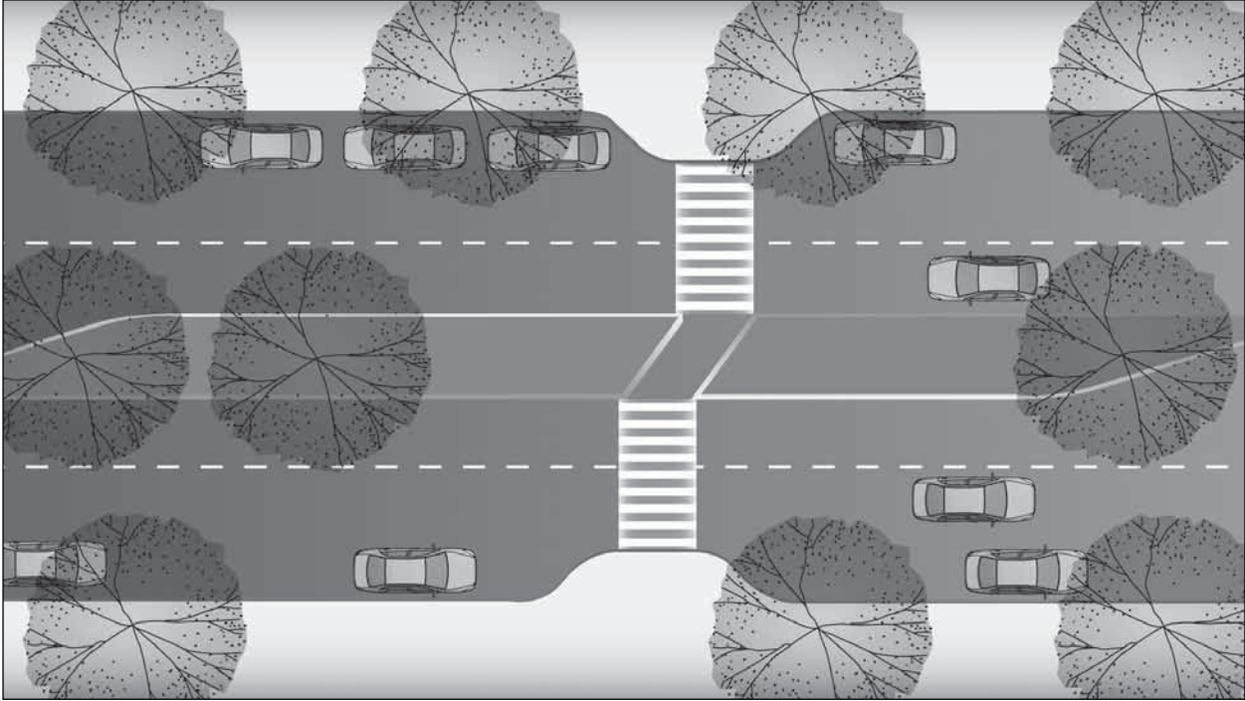
<b>General</b>
The decision to locate a midblock crosswalk will be based on numerous factors. Generally, however, consider providing a marked midblock crossing when protected intersection crossings are spaced greater than 400 feet or so that crosswalks are located no greater than 200 to 300 feet apart in high pedestrian volume locations, and meet the criteria below.
Midblock crossings may be considered when there is significant pedestrian demand to cross a street between intersections, such as connecting to major generators or transit stops.
Midblock crosswalks should be located at least 100 feet from the nearest side street or driveway so that drivers turning onto the major street have a chance to notice pedestrians and properly yield to pedestrians who are crossing the street.
<b>Criteria</b>
Streets with an average daily traffic volume (ADT) of 12,000 vehicles per day or less.
Multilane streets carrying less than 15,000 ADT if a raised pedestrian refuge median is provided.
Operating speeds less than 40 mph.
A minimum pedestrian crossing volume of 25 pedestrians per hour for at least four hours of a typical day.
Adequate sight distance is available for pedestrians and motorists.
<b>Recommendations</b>
Conform to PROWAG guidelines for the disabled and visually impaired.
Unsignalized midblock crosswalks should not be provided on streets where traffic volumes do not have gaps in the traffic stream long enough for a pedestrian to walk to the other side or to a median refuge. At locations with inadequate gaps that also meet MUTCD signalization warrants, consider a signalized midblock crossing.
Consider a signalized midblock crosswalk (including locator tone and audio pedestrian signal output as well as visual pedestrian countdown signal heads) where pedestrians must wait more than an average of 60 seconds for an appropriate gap in the traffic stream. When average wait times exceed 60 seconds, pedestrians tend to become impatient and cross during inadequate gaps in traffic. If this initial threshold is met, check pedestrian signal warrants in the MUTCD.
Provide overhead safety lighting on the approach sides of both ends of midblock crosswalks.
Provide wheelchair ramps or at-grade channels at midblock crosswalks with curbs and medians.
Provide raised median pedestrian refuge at midblock crossings where the total crossing width is greater than 60 feet, and on any unsignalized multi-lane thoroughfare crossing.
Use high-visibility (ladder-style) crosswalk markings to increase visibility longitudinally.
Provide advance stop or yield lines to reduce multiple-threat crashes.
Provide advance crosswalk warning signs for vehicle traffic.
Provide curb extensions at midblock crosswalks with illumination and signing to increase pedestrian and driver visibility.
"Z" crossing configurations should be used for midblock crossings with medians wherever possible (see <b>Figure 9.16</b> ). Provide an at-grade channel in median at a 45-degree angle toward advancing traffic to encourage pedestrians to look for oncoming traffic.
<b>Other Considerations</b>
A strategy to calm traffic speeds in advance of and at a midblock crossing is to raise the pavement to meet the sidewalk elevation by use of gentle ramps (see <b>Figure 9.17</b> ). Consider use of overhead flashing beacons.

Sources:

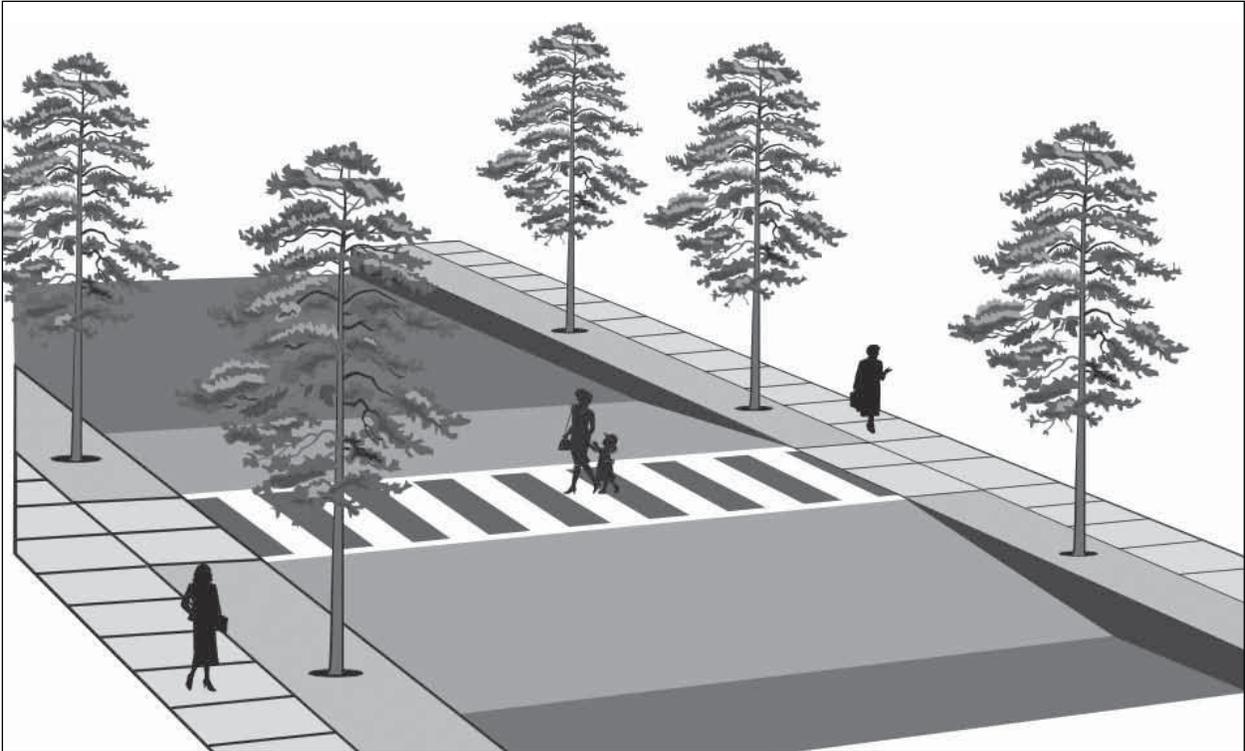
*Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations*, FHWA, 2002

*Manual on Uniform Traffic Control Devices*, FHWA, 2009 Edition

*Guide for the Planning, Design and Operation of Pedestrian Facilities*, AASHTO, 2004



**Figure 9.16** Midblock crossings with a “Z” configuration force pedestrians crossing the median to look toward oncoming traffic. Avoid street trees that interfere with visibility. Source: Kimley-Horn and Associates, Inc.



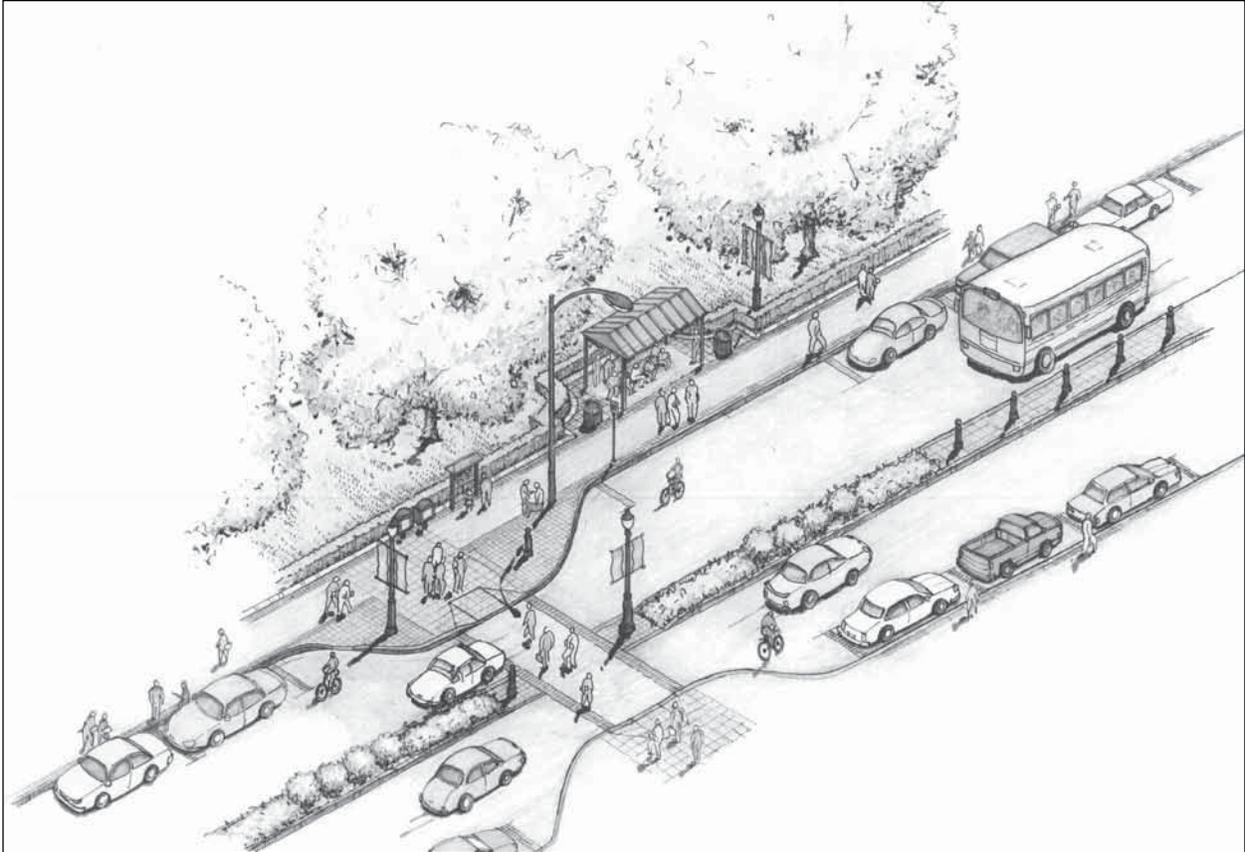
**Figure 9.17** The raised roadway crosswalk concept combines midblock crosswalks with traffic calming devices. Source: Kimley-Horn and Associates, Inc.



**Figure 9.18** Midblock crossing with pedestrian detection and in-pavement lights. Source: Kimley-Horn and Associates, Inc.



**Figure 9.19** Example of a signalized midblock crossing. Source: Kimley-Horn and Associates, Inc.



**Figure 9.20** Refuge islands can be used at midblock locations, channelized right turns, or at long intersection crossings. Source: Kimley-Horn and Associates, Inc.

## Pedestrian Refuge Islands

### Background and Purpose

Refuge islands provide pedestrians and bicyclists a refuge area within intersection and midblock crossings. While in walkable urban areas it is desirable

that thoroughfares have short crossings, on wide thoroughfares, or where less mobile pedestrians need to cross, refuge islands provide a location for pedestrians or bicyclists to wait partially through their crossing. Refuge islands also break up crossings at complex multilane and multilegged intersections into shorter and easier portions for pedestrians to cross.

#### Related Thoroughfare Design Elements

- Lane width
- Right-turn channelization
- Modern roundabouts
- Medians
- Midblock crossings
- Curb extensions

### General Considerations

Refuge islands are provided in the median and on right-turn channelized islands (**Figure 9.20**). Refuge islands should be considered for intersections and midblock crossings for which one or more of the following conditions apply:

- Unsignalized midblock and intersection crossings of a high-volume thoroughfare of four or more lanes to allow crossing pedestrians and bicyclists to concentrate on crossing one direction of travel at a time; or

- Signalized crossings frequently used by a number of people who walk slower than 3.5 feet per second, such as older persons, schoolchildren, persons with disabilities and so forth.

At signalized intersections, the provision of pedestrian refuges increases the crossing distance of most pedestrians (walking at a rate of 3.5 to 4 feet per second) who do not need to use the refuge and increases the traffic signal's overall cycle length and resulting delay (delay that is also experienced by pedestrians). Thus, the practitioner needs to balance the needs of all users when considering a refuge in the second condition above.

## Recommended Practice

Recommended practices regarding pedestrian refuge islands include the following:

- Islands should be sufficiently large to command attention. For pedestrian refuge, islands should have an area at least 120 square feet with minimum dimensions of 6 feet wide and 20 feet long.
- Refuge islands are generally good practice in urban areas to reduce pedestrian exposure to traffic. Specifically, refuge islands may be considered on urban thoroughfares where the unsignalized pedestrian crossing crosses four or more lanes or greater than 60 feet, or under special circumstances such as school crossings and where elderly pedestrians cross.
- Medians expected to be used as pedestrian refuges should have vertical curbs to delineate the pedestrian refuge from the surrounding roadway.
- If part of a designated multi-use trail system, refuge islands are recommended to be 10 feet wide (8 feet minimum).
- Crossing through pedestrian refuges must be accessible with channels at street grade, detectable warnings and audio and visual output at signalized crossings.

## Justification

Short crosswalks help pedestrians cross streets more safely with less exposure to vehicle traffic. They also require shorter pedestrian signal phases to cross, thereby reducing traffic delays. Pedestrian comfort and safety when crossing wide intersections is an essential component of good pedestrian facility design. On wide streets, the median can provide a refuge for those who begin crossing too late or are slow walkers. At unsignalized intersection and midblock crossings, medians permit crossings to be accomplished in two stages, so that pedestrians only have to concentrate on crossing one direction of the roadway at a time.

## Transit Design

### Background and Purpose

Many urban thoroughfares accommodate public transportation. The types of services accommodated on thoroughfares ranges from local bus service to bus rapid transit (BRT) to trolleys and light rail transit (LRT). These types of transit service can be accommodated either within a dedicated right of way in the thoroughfare or in mixed-flow lanes. In both cases the design of the thoroughfare needs to consider the special requirements of transit vehicles, running ways and operations, whether they exist or are planned for the future. The purpose of this section is to identify

#### Related Thoroughfare Design Elements

- Cross-section determination
- Lane width
- Medians
- Bike lanes
- Curb return radii
- Curb extensions
- Bus stops in the traveled way
- Bus stops at intersections

**Table 9.5 Types of Public Transportation Using Urban Thoroughfares**

Transit Type	Definition
Local Bus	Bus service operating at a fixed frequency that serves designated stops along a fixed route. Fares are collected onboard by the bus operator. Local bus service usually operates in mixed-flow lanes on urban thoroughfares. The typical average operating speed is low and is dependent on the operating speed of the urban thoroughfare.
Rapid Bus	Bus service similar to local bus serves designated stops along fixed route but with fewer stops than local service. This service is also known as commuter express. Fares are collected onboard by the bus operator. Rapid bus service usually operates along mixed-flow lanes on urban thoroughfares. Rapid buses may operate only during peak travel periods along peak directions. Some rapid bus systems use transit priority signal systems to improve headways, and queue jump lanes to bypass congestion at intersections.
Bus Rapid Transit (BRT)	Enhanced bus service that operates within its own right of way or designated lanes along the urban thoroughfares. BRT may utilize off-board fare collection to minimize boarding delays. BRT stops are typically spaced one mile apart and operate with high-frequency headways. The average speed of BRT is higher than that of rapid bus. BRT buses and stations are branded to distinguish them from local bus services. Stations frequently have more passenger amenities than typical bus stops. BRT systems use transit priority signal systems to improve headways, and queue jump lanes to bypass congestion at intersections.
Streetcar/Light Rail Transit (LRT)	Streetcars and LRT are fixed guideway transit systems. Streetcars (or trolleys) are electrically powered vehicles that may share the street with other modes of transportation and operate in mixed-flow lanes. LRT is typically electrical powered rail cars within exclusive rights of way in thoroughfare medians but may also operate in mixed-flow lanes. LRT is provided with traffic signal prioritization at intersections and requires special signal phasing to reduce conflicts. LRT utilizes off-board fare collection at transit stations. Transit stations, whether on the median or edges of thoroughfares, may require substantial right of way.

the key elements of transit that affect the design of thoroughfares. Detailed design guidance on dedicated transitways, particularly for rail systems, is beyond the scope of this report, but the information presented here can inform the thoroughfare planning and design process.



**Figure 9.21** An example of a dedicated transitway in the outside lane of an urban thoroughfare. Note the bike lane located between the curb and the transitway. Source: Kimley-Horn and Associates, Inc.

## Types of Transit on Thoroughfares

The different types of public transportation systems that use urban thoroughfares have varying physical and operating characteristics that will establish the design controls and geometric design parameters in thoroughfare design. It is important for the practitioner to understand the dimensions and capabilities of the type of transit using, or expecting to use, the thoroughfare and the ramifications the transit vehicles, their operation and their stops and stations will have on the design of the thoroughfare.

**Table 9.5** describes the common types of public transportation systems using urban thoroughfares.

## Transit Facilities on Thoroughfares

Transit on urban thoroughfares can utilize one or more of the following running way configurations:

- Mixed-flow travel lanes;
- Transit or high-occupancy vehicle (HOV) lanes in median or adjacent to mixed-flow lanes used for transit either full time or during peak periods;

- Reversible or contraflow dedicated transit lanes (in median or in outside travel lanes);
- Dedicated and separated transitway in inside or outside travel lanes (Figures 9.21 and 9.22); and
- Dedicated and separated transitway within thoroughfare median (Figure 9.23);
- Transit-only streets, busways, or transit malls.

Each running way configuration requires that the practitioner understand the right of way and dimensions required (not only for the running ways but for stops and stations), the transition required when changing from one configuration to another and how the transit vehicle will use intersections. Further, rail systems can be single tracked, double tracked, or both, which affects thoroughfare width planning.

Like running ways, bus and rail stops and stations can have multiple configurations depending on the type of transit, the available right of way, the type of service and other factors. As used in this report, a “stop” is a location where a transit vehicles stops to allow passengers to board or alight. A stop, at a minimum, is identified by a sign but may have some passenger amenities such as benches and shelters. A “station” is a more elaborate transit stop with substantial passenger amenities and may have facilities such as ticket



**Figure 9.22** A simulation of a bus rapid transit center median station with dual outside platforms located at the far side of an intersection. Source: AC Transit.

offices, restrooms, or other services. Stations may accommodate multiple vehicles or have integrated intermodal facilities. Stops and stations can utilize one or more of the following configurations:

### Local, Rapid and Bus Rapid Transit

- Midblock bus stop (curbside, pullout or bay, or bus bulb; see section on Bus Stops in the Traveled Way in this chapter);
- Near-side or far-side intersection bus stop (curbside, pullout or bay, or bus bulb; see Bus Stops at Intersections in Chapter 10); and
- Center median station with single center or dual outside platforms (midblock or near and far side of intersection), potentially with crossover for buses with right-side doors.

### Light Rail, Streetcar, or Trolley Transit

- Median station with dual side platforms;
- Median station with single center platform;
- Median station with single side platform (midblock or near and far side of intersection); and
- Curbside station at outside edge of thoroughfare traveled way.

The thoroughfare designer needs to coordinate with the responsible transit agencies to identify the appro-



**Figure 9.23** This thoroughfare in Houston, Texas has light rail transit running in dedicated inside travel lanes. Source: Texas Transportation Institute.

**Table 9.6 Integrating Transit into Thoroughfare Planning and Project Development**

Thoroughfare Planning or Project Development Stage	Transit Considerations
<b>Systems and Network Planning</b> Identify thoroughfare network deficiencies and conceptual solutions	Identify transit system deficiencies and long range transit needs
<b>Corridor Planning</b> Develop and assess alternatives for corridor	Develop and assess thoroughfare and transit alternatives within the corridor
<b>Project Scoping</b> Develop project definitions that address deficiencies	Identify transit elements to be included in the definition of thoroughfare projects
<b>Programming</b> Prioritize projects and define program based on funding availability	Develop transit project phasing and identify transit elements to be included in project funding
<b>Environmental and Design</b> Design project, assess impacts and estimate cost	Identify transit requirements to be integrated into thoroughfare design

Adapted from *Transit Vehicles and Facilities on Streets and Highways (Phase II) Final Report*. Transit Cooperative Research Program Project D-09, 2007. Privileged Document.

appropriate running way configuration, transitions and location and design of stops and stations.

## Planning for Transit

Transit systems are planned at the regional, citywide and/or corridor level (see Chapter 2). Most large-scale rail transit system decisions (technology, type, service and routing) are made in statewide or regional long-range transportation plans. Typically, an alternatives analysis that evaluates the feasibility of implementing the transit system on the proposed routes is prepared for major public transportation systems such as LRT or BRT that seek federal funding. These studies may even include preliminary engineering. Transit systems planning and corridor planning follow the same general process outlined in Chapter 2 for the thoroughfare planning process.

Transit considerations can be integrated into thoroughfare planning and design at several stages within the regional planning, corridor planning and project development processes as outlined in **Table 9.6**.

When designing thoroughfares that are identified as future transit corridors, the practitioner will need to consider a number of factors in order to reserve the appropriate right of way and to ensure the design is relatively easily converted to accommodate transit. Some of these factors are identified in **Table 9.7**. In addition

to specific design issues, the practitioner may need to consider other planning considerations such as:

- Potential for converting bus transit to LRT needs to consider LRT design parameters for vertical clearance, track integration, right of way, grades, pavement structural design, drainage and utilities for LRT power and communication.
- Stop and station locations and spacing to meet changing context and future development.
- Potential change in transit routing.
- Alternatives analysis and trade-offs assessment of transit priority treatments.
- Coordinating with transit agencies to install fiber-optic cabling to serve intelligent transportation systems (ITS) on transit corridors, such as automated passenger information systems at stops and stations.

### Transit Design Parameters

Although it is not the intent of this report to present guidelines for the extensive field of transit facility design, **Table 9.8** presents a select number of minimum dimensions and design parameters for some of the more common transit facility components that might be useful to the thoroughfare design practitioner in determining cross-sectional elements.

**Table 9.7 Transit Related Factors to Consider in Thoroughfare Design**

Thoroughfare Design Component	Factors to be Considered
Streetside (Chapter 8)	Streetside width at stops or stations
	Space for passenger requirements such as shelters, seating, waiting areas, trees, lighting and so forth.
	Accessibility requirements (lift pads)
Traveled Way (Chapter 9)	Available total right of way to accommodate running ways, stops and stations
	Lane width to accommodate transit vehicle in mixed-flow lanes
	Type of running way and separation (dedicated transitway, reversible/contraflow, HOV, median lanes, concurrent lanes)
	Median width to accommodate running ways and stations
	Pedestrian access to median stations
	Ability to accommodate on-street parking on transit streets
	Parking restrictions near stops and stations
	Bike/bus conflicts where buses stop in bike lane
	Pavement depth to accommodate buses; concrete pads at bus stops
	Additional width for transit facilities versus pedestrian crossing distance
	Roadway structural design for LRT
	Horizontal and vertical clearances for transit; maintenance requirements such as tree pruning
	Necessity for bus bays
	Transit operations on one-way streets, location of stops, turns
	Provision of an enforcement area on exclusive bus facilities (e.g., extended bus turnouts)
Prohibition of turns across median running ways	
Overhead clearance for catenary power supply or trolley wires and space to mount poles	
Intersections (Chapter 10)	Transit vehicle turning radius and curb return/extension design
	Queue jump lanes and special signal phasing
	Accommodating transit vehicles in roundabouts
	Near-side or far-side bus stops, BRT or rail stations and traffic operations
	Transit priority signal systems or special phasing for rapid and BRT
	Bus priority treatments; intersection design when contraflow bus lanes are used
	Special signal phasing and equipment for LRT
	Vehicle left-turn lanes adjacent to median stations
	Vehicle turn prohibitions in constrained rights of way or for operational efficiency
	Curb extension bus stop versus curbside stop
	Pavement grades through intersections and bus passenger comfort
	Movement restrictions and bus exemptions

**Table 9.8 Minimum Dimensions for Transit Facilities in Thoroughfares**

<b>Transit Facility or Design Element</b>	<b>Minimum Dimension</b>
Lane width to accommodate standard urban bus, LRT vehicle, or streetcar	11 feet
Curbside bus stop length and no-parking zone (add 20 feet for articulated vehicles)	
Near-side bus stop	100 feet
Far-side bus stop	80 feet (Plus 5 feet from crosswalk or curb return)
Far-side bus stop after turn	90 feet (Plus 5 feet from crosswalk or curb return)
Midblock	120 feet
Bus bulb stop length (near side or far side)	40 feet
Distance between front of vehicle at near-side stop and crosswalk	10 feet
Single-side LRT/BRT platform width conforming to ADA guidelines	10 feet (8 feet plus 2 feet tactile strip)
Distance between LRT double track centerlines	12 feet
Maximum grade for LRT operation	6%
Height of platform	Low: 10 inches High: 36 inches
Width of two-track LRT channel	22 feet
Vertical clearance for LRT (top of rail to bottom of wire)	11.5 feet
Width of right of reserve for two tracks	19–33 feet
LRT/BRT station widths (including running way)	
Dual outside platforms	41 feet
Single center platform	55 feet
Single outside platform	31 feet

# Bus Stops in the Traveled Way

## Background and Purpose

There are more than 9.4 billion trips made by transit in the United States each year, with nearly 5.3 billion trips made by bus (National Transit Database 2006). Buses are the most common form of mass transit in the country, and the majority of bus travel occurs on urban thoroughfares in metropolitan areas. Since urban thoroughfares serve as the primary access and mobility routes for mass transit, they are the best locations for investment in transit facilities and public amenities that provide direct access to bus stops and functional, attractive and comfortable places to wait for transit. The placement and design of bus stops affect the efficiency of the transit system, traffic operations, safety and people's choices to use transit. Since there is no equivalent to the AASHTO Green Book for transit design guidance, transit agencies develop guidelines and practices for bus stop planning, placement and design. Design guidelines include compliance with ADA requirements to ensure that transit is accessible. This section addresses general guidance for the planning and design of bus stops on urban thoroughfares compiled from the design guidelines of transit agencies. Location-specific guidance should be obtained from local transit agencies.

### Related Thoroughfare Design Elements

- Lane width
- Midblock crossings
- Curb extensions
- Transit design
- On-street parking and configuration

## General Principles and Considerations

### Fundamentals of Bus Stop Placement

The location of a bus stop must address both traffic operations and passenger accessibility issues. If possible, the bus stop should be located in an area where typical amenities, such as a bench or shelter, can be placed in the public right of way. A bus stop location

should consider potential ridership, traffic and rider safety and bus operations elements that require site-specific evaluation. Significant emphasis should be placed on factors affecting personal security. Well-lit open spaces visible from the street create a safer environment for waiting passengers.

Elements to consider when determining bus stop placement include:

- Proximity to major trip generators;
- Presence of sidewalks, crosswalks and curb ramps;
- Nearby enhanced crossings, either midblock or at an intersection;
- Access for people with disabilities;
- Passenger transfers to other routes; and
- Effect on adjacent property owners.

Traffic and rider safety elements to consider in bus stop placement include:

- Conflict between buses, other traffic and pedestrians;
- Crossing to an opposite bus stop—every bus stop should be considered a pedestrian crossing point;
- Passenger protection from passing traffic;
- Width of sidewalks;
- Width of furnishings zone as well as locations of any obstructions;
- Pedestrian activity adjacent to stop;
- All weather surface to step to/from the bus;
- Open and visible spaces for personal security and passenger visibility; and
- Street illumination.

Bus operations elements to consider in bus stop placement include:

- Accessibility and availability of convenient curb space;
- Adequate curb space for the number of buses expected at the stop at any one time;
- On-street automobile parking and truck delivery zones;

**Table 9.9 Advantages and Disadvantages of Midblock Bus Stops**

Advantages	Disadvantages
Minimizes sight distance problems for motorists and pedestrians	Requires additional distance for no-parking restrictions
Might result in passenger waiting areas experiencing less pedestrian congestion	Increases walking distance for patrons crossing at an intersection or requires special features to assist pedestrians with midblock crossing
Might be closer to passenger origins or destinations on long blocks	Encourages uncontrolled midblock pedestrian crossings
Might result in less interference with traffic flow	Only serves adjacent generators and does not afford system transfers to other lines often found at intersections

- Traffic control devices near the bus stop, such as signals or STOP signs;
- Volumes and turning movements of other traffic, including bicycles;
- Proximity and traffic volumes of nearby driveways;
- Street grade;
- Ease of reentering traffic stream; and
- Proximity to rail crossings.

The preferred location for bus stops is the near side or far side of an intersection (see the section on intersection bus stops in Chapter 10). Intersection stops provide the best pedestrian accessibility from both sides of the street and the cross streets and provides connection to intersecting bus routes.

Bus stops may also be placed at a midblock location on long blocks or to serve a major transit generator. At midblock bus stops ensure crosswalks are placed behind the bus stop, so passengers do not cross in front of the bus, where they are hidden from passing traffic. **Table 9.9** presents the advantages and disadvantages of midblock bus stops.

Stops should be placed to minimize the difficulties associated with lane changes and weaving maneuvers of approaching vehicles. Where it is not acceptable to stop the bus in traffic and a bus pullout is justified, a far-side

### Standard transit bus dimensions

Overall height: 10 feet, 6 inches

Overall width: 10 feet, 4 inches (including mirrors)

Overall length (large bus): 40 feet

Overall length (articulated bus): 60 feet

### Wheelchair lift dimensions

Width: 4 feet

Extension (from edge of bus): 4 feet, 6 inches

### Turning radii

40-foot coach:

Inner rear wheel – 25.5 feet

Outer front corner – 47.8 feet

Centerline radius – 40.8 feet

60-foot articulated:

Inner rear wheel – 21.3 feet

Outer front corner – 44.3 feet

Centerline radius – 35.5 feet

Source: Orange County Transportation Authority (OCTA) *Bus Stop Safety and Design Guidelines*, Orange County, California

or midblock curbside stop is generally preferred (see section on intersection bus stops in Chapter 10).

### Spacing of Bus Stops

Optimal bus stop spacing varies depending upon the type of transit service provided, urban context zone, location of major attractors, physical barriers and local community goals. Appropriate spacing ranges from 400 to 500 feet for downtown circulator shuttles and low-volume community service routes to greater than 2,000 feet (up to one mile) for bus rapid transit and express lines. Designers should consult with the local transit provider for design guidance on bus stop spacing and placement.

## Recommended Practice

### Design Vehicle

On urban thoroughfares with transit routes, the bus is one of the design vehicles used in thoroughfare design. Some transit agencies use smaller, urban-scaled transit vehicles (32-foot coach) and use of vehicles with the smallest possible turning radii should be encouraged. Most fleets use standard coaches with the design specifications described here. Important dimensions of standard and articulated buses are shown in the sidebar, including the turning radii requirements for a 40-foot coach and 60-foot articulated bus. The minimum inside radius is 21 to 26 feet and the minimum outer radius is 44 to 48 feet. Turning templates should be used in the design of facilities to identify curb return radius and required pavement width to avoid vehicle encroachment into opposing travel lanes. Additional allowance should be made for:

- Bicycle racks on front of bus (which adds 3 feet to the length of the bus); and
- Restrictions to bus overhang.

### Parking Restrictions at Bus Stops

It is important that parking restrictions (either curb markings or NO PARKING signs) be placed at bus zones (**Figure 9.24**). The lack of parking restrictions impacts bus operations, traffic movement, safe sight distance and passenger access. Considerations include:



**Figure 9.24** Parking restrictions at a bus stop.  
Source: Texas Transportation Institute.

- Bus may have to double park when at a stop, interfering with traffic movements;
- Passengers would have to maneuver between parked vehicles when entering or exiting the bus, which can endanger the passengers; and
- Bus could not use the curb/sidewalk to deploy its lift to board or alight wheelchair passengers.

In addition to a minimum 40- to 60-foot long bus stop, no-parking zones before and after the bus stop allow buses to pull into the bus stop and reenter traffic. Use the following dimensions for no-parking zones at midblock bus stops that typically accommodate a single bus:

- Before stop: 40-foot minimum.
- After stop: 40-foot minimum.

Parking restrictions are not necessary when curb extension bus stops are provided.

### Curb Extension Bus Stops at Midblock Locations

Bus bulbs (or curb extension bus stops) are bus stops in which the curb is extended into the on-street parking lane, and the bus stops within the travel lane. Refer to Chapter 10 (Curb Extension Bus Stops) for more information on this type of stop.



**Figure 9.25** A typical bus turnout on an arterial Avenue. Source: Kimley-Horn and Associates, Inc.

### Bus Turnouts

Bus turnouts (a recessed curb area located adjacent to the traffic lane as shown in **Figure 9.25**) are desirable only under selected conditions because of the delay created when the bus must reenter traffic. Bus turnouts are typically used only on thoroughfares with higher target speeds than those included in this report.

Bus turnouts have the following advantages:

- Allow traffic to proceed around the bus, reducing delay for other traffic;
- Maximize vehicular capacity of high-volume vehicle mobility priority thoroughfares;
- Clearly define the bus stop;
- Passenger loading and unloading can be conducted in a more relaxed manner; and
- Eliminate potential rear-end accidents.

Bus turnouts have the following disadvantages:

- Make it more difficult for buses to reenter traffic, increasing bus delay and average travel time for buses;
- Difficulty of buses pulling parallel to curb, reducing accessibility;
- Greater crash risk for buses pulling back into traffic than buses stopped in traffic lane; and
- Use additional space and might require right-of-way acquisition.

### Bus Turnout Design

Typical urban bus turnouts are usually comprised of an entrance taper (40 to 60 feet), stopping area (40 to 60 feet per each standard and articulated bus respectively) and exit taper (40 to 60 feet).

### Passenger Boarding Area

The bus stop passenger boarding area is the area described as a firm, solid platform for deployment of wheelchair lifts and for other bus stop features, such as shelters, and benches. The boarding area must include a front and rear loading area free of obstacles. The boarding area may also be a pathway, but greater clearance than a typical sidewalk is required to allow deployment of the wheelchair lift. **Figure 9.26** shows a basic boarding area.

The following criteria for boarding areas should be used to ensure compliance with PROWAG requirements:

- Door clearance: minimum of 5 feet wide along the curb by 8 feet deep (from face of curb to back of boarding area);
- Distance between front and rear boarding area is 18 feet;
- Surface material is stable, firm and slip resistant;
- Slope does not exceed 1 foot vertical over 20 feet horizontal (5 percent);
- Cross slope does not exceed 1 foot vertical over 50 feet horizontal (2 percent);



**Figure 9.26** A simple passenger boarding area. Source: Kimley-Horn and Associates, Inc.

- Clear throughway width of 48 inches maintained in boarding area; and
- Vertical clearance of 84 inches maintained in boarding area.

Every bus stop should include the following minimum elements for passenger accessibility, safety and comfort:

- In streetsides with a detached sidewalk (planting strip between curb and sidewalk), practitioners should:
  - Provide a landing area adjacent to the curb for a minimum distance of 34 feet in length and a minimum of 8 feet in depth (from face of curb); and
  - Provide a connecting pathway from pedestrian throughway to landing area.
- Provide convenient pedestrian pathways/access ways to and from adjacent buildings.
- Locate the bus stop so coach operators have a clear view of passengers and waiting passengers can see oncoming buses.
- Minimize driveways in and adjacent to the bus stop area.
- Locate street furniture more than 2.5-foot tall in such a way as to provide motorists exiting nearby driveways clear visibility of the street.
- Passenger boarding area: Pads must have a smooth, broom-finished surface to accommodate high heels and wheelchairs and must have high-strength capacity to bear the weight of a shelter. Pavers (textured/decorative tiles) can be used in combination with a concrete pad for aesthetics. Slope of pad should match slope of adjacent sidewalk and allow drainage of pad (2 percent maximum per PROWAG requirements).
- Landscaping near the passenger boarding area is encouraged to maximize passenger comfort but should be placed far enough back from the curb face to not interfere with the bus or passenger visibility. All landscaping should be located so as not to obstruct the shelter canopy or obscure sight lines at the bus stop. Shade trees are desirable and the preferred location is at the back of the sidewalk.

- Maintain at least 5 feet of clearance between bus stop components and fire hydrants.
- Locate bus stops where there is a standard curb in good condition. Bus stops are designed with the assumption that the bus is the first step. It is more difficult for the elderly and mobility-impaired passengers if the curb is absent or damaged.
- All street furniture should be surrounded by at least 4 feet of horizontal clearance wherever possible for access and maintenance between components. **Figure 9.27** illustrates a typical layout of a shelter and other street furniture.
- There should be at least 10 feet of clearance between the front edge of a pedestrian crosswalk and the front of a bus at a near-side bus stop, and 5 feet between the back edge of a crosswalk and the rear of the bus at a far-side bus stop.
- Whenever possible, avoid placing a bus stop so that the bus wheels will cross over a catch basin as it pulls to the curb, causing the bus to lurch and possibly throw off passenger balance. Additionally, it could eventually cause excessive settlement of the catch basin's structure.
- To avoid splashing waiting passengers as the bus pulls to the curb in wet weather, consider draining away from the curb (**Figure 9.28**).

### Passenger Security

Security is one of the primary issues associated with the design of bus stops. Personal security is consistently mentioned in transit studies as a major concern among transit users. The following guidelines should be considered to improve security at bus stops:

- Place bus stops in locations that provide between 2 to 5 lumens of illumination within the bus stop area. If street lighting does not exist, solar lighting could be considered to enhance security at night.
- Ensure adjacent shrubbery is trimmed low and thinned so passengers can view over and behind any hedges. Consider using plants that are open and do not form solid hedges of vegetation.
- Ensure clear visibility of, through and around the bus stop for both passenger surveillance of the environment and law enforcement surveillance. Pro-



**Figure 9.27** An example layout of a shelter and other street furniture. Source: Texas Transportation Institute.



**Figure 9.28** This bus stop is designed so that stormwater drains away from the curb into a slot drain located in the travel lane. This design keeps buses from splashing waiting passengers when pulling to the curb. Source: Texas Transportation Institute.

vide adequate lines of sight for passengers and law enforcement officers approaching the bus stop.

- Ensure that the pedestrian circulation routes through bus stops and waiting areas are not blocked from view by walls or other structures.
- When placing bus stops, avoid nearby edges and corners of walls that create blind spots.
- Avoid design features that degrade access and security, including sound walls or similar structures that isolate passengers from surrounding neighborhoods. In general, there is no reason to locate bus stops adjacent to sound walls or tall fences, as these locations preclude direct access from adjacent land uses. If unavoidable, provide a pedestrian passage through the wall.
- If possible, provide a public telephone or place the bus stop in view of a public telephone. Consider installation of emergency call boxes at isolated locations.
- Provide secure bicycle parking and ensure that proper clearances are maintained when bicycles are parked.
- If possible, provide multiple exits from bus shelters.
- Remove all evidence of vandalism and regularly repair and maintain benches and shelters to provide passengers with a sense of security.

## Justification

Bus stops should be designed to first expedite the safe and efficient loading and unloading of passengers (including those with disabilities) and to allow for efficient transition of the bus between the travel lanes and the bus stop. Because of the multimodal function of urban thoroughfares and to make transit competitive with auto travel, consideration should be given to design features that minimize delay for buses reentering the traffic stream (far-side bus stop placement and curb extension bus stops). The boarding area must be designed, at a minimum, to accommodate ADA/PROWAG requirements, but consideration should be given to boarding areas that can accommodate passenger amenities such as shelters, benches, trees and bicycle parking, even if these amenities will be implemented in the future.

## Special Consideration with Stormwater Management

The management of stormwater on walkable urban thoroughfares improves the walking and bicycling environment, aesthetics and the quality of the community as a whole. Green stormwater management practices add value and multiple functionality and should be considered in thoroughfare improvement projects.

## Swales in Stormwater Management

Green swale areas can be located in medians, planting strips, islands and other landscaped areas to which stormwater can be directed. Swales are depressed areas that are normally highly porous but are planted with low-maintenance, frequently indigenous types of grass or vegetation that are compatible with the detention, absorption and filtration functions they are designed to serve. The photos below show an example of a median swale, but similar swales can be located in planting strips adjacent to curbs or other locations within the right of way.



If the local soil doesn't percolate or if the median slopes, the design will need a subsurface drain inlet to the storm drain system at the downstream end (as shown in the photo above). Consider that loose soil around the plants would be carried into the storm drain with the first storm requiring fabric or other erosion control on the soil or a sediment trap in the inlet structure.

Source: City of Gresham, OR

Stormwater runoff from thoroughfares and their streetsides must be handled in the right of way. Different communities treat stormwater differently. For some the conventional way is to collect and carry it in storm sewer pipe networks to a treatment plant then an outfall into a water body. For other communities, stormwater is controlled at the source or through treatment control best management practices.

### Related Thoroughfare Design Elements

- Streetside
- On-street parking
- Medians
- Street trees and street trees in medians

## Background and Purpose

Urban areas have a high percentage of impervious surfaces. This creates the need for stormwater systems that can carry the runoff away from the area or treat, absorb and/or detain the runoff at its source. Failure to sufficiently handle stormwater can result in increased volume and rate of runoff from impervious surfaces increasing the demand for stormwater system capacity. If the system capacity cannot be increased, this can cause flooding and erosion, increase sedimentation and damage the natural habitats that accept the runoff. Further, the concentration of pollutants in the runoff can impact water quality.

A “green street” is a thoroughfare that provides water-quality treatment, retention and/or detention for some or most stormwater within the right of way through use of vegetated facilities, usually swale areas, to reduce, delay and/or filter the amount of water piped directly to outfalls. This report provides a brief discussion of reducing and treating stormwater using source control or treatment control best management practices (BMPs). BMPs are used to accommodate stormwater runoff in one or more ways:

1. **Infiltration**—water enters the ground directly or through pervious surfaces and percolates into the soil.

2. **Retention and detention**—methods to store runoff for later release. Detention measures store water for up to several days after a storm and are usually dry until the next storm. Retention measures are permanent basins that retain water.
3. **Biofiltration**—allow runoff to flow slowly through vegetated slopes and channels, which also capture sediment and pollutants.
4. **Mechanical filtering, screening and de-sedimentation**—devices that can be installed in or adjacent to thoroughfares within the public right of way that use various means to capture solids, such as litter and leaves, or fine particulates, such as dirt and metals.

Where thoroughfare designs can accommodate significant green space, vegetated or grass swales in the streetside or the median can be used to absorb, detain and/or filter runoff. This can reduce the necessary storm sewer capacity and treatment of the runoff.

## General Principles

While there are numerous practices for addressing stormwater runoff on sites, the following principles are specific to urban thoroughfare design. These principles represent an objective that either slows or delays the movement of stormwater runoff into the storm drain system, filtrates sediment and pollutants from runoff, or both. Municipalities should encourage developers to implement landscape designs and site BMPs that mitigate increases in site runoff. This reduces the runoff that reaches thoroughfares from adjacent development.

- Minimize the width of the street to the extent feasible to reduce impervious surface.
- Provide pervious surfaces where possible. For example, use streetside planting strips to collect runoff from sidewalks or use pervious hardscape within streetsides of urbanized areas where parkrows are not provided. Consider the maintenance and longevity implications of surfaces that take vehicle loads.
- When retention or detention methods are used, incorporate them into urban water features that

add aesthetic and place-making value to the function.

- Provide mechanical traps to capture pollutants and particulate matter such as dirt and leaves. Consider the maintenance requirements of these features.
- Where the context allows, direct runoff into biofilters or swales rather than underground storm drains.

Where a rigid pavement edge is necessary, consider that swales or other filtration devices can run parallel to the street (in the streetside planting strip or in the median) but also can intersect the street at cross-angles and run between residential lots or within parks or open space.

## Guidelines

Complete guidance in relation to storm water management is beyond the scope of this report. Designers are encouraged to seek out other references, such as those outlined at the end of this chapter, or to seek guidance from their local stormwater management agency or water quality control board. However, several guidelines can be followed to develop an initial concept for using a green approach to stormwater management:

- Consider swales for use in medians, planting strips, planters, curb extension, islands, or other green areas of significant size where runoff can be collected and detained until filtered or absorbed or flowed into inlets at the end of swales.
- Employ swales where they can slope downward from the curb or sidewalk.
- Design gutters and curbs so water can enter the swale through breaks or other openings in the curbs; provide for runoff to enter swales directly from adjacent sidewalks or piped from elsewhere in the right of way.
- Considering appearance, cleaning, maintenance and amount of stormwater to be handled in the design of BMPs.
- Blend BMPs in with the rest of the thoroughfare design and context; consider pedestrian con-

nectivity; parking, bicycle and transit needs and provisions; safety; and emergency access.

- Use native, flood-tolerant plants that need little watering, fertilizers, or maintenance.
- Develop and implement a cleaning and maintenance program to preserve stormwater system functionality, appearance and plants.
- Install various commercially available traps, filters and detention or retention devices. Consider the maintenance requirements of these devices.

## Recommended Practice

Pervious surfaces and “green” stormwater management should be used in medians, planting strips, planters, islands, sidewalk extensions and other applicable spaces within the right of way where natural stormwater detention, filtration, or absorption is desired, soil conditions are compatible, and where a suitable design is compatible with and supportive of the desired use and appearance of the thoroughfare and surrounding context.

## Justification

The growing amount of impervious surfaces in urban areas is increasing runoff and therefore the need for increased stormwater management infrastructure. It also is carrying more waterborne street pollutants needing treatment. The Environmental Protection Agency’s (EPA’s) Clean Water Act has authorized the National Pollutant Discharge Elimination System (NPDES), regulations for improving water quality by addressing point sources that discharge pollutants into waterways, such as stormwater collected in thoroughfares. Use of BMPs within the thoroughfare rights of way can reduce the demand for both storm sewer and treatment facility capacity and also can serve multiple functions.

## Special Consideration with Snow Removal

### Background and Purpose

During and after a snowstorm, most snow plows operate in emergency or “hurry-up” mode, focusing on opening up lanes for vehicles. Often, when snow is scraped from the vehicular lanes, it is piled up in the bicycle lane, parking lane, or along the sidewalk, thus making it difficult for bicyclists and pedestrians to use the facilities that have been provided for them.

Snow and ice blockages can force pedestrians onto the street at a time when walking in the roadway is particularly treacherous. Many localities that experience regular snowfalls have enacted legislation requiring homeowners and businesses to clear the sidewalks fronting their property within a reasonable time after a snowfall occurs. In addition, many public works agencies adopt snow removal programs that ensure that the most heavily used pedestrian routes are cleared, including bus stops and curb ramps at street crossings, so that snow plows do not create impassable ridges of snow. Adding to the problem, piled snow can create sight distance restrictions.

In some states snow plow operations clear the entire roadway from curb to curb. After the roadway is cleared, a smaller “snow blow” (such as brushes, pickups and plows) are used to clear pedestrian facilities.

In areas that receive regular snow, there will be trade-offs between the recommendations of this report and the efficiency of snow plowing. Some of the recommended design elements such as curb extensions and on-street parking will affect snow plowing operations.

### Related Thoroughfare Design Elements

- Streetside
- Bicycle lanes
- On-street parking and configuration
- Medians

These trade-offs need to be clearly communicated in the design process. Further, early collaboration with officials in charge of snow removal is imperative for a successful design.

## Recommended Practice

The following practices are recommended regarding snow removal in the design of walkable urban thoroughfares:

- Streetsides should be designed to accommodate a normal level of plowed snow behind the curb without blocking the pedestrian throughway. A wide planting strip or furnishings zone can accommodate plowed snow.
- Avoid designing objects in the furnishings zone that interfere with the ability to plow snow onto the streetside, such as large raised planters, continuous hedges and large utility and traffic control cabinets. Objects that snow can wrap around include trees, signs and light poles.
- The salting of streets for deicing can adversely affect landscaping in the streetside. If salt is used, design the furnishings zone with hard-scape or setback plantings and trees beyond the plow line.

## Works Cited

American Association of State Highway and Transportation Officials. 1999. *Guide for the Development of Bicycle Facilities*. Washington, DC: AASHTO.

American Association of State Highway and Transportation Officials. 2004a. *Policy on Geometric Design of Streets and Highways*, Fifth Edition. Washington, DC: AASHTO.

American Association of State Highway and Transportation Officials. 2004b. *A Guide for Achieving Flexibility in Highway Design*. Washington, DC: AASHTO.

Federal Highway Administration. 2009. *Manual on Uniform Traffic Control Devices*. Washington, DC: FHWA.

Federal Highway Administration. 1994. *Selecting Roadway Design Treatments to Accommodate Bicycles*. Washington, DC: FHWA.

Institute of Transportation Engineers. 2002. *Innovative Bicycle Treatments*. Washington, DC: ITE.

National Transit Database. 2002. *National Transit Summaries and Trends*.

Transportation Research Board. 2003. *Access Management Manual*. Washington, DC: TRB.

Transportation Research Board. 2000. *Highway Capacity Manual*. Washington, DC: TRB.

Transportation Research Board. 1986. *NCHRP Report 282: Multilane Design Alternatives for Improving Suburban Highways*. Washington, DC: TRB.

Transportation Research Board. 2003. *NCHRP Report 500: A Guide for Addressing Collisions with Trees in Hazardous Locations*. Washington, DC: TRB.

Rosales, Jennifer. 2007. *Road Diet Handbook: Setting Trends for Livable Streets, Second Edition*. New York, NY: Parsons Brinkerhoff.

United States Access Board. *Accessible Public Rights-of-Way*. <http://www.access-board.gov/prowa/>.

## Sources of Additional Information

American Association of State Highway and Transportation Officials. *Guide for the Design and Operation of Pedestrian Facilities*. Washington, DC: AASHTO, 2001.

American Association of State Highway and Transportation Officials. *Roadside Design Guide*. Washington, DC: AASHTO, 2002.

American Association of State Highway and Transportation Officials. *Highway Safety Design and Operations Guide*. Washington, DC: AASHTO, 1997.

American Planning Association. *Bicycle Facility Planning*. APA, 1995.

- City of Eugene. *Arterial Collector Street Plan—Design of Transit Facilities*. Eugene: Department of Public Works, November 1999.
- Metro. *Creating Livable Streets—Street Design Guidelines for 2040, 2nd Edition*. Portland, OR: Portland Metro, 2002.
- City of Los Angeles, Department of Public Works. *Public Agencies Activity Stormwater Guide, Second Edition*. [www.lastormwater.org](http://www.lastormwater.org).
- Federal Highway Administration. *Flexibility in Highway Design*. Washington, DC: FHWA, 1997.
- Federal Highway Administration. *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations*. Washington, DC: FHWA, 2002.
- Federal Highway Administration. Characteristics of Emerging Road Users and Their Safety. *FHWA-HRT-04-103*.
- Grand Junction/Mesa County Metropolitan Planning Organization. *Transit Design Standards and Guidelines*.
- Metropolitan Transit Development Board. *Designing for Transit—A Manual for Integrating Public Transportation and Land Development in the San Diego Metropolitan Area*. San Diego: July 1993.
- Texas Transportation Institute. *Guidelines for Planning, Designing and Operating Bus-Related Street Improvements*.
- Tri-Met. *Bus Stops Guidelines*. October 2002.
- American Association of State Highway and Transportation Officials. *Transit Vehicles and Facilities on Streets and Highways (Phase II)*. Future publication.
- Transportation Research Board. *NCHRP Report 330: Effective Utilization of Street Width on Urban Arterials*. Washington, DC: TRB, 1990.
- Transportation Research Board. *NCHRP Synthesis 225: Left-Turn Treatments at Intersections*. Washington, DC: TRB, 1996.
- Transportation Research Board. TCRP 19: *Guidelines for the Location and Design of Bus Stops*, Washington, DC: TRB, 1996.
- Transportation Research Board. Location and Design of Bus Stops, Transit Cooperative Research Program. Washington, DC: TRB, July 1996.
- Transportation Research Board. *TCRP Report 65—Evaluation of Bus Bulbs*. Washington, DC: TRB, 2001.
- Orange County Transportation Authority. *Bus Stop Safety and Design Guidelines*. Kimley-Horn and Associates, Inc., July 2004.
- Oregon DOT. *Design Guidelines for Public Transportation*, 2002.
- Oregon DOT. *Oregon Bicycle and Pedestrian Plan*.
- Urban Land Institute. *Dimensions of Parking, 4th Edition*. Urban Land Institute, 2004.
- Valley Metro, Arizona. *Bus Stop Handbook: Street Improvements for Transit*. Valley Metro (AZ), December 1993.
- Valley Metro, Arizona. *Passenger Facilities Handbook: Off-Street Improvements for Transit*. Valley Metro (AZ), June 1995.
- AC Transit. Designing with Transit: Making Transit Integral to East Bay Communities. [www.actransit.org/pdf/designing\\_with\\_transit.pdf](http://www.actransit.org/pdf/designing_with_transit.pdf), 2004.
- Federal Highway Administration. FHWA-PD-94-023. *The National Bicycling and Walking Study—Transportation Choices for a Changing America*; Final Report. Washington, DC, 1994.
- Public Rights-of-Way Access Advisory Committee (PROWAAC). *Special Report: Accessible Public Rights-of-Way: Planning and Designing for Alterations*, 2007.
- California Stormwater Quality Association. *California Stormwater Best Management Practices Handbook for New Development and Redevelopment*. January 2003. [www.cabmphandbooks.com](http://www.cabmphandbooks.com).

California Department of Transportation. *Office of Storm Water Management and Design Storm Water Quality Handbook: Project Planning and Design Guide*, May 2007.

City of Portland. *Stormwater Solutions Handbook*. [www.portlandonline.com/bes](http://www.portlandonline.com/bes).

City of Portland. *Stormwater Management Manual*. 2004. [www.portlandonline.com/bes](http://www.portlandonline.com/bes).

City of Portland. *Green Streets Cross-Bureau Team Report, Phase 1*. March 2006 and *Phase 2*, March 2007. [www.portlandonline.com/shared](http://www.portlandonline.com/shared).

Urban, Jim. *Up by Roots: Healthy Soil and Trees in the Built Environment*.



# Intersection Design Guidelines

# Chapter 10

Sidewalk width appropriate to function of adjacent land use

Farside bus stops with shelter and amenities

On-Street Parking

High visibility crosswalks alternative paving or ladder/zebra striping

ADA Ramps

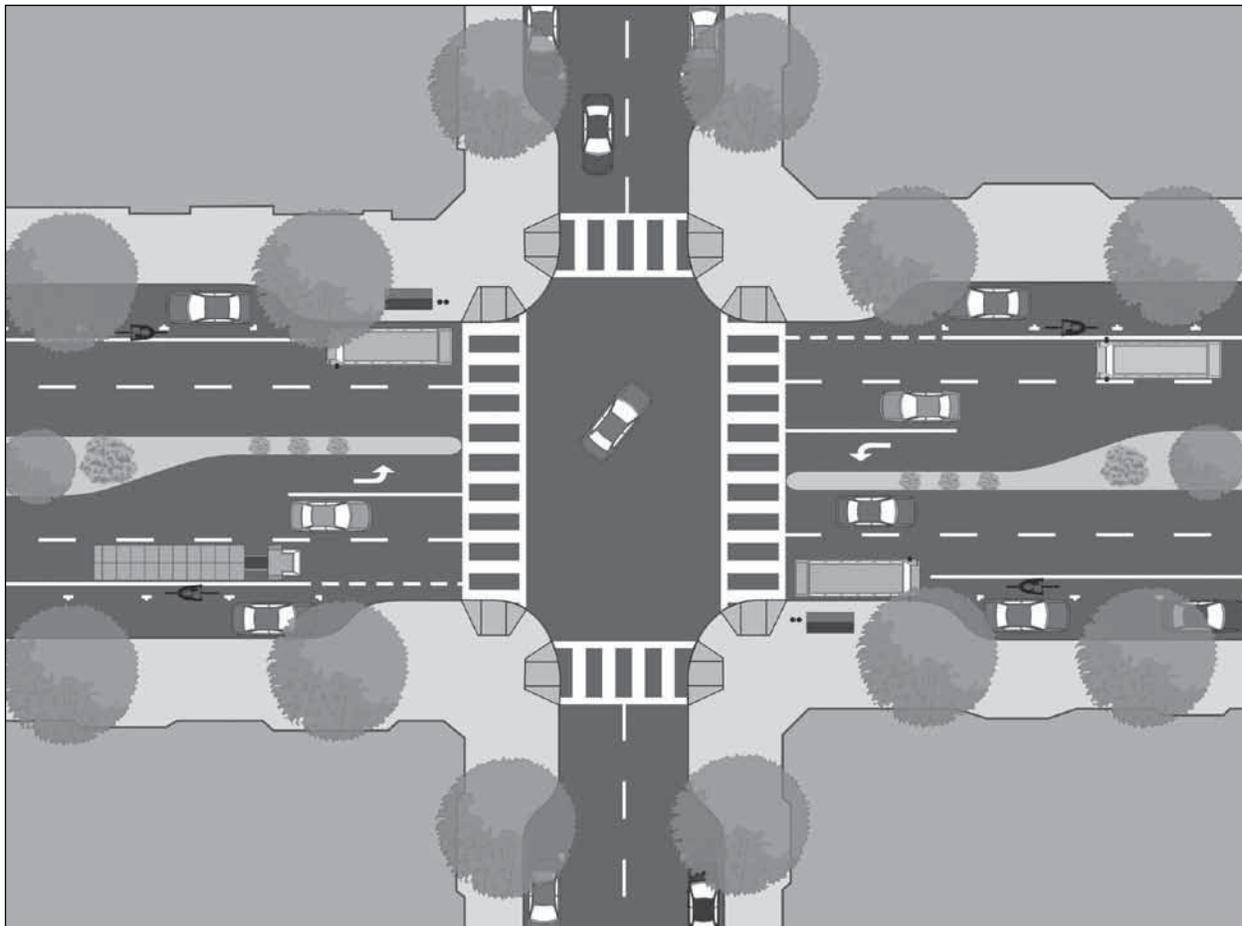
## Introduction

Multimodal intersections operate with pedestrians, bicycles, cars, buses and trucks, and in some cases, trains. The diverse uses of intersections involve a high level of activity and shared space. Intersections have the unique characteristic of accommodating the almost-constant occurrence of conflicts between all modes, and most collisions on thoroughfares take place at intersections. This characteristic is the basis for most intersection design standards, particularly for safety.

Designing multimodal intersections with the appropriate accommodations for all users is performed on a

case-by-case basis. The design extends beyond the immediate intersection and encompasses the approaches, medians, streetside and driveways, and adjacent land uses (**Figure 10.1**). The designer should begin with an understanding of the community objectives and priorities related to design trade-offs such as vehicular capacity and level of service, large-vehicle turning requirements, conflicts, pedestrian and bicycle convenience, accessibility and the efficiency of public transit service. Intersections are perhaps the most sensitive operational component of thoroughfare systems (**Figure 10.2**).

In urban areas, intersections have a significant place-making function as well as a transportation func-



**Figure 10.1** The design of intersections encompasses the intersection itself and the approaches to the intersection. It can even affect adjacent land uses. Source: Digital Media Productions.



**Figure 10.2** Intersections have the unique characteristic of accommodating the almost-constant occurrence of conflicts between all modes. Source: Texas Transportation Institute.

tion. Significant land uses and architecturally significant buildings are located at intersections and might provide pedestrian access directly from the corners. Intersections may also serve as gateways and are frequently the first thing visitors see when they enter a neighborhood (**Figure 10.3**). It is often requested that the practitioner include aesthetic treatments in intersection design.

## Objectives

This chapter:

1. Describes several fundamental aspects of intersection design, including managing multimodal conflicts, sight distance and layout; and
2. Provides general principles, considerations and design guidelines for key intersection components including curb return radii, channelized right turns, modern roundabouts, crosswalks, curb extensions, bicycle lanes and bus stops.

### General Principles and Considerations

Intersections are required to meet a variety of user expectations, particularly for users of motor vehi-

cles. Drivers expect to safely pass through intersections with minimal delay and few conflicts. Drivers of large vehicles expect to be able to negotiate turns easily. In urban areas, however, expectations based on rural and suburban experiences are unreasonable. Intersection users in urban areas will experience delays and conflicts between vehicles, pedestrians and bicyclists. Driver expectations need to shift toward taking turns with other modes and a sense of uncertainty, which creates a slower, vigilant and safer environment.

Successful multimodal intersection design is based on several fundamental geometric design and operational principles. These principles include:

- Minimize conflicts between modes (such as signal phasing that separates vehicle movements and pedestrian crossings, bicycle lanes extended to the crosswalk, pedestrian refuge islands, low-speed channelized right turns and so forth.) Provide crosswalks on all approaches.
- Accommodate all modes with the appropriate levels of service for pedestrians, bicyclists, transit and motorists given the recommended speed, volume and expected mix of traffic.



**Figure 10.3** Intersections are community gateways. Landscaping in the center island of an intersection. Source: Kimley-Horn and Associates, Inc.

- Avoid elimination of any travel modes due to intersection design. Intersection widening for additional turn lanes to relieve traffic congestion should be balanced against impacts to pedestrians, bicyclists and transit.
- Provide good driver and nondriver visibility through proper sight distance triangles and geometric features that increase visibility, such as curb extensions.
- Minimize pedestrian exposure to moving traffic. Keep crossing distances as short as practical and use operational techniques (protected left-turn signal phasing and prohibited right turn on red) to separate pedestrians and traffic as much as possible.
- Design for slow speeds at critical pedestrian-vehicle conflict points, such as corners, by using smaller curb return radii or low-speed channelized right-turn lanes.
- Avoid extreme intersection angles and break up complex intersections with pedestrian refuge islands. Keep intersections easily and fully comprehensible for all users. Strive for simplicity in intersection design—avoid designing intersections with more than four approaches (or consider a modern roundabout) and keep cross streets as perpendicular as possible.
- Ensure intersections are fully accessible to the disabled and hearing and sight impaired. Provide flush access to crossings, visual and audio

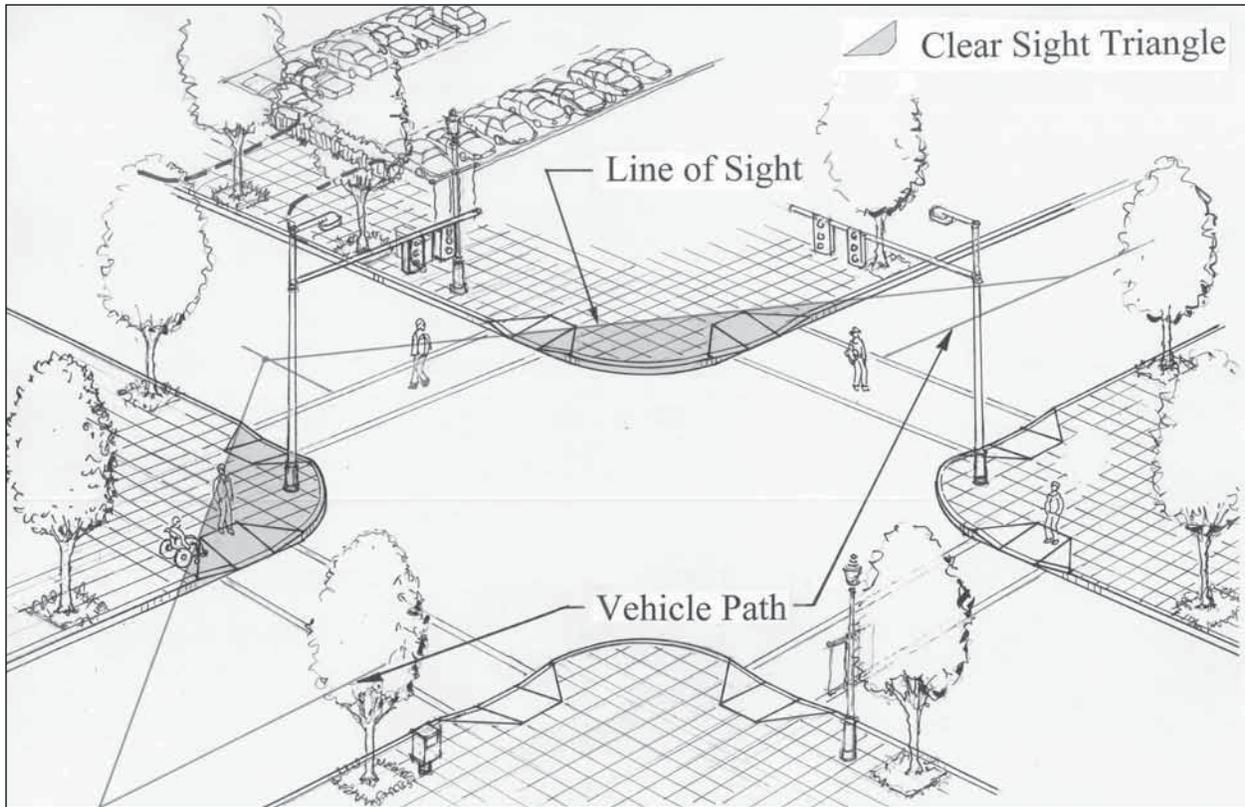


**Figure 10.4** Intersections must be accessible to pedestrians with disabilities. This curb extension is equipped with curb ramps and high-contrast detectable warnings. Source: Kimley-Horn and Associates, Inc.

information about WALK/DON'T WALK phases and detectable warnings underfoot to distinguish pedestrian from vehicular areas (**Figure 10.4**).

Considerations regarding intersection design include the following:

- The preferred location for pedestrian crossings is at intersections. However, if the block length exceeds 400 feet, consider adding a midblock crossing. The target spacing for pedestrian crossings in more intensive urban areas (C-4 to C-6) is every 200 to 300 feet.
- Increases in intersection vehicular capacity by adding lanes increase pedestrian wait times and crossing distances, and discourage pedestrian activity and bicycle use. Therefore, consider interconnecting streets in the network, using parallel routes and other strategies before increasing the number of travel lanes beyond the number of lanes recommended in **Table 6.4** in Chapter 6.
- Where possible, facilitate shared cross-access legal agreements between adjacent properties to close and consolidate nonresidential driveways near an intersection. Integrate access management policies and techniques into long-range transportation plans, area plans and design standards.
- If needed to reduce speeds along a thoroughfare, use speed tables or narrower lanes starting on



**Figure 10.5** Sight distance triangle at intersections. The required sight distance varies with the type of intersection control. Refer to AASHTO Green Book for more details. Source: Kimley-Horn and Associates, Inc.

the approach to intersections, or other speed-management techniques (see Chapter 9 section on Speed Management).

- Traffic control alternatives should be evaluated for each intersection, including stop control, traffic signals and modern roundabouts.
- Design for U-turn movements to facilitate access to property whenever adding a raised median. Use local, state, or the American Association of State Highway and Transportation Officials (AASHTO) guidelines to determine the U-turn radii needs. While local standards vary, it is desirable to use a passenger car as the design vehicle for U-turns on walkable urban thoroughfares.
- The median or the median nose adjacent to a turn lane should extend to the crosswalk. Medians can end prior to the crosswalk for a continuous pedestrian crossing or can extend through the crosswalk if a channel at street grade or a ramp is provided through the median. Median noses extended through the crosswalk provide

a refuge area for pedestrians. Carefully review turning radii of large vehicles that may strike the extended median nose.

### Intersection Sight Distance

Specified areas along intersection approaches, called clear sight triangles (shown in **Figure 10.5**), should be free of obstructions that block a driver's view of potentially conflicting vehicles or pedestrians entering the traveled way. The determination of sight triangles at intersections varies by the target speed of the thoroughfares, type of traffic control at the intersection and type of vehicle movement.

In urban areas, intersection corners are frequently entrances to buildings and are desirable locations for urban design features, landscaping and other streetside features. In designing walkable urban thoroughfares, the practitioner works in an interdisciplinary environment and has a responsibility to balance the desire for these streetside features with the provision of adequate sight distance, ensuring safety for all users. In urban

areas, examples of objects that limit sight distance include vehicles in adjacent lanes, parked vehicles, bridge piers and abutments, large signs, poorly pruned trees, tall shrubs and hedges, walls, fences and buildings.

Considerations regarding intersection sight distance include the following:

- Based on AASHTO guidelines, urban traffic controls (e.g., traffic signals, stop signs) alleviate the need for large sight triangles where such controls are employed. Where necessary sight triangles cannot be achieved, target speed, intersection traffic control types, sight line obstructions and/or other design elements should be changed.
- If the sight triangle for the appropriate target speed and intersection control is obstructed, every effort should be made to eliminate or move the obstruction or mitigate the obstruction (for example, install curb extensions to improve visibility of crossing pedestrians, prune street trees to branch height greater than 8 feet, or use lower appurtenances).

### Managing Modal Conflict at Intersections

Strategies to eliminate or avoid conflict can result in designs that favor one mode over others. For example, eliminating crosswalks at an urban intersection with a high volume of turning vehicles as a strategy to eliminate conflicts will discourage walking. The practitioner must weigh the ever-present trade-offs between vehicle level of service, large-vehicle accommodation and pedestrian and bicycle connectivity and convenience. For the most part, in urban areas, the trade-offs are clear; every user shares the intersection and equally shares in the benefits and drawbacks of multimodal design.

In locations where the community places a high priority on vehicular level of service, intersection designs should incorporate mitigating measures such as pedestrian countdown signals, pedestrian refuge islands and the replacement of free-flow right turns with low-speed channelized right turns (see applicable section in this chapter).

When improving safety at intersections, it is important that the measures that are used to improve vehicle

traffic flow or reduce vehicle crashes not compromise pedestrian and bicycle safety. Safety aspects need to be identified in an engineering review. The following strategic decisions need to be considered when improving intersection safety design and operation:

- Minimize vehicle-pedestrian conflicts without reducing accessibility or mobility for any user;
- When it is not possible to minimize all conflicts, reduce the exposure of pedestrians and bicyclists to motor vehicle traffic while maintaining a comfortable walking environment; and
- Design intersections so that when collisions do occur, they are less severe.

Traffic engineering strategies can be highly effective in improving intersection safety. These strategies consist of a wide range of devices and operational modifications. Some examples include the following:

- **Addition of left turn lanes at intersections.** Turn lanes are used to separate turning traffic from through traffic. Studies have shown that providing turn lanes for left-turning vehicles can reduce accidents. In walkable urban areas, turn lanes should be limited to a single left-turn lane. The operational benefits of adding turn lanes should be weighed against the increase in pedestrian crossing time.
- **Signals.** Increase the size of signal lenses from 8 to 12 inches to increase their visibility; provide separate signal faces over each lane; install high-intensity signal indications; and change signal timing, including the length of yellow-change and red-clearance intervals. Consider protected left-turn phasing as a strategy to reduce vehicle-pedestrian conflicts.
- **Innovative intersection design.** In appropriate applications, consider innovative intersection designs such as modern roundabouts. Roundabouts reduce speed, eliminate certain types of crashes and lessen the severity of other types of crashes. Examples of an alternate intersection design include “indirect left-turn” intersections, where left turns are accommodated at midblock U-turns to convert left turns to right turns, or “bowtie” intersections where left turns from the major street are directed to nearby roundabouts on the minor street where they make a U-turn

followed by a right turn at the major intersection. Each alternative design has advantages and disadvantages and handles pedestrians and bicyclists differently. The CSS process needs to weigh the trade-offs to select the best alternative.

- **Improve drivers' visibility of pedestrians.** Restrict parking near intersections, properly trim vegetation, move stop lines back from crosswalks by 4 feet, use longitudinal crosswalk striping and use curb extensions.

## Design Elements for Intersections in Walkable Areas

Most urban signalized intersections provide basic pedestrian facilities, including crosswalks, pedestrian signal heads, curb ramps and appropriate pedestrian clearance times. Many urban and especially suburban unsignalized intersections are unmarked for pedestrians. Older intersections in walkable urban areas need to be updated to conform to Americans with Disabilities Act (ADA) Public Rights-of-Way Accessibility Guidelines (PROWAG) requirements, better serve bicyclists, improve transit operations, or to simply enhance the pedestrian environment. This section provides a summary of intersection design features the practitioner may want to consider when designing walkable urban intersections.

### Uncontrolled Intersections

Common engineering practice is to exclude marked crosswalks from intersections without traffic control approaching the crossing. This is due to a number of factors including avoiding a false sense of security provided by crosswalks when traffic is uncontrolled, encouraging pedestrian caution when legally crossing at intersections without crosswalks, as well as raising liability and maintenance concerns. Indeed, several research studies have shown that pedestrian-vehicle crash rates are higher at unsignalized intersections with marked crosswalks versus those without.

The authors of NCHRP Report 562, *Improving Pedestrian Safety at Unsignalized Intersections*, found that the “safest and most effective pedestrian crossings use several traffic control devices or design elements to meet the information and control needs of both motorists and pedestrians.” The NCHRP study and other research

has found that marked crosswalks alone are insufficient and, when used, should be used in conjunction with other measures depending on the circumstances. In combination with marked crossings, measures to enhance uncontrolled intersections include:

- High visibility crosswalk markings such as longitudinal bars;
- A median refuge island (minimum of 6 feet) to make the street crossing in stages and more convenient;
- Street and crosswalk illumination;
- Advanced yield lines to improve the visibility of crossing pedestrians and reduce “multiple threat” type crashes;
- Installation of curb extensions to shorten crossing distance and improve driver and pedestrian visibility;
- Installation of pedestrian-activated flashing beacons to warn motorists of crossing pedestrians;
- Motorist signs to indicate that pedestrians have the legal right of way, “YIELD TO PEDESTRIANS,” “STOP HERE FOR PEDESTRIANS,” or internally illuminated pedestrian crossing signs; and
- Pedestrian signs or median designs (“Z” crossings) that encourage or facilitate looking for potential conflicts.

### Signalized Intersections

Signalized intersections, while providing some level of pedestrian protection by controlling traffic, have many available design features that increase pedestrian visibility, information and convenience. These features are listed in **Table 10.1**.

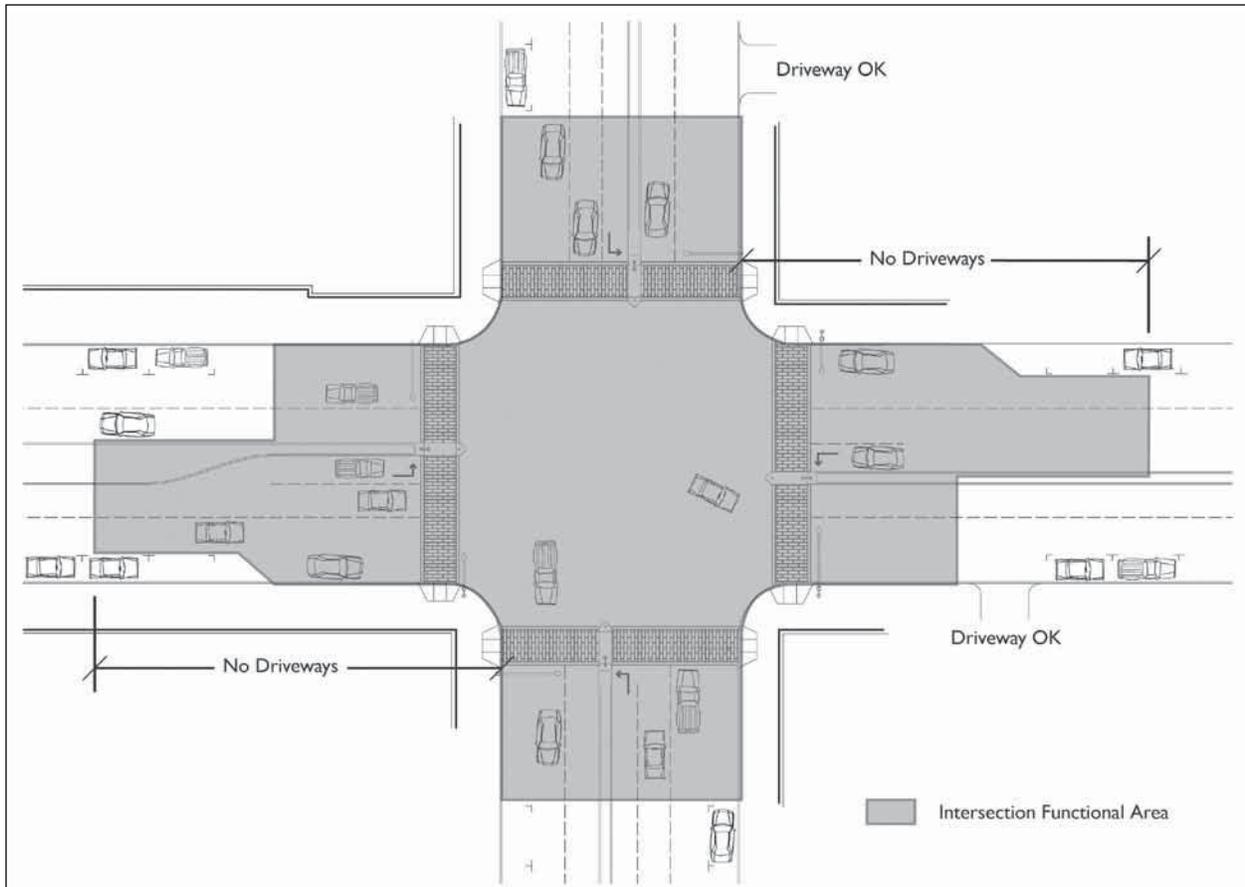
## Design Guidance

### Intersection Geometry

This section provides general principles, considerations and guidelines on the geometric layout of urban at-grade multimodal intersections and the key components that comprise geometric and operational design. These guidelines include a section on the application and design of modern roundabouts as an alternative to the conventional intersection.

**Table 10.1 Pedestrian and Bicycle Features at Signalized Intersections**

<p><b>Shorter and more visible crosswalks</b></p>	<ul style="list-style-type: none"> <li>• Crosswalks on all approaches;</li> <li>• Longitudinal markings (possible use of colored and/or textured paving);</li> <li>• Reduced overall street widths by reducing the number of travel and turn lanes, or narrowing travel lanes;</li> <li>• Curb extensions with pedestrian push buttons on extensions; and</li> <li>• Median refuges on wide streets (greater than 60 feet) with median push buttons.</li> </ul>
<p><b>Priority for pedestrians, bicyclists, and accessibility</b></p>	<ul style="list-style-type: none"> <li>• Shorter cycle lengths, meeting minimum pedestrian clearances (also improves transit travel times);</li> <li>• Longer pedestrian clearance times (based on 3.5 feet/sec. to set flashing (clearance) time and 3.0 feet/sec for total crossing time);</li> <li>• Reduced conflicts between pedestrians and turning vehicles achieved with:             <ul style="list-style-type: none"> <li>• Pedestrian lead phases;</li> <li>• Scramble phases in very high pedestrian volume locations;</li> <li>• Restricted right turns on red when pedestrians are present during specified hours; and</li> <li>• Allowing right turns during cross-street left turn phases reduces the number of right turn conflicts during pedestrian crossing phase.</li> </ul> </li> </ul>
<p><b>Low speed channelized right turn lanes</b></p>	<ul style="list-style-type: none"> <li>• Adequate sized islands for pedestrian refuge;</li> <li>• Raised pedestrian crossing/speed table within channelized right turn lane; and</li> <li>• Signal control of channelized right turn in high pedestrian volume locations.</li> </ul>
<p><b>Improved pedestrian information</b></p>	<ul style="list-style-type: none"> <li>• Pedestrian countdown timers; and</li> <li>• “Look Before Crossing” markings or signs.</li> </ul>
<p><b>Bicycle features</b></p>	<ul style="list-style-type: none"> <li>• Bicycle lanes striped up to crosswalk (using “skip lines” if vehicular right turns are allowed);</li> <li>• Bicycle detectors on high volume routes, or bicyclist-accessible push buttons;</li> <li>• Adequate clearance interval for bicyclists;</li> <li>• Colored paving in bicycle/vehicle lanes in high-conflict areas; and</li> <li>• “Bike Boxes” (painted rectangle along right hand curb or behind crosswalk) to indicate potential high-conflict area between bicycles continuing through an intersection and right turning vehicles, and to allow bicyclists to proceed through intersection or turn in advance of vehicles.</li> </ul>
<p><b>High-priority transit thoroughfare elements</b></p>	<ul style="list-style-type: none"> <li>• Adaptive Transit Signal Priority (TSP) when transit detected;</li> <li>• Extended green phase on bus route (rapid transit signal priority);</li> <li>• Truncated green phase for cross street;</li> <li>• Re-order phasing to provide transit priority (transit priority not to be given in two successive cycles to avoid severe traffic impacts);</li> <li>• Other bus priority signal phasing (sequencing)</li> <li>• Queue jump lanes and associated signal phasing; and</li> <li>• Curb extension bus stops, bus bulbs.</li> </ul>
<p><b>Accessibility and space for pedestrians</b></p>	<ul style="list-style-type: none"> <li>• Properly placed pedestrian actuation buttons, with audible locator tones;</li> <li>• Detectable warnings;</li> <li>• Two curb ramps per corner depending on radius of curb return and presence of curb extensions;</li> <li>• Clear pedestrian paths (and shoulder clearances) ensuring utilities and appurtenances are located outside pedestrian paths;</li> <li>• Vertical and overhang clearance of street furnishings for the visually impaired;</li> <li>• Properly placed signal poles and cabinets:             <ul style="list-style-type: none"> <li>• Behind sidewalks (in landscaping or in building niches);</li> <li>• In planting strips (furnishings zone); and</li> <li>• In sidewalk or curb extensions, at least three feet from curb ramps.</li> </ul> </li> </ul>
<p><b>Traffic operations for safe speeds and pedestrian convenience</b></p>	<ul style="list-style-type: none"> <li>• Target speeds between 25–35 mph;</li> <li>• Signal progression at target speeds; and</li> <li>• Fewer very long/very short cycle lengths.</li> </ul>
<p><b>Higher priority on aesthetics</b></p>	<ul style="list-style-type: none"> <li>• Textured and colored material within the streetside;</li> <li>• Colored material within crosswalks, but avoid coarse textures which provide rough surfaces for the disabled;</li> <li>• Attractive decorative signal hardware, or specialized hardware; and</li> <li>• Attention to landscaping and integration with green street stormwater management techniques.</li> </ul>



**Figure 10.6** Many decisions are made within the functional area of an intersection.  
Source: Community, Design + Architecture.

## General Intersection Layout

Intersection layout is primarily composed of the alignment of the legs; width of traffic lanes, bicycle lanes, crosswalks, and sidewalks on each approach; number of lanes, median and streetside elements; and the method of treating and channelization of turning movements. Like the design of the thoroughfare's cross-section, the design of an intersection's layout requires a balance between the needs of pedestrians, bicyclists, vehicles, freight and transit in the available right of way. Beyond intersection layout, the practitioner needs to work with a multidisciplinary team to address accessibility, traffic control and placement of equipment, traffic operations, lighting (safety and pedestrian scaled), landscaping and urban design.

### Intersection Fundamentals

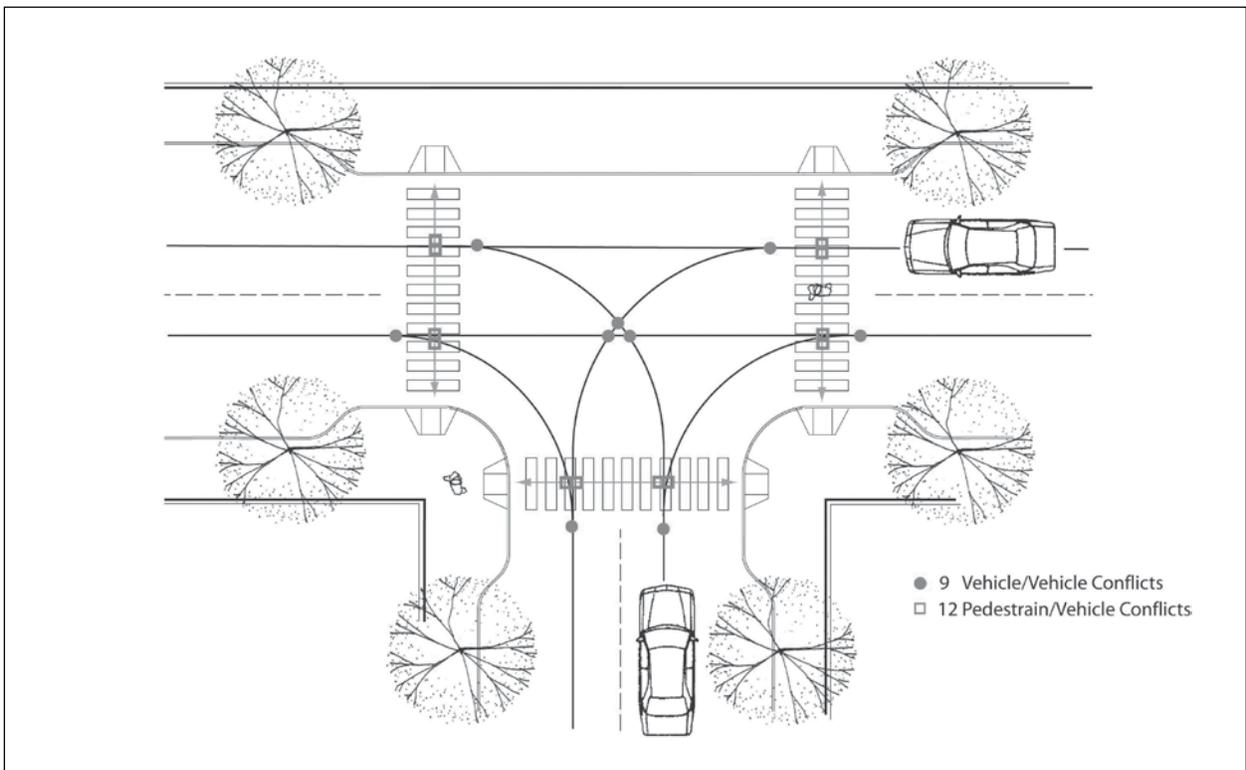
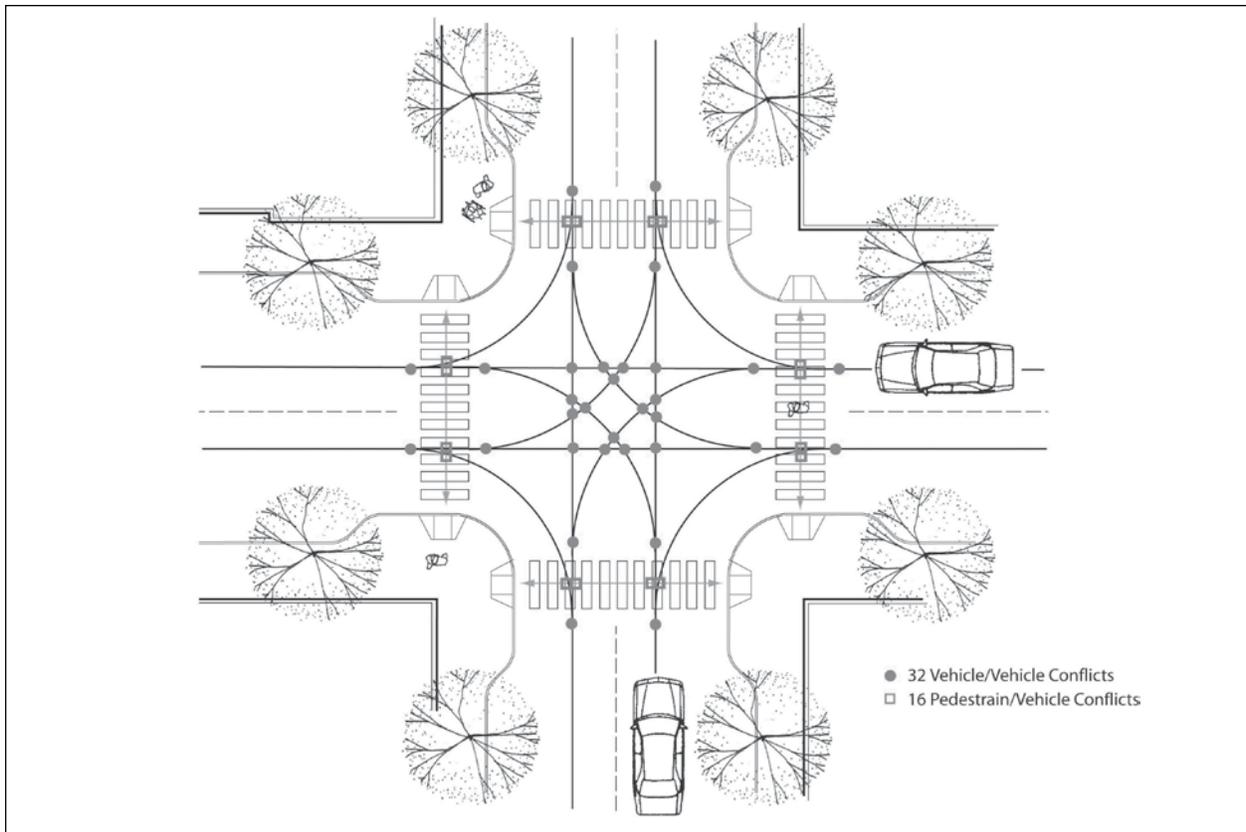
Intersections are composed of a physical area—the area encompassing the central area of two intersect-

ing streets as shown in **Figure 10.6**. The functional area is where drivers make decisions and maneuver into turning movements. The three parts of the functional area include (1) the perception-reaction distance, (2) maneuver distance and (3) storage distance. AASHTO's *A Policy on Geometric Design of Highways and Streets* (2004a) addresses the issues and provides guidance for the detailed geometric design of the functional area.

The basic types of intersections in urban contexts include the T-intersection (a three-leg intersection), cross-intersection (four-leg intersection), multileg intersection (containing five or more legs) and the modern roundabout, which is discussed later in this chapter.

### Intersection Conflicts

Intersections, by their very nature, create conflicts between vehicles, pedestrians and bicyclists. **Figure 10.7** illustrates the number of conflicts between different



**Figure 10.7** Vehicle and pedestrian conflicts at three- and four-leg intersections. Source: Community, Design + Architecture, adapted from an illustration by Michael Wallwork.

modes at three- and four-leg intersections. According to AASHTO's *Guide for the Planning, Design and Operation of Pedestrian Facilities* (2004b), the following are principles of good intersection design for pedestrians:

- **Clarity**—making it clear to drivers that pedestrians use the intersections and indicating to pedestrians where the best place is to cross;
- **Predictability**—drivers know where to expect pedestrians;
- **Visibility**—good sight distance and lighting so that pedestrians can clearly view oncoming traffic and be seen by approaching motorists;
- **Short wait**—providing reasonable wait times to cross the street at both unsignalized (via gaps created in traffic or two-stage crossings) and signalized intersections (via signal cycle length);
- **Adequate crossing time at signalized intersections**—the appropriate signal timing for all types of users to cross the street;
- **Limited exposure**—reducing conflict points where possible, reducing crossing distance and providing refuge islands when necessary; and
- **Usable crossing**—eliminating barriers and ensuring accessibility for all users.

## General Principles and Considerations

General principles and considerations for the design of intersection layouts include the following:

- Intersections should be designed as compact as practical in urban contexts. Intersections should minimize crossing distance, crossing time and exposure to traffic and should encourage pedestrian travel.
- A design speed appropriate for the context. Motorists traveling at slower speeds have more time to perceive and react to conflicts at intersections.
- Intersection approaches should permit motorists, pedestrians and bicyclists to observe and react to each other. Intersection approaches should, therefore, be as straight and flat as possible, and adequate sight distances should be maintained.

- Avoid providing very short radius horizontal curves approaching the major street to mitigate acute approach alignments, as motorists might encroach into opposing travel lanes at such curves.
- Avoid placing intersections on sharp horizontal or vertical curves where sight distances may be reduced. Intersections should not be placed on either end of a curve unless sufficient sight distance is available.
- Functional areas of adjacent intersections should not overlap.
- Channelizing islands to separate conflicts are important design elements within intersection functional areas. These include properly designed channelized right turns (see section on right-turn channelization in this chapter).
- Intersections that accommodate fixed-guideway transit have special challenges (see section on Transit Design in Chapter 9).

## Curb Return Radii

### Background and Purpose

#### Related Thoroughfare Design Elements

- Transit design
- On-street parking and configuration
- Right-turn channelization
- Pedestrian refuge islands
- Bicycle lanes

Curb returns are the curved connection of curbs in the corners formed by the intersection of two streets. A curb return's purpose is to guide vehicles in turning corners and separate vehicular traffic from pedestrian areas at intersection corners. The radius of the curve varies, with larger radii used to facilitate the turning of large trucks and buses. Larger radius corners increase the length of pedestrian crosswalks, and increase vehicular turning speeds.

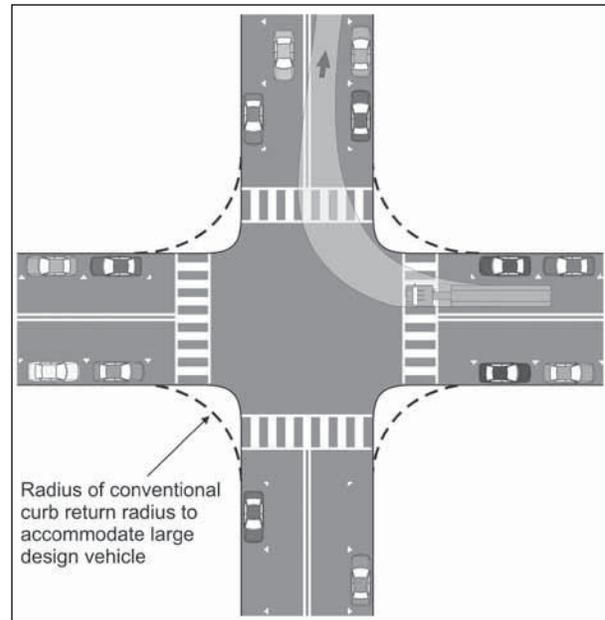
In designing walkable urban thoroughfares, the smallest practical curb-return radii are used to shorten the length of the pedestrian crosswalks. Based on this function, this report suggests a general strategy for selecting curb-return radii design criteria and discusses situations requiring larger design vehicles. The primary benefits of smaller curb-return radii to pedestrians in urban areas include:

- Increasing motorist visibility of pedestrians waiting to cross the street;
- Reducing pedestrian crossing distance (which also benefits vehicles with a shorter cycle length at signalized intersections) and exposure to traffic;
- Providing the shortest accessible route for disabled persons as required under ADA; and
- Reducing speed of turning vehicles and severity of crashes if they occur.

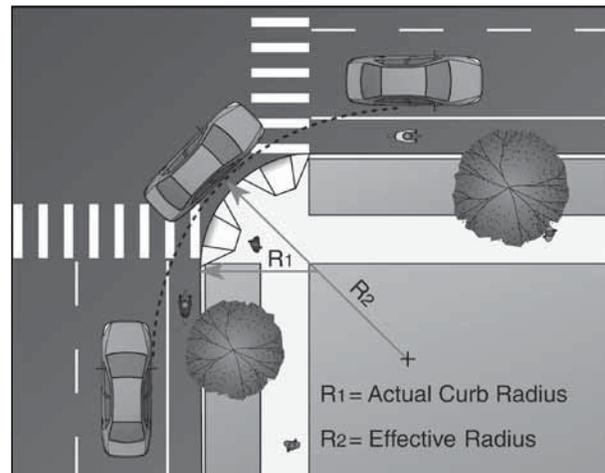
## General Principles and Considerations

General principles and considerations regarding curb return radii include the following:

- In walkable areas, the first consideration is keeping crossing distance as short as possible. Consider alternatives to lengthening the curb radius first, then consider lengthening the radius if no other alternative exists.
- Curb-return radii should be designed to accommodate the largest vehicle type that will frequently turn the corner (sometimes referred to as the design vehicle). This principle assumes that the occasional large vehicle can encroach into the opposing travel lane as shown in **Figure 10.8**. If encroachment is not acceptable, alternative routes for large vehicles should be identified.
- Curb-return radii should be designed to reflect the “effective” turning radius of the corner. The effective turning radius takes into account the wheel tracking of the design vehicle utilizing the width of parking and bicycle lanes. Use of the effective turning radii allows a smaller curb-return radius while retaining the ability to accommodate larger design vehicles (**Figure 10.9**).



**Figure 10.8** Smaller curb-return radii shorten the distance that pedestrians must cross at intersections. The occasional turn made by large trucks can be accommodated with slower speeds and some encroachment into the opposing traffic lanes. Source: Kimley-Horn and Associates, Inc.



**Figure 10.9** The existence of parking and bicycle lanes creates an “effective” turning radius that is greater than the curb-return radius. Source: Kimley-Horn and Associates, Inc., adapted from the *Oregon Bicycle and Pedestrian Plan*.

- In urban centers (C-5) and urban cores (C-6) where pedestrian activity is intensive, curb-return radii should be as small as possible.
- On multilane thoroughfares, large vehicles may encroach entirely into the adjacent travel lanes (in the same direction of travel).

- To help select a design vehicle, identify bus routes to determine whether buses are required to turn at the intersection. Also check transit service plans for anticipated future transit routes. Map existing and potential future land uses along both streets to evaluate potential truck trips turning at the intersection.
- Curb-return radii of different lengths can be used on different corners of the same intersection to match the design vehicle turning at that corner. Compound, spiral, or asymmetrical curb returns can be used to better match the wheel tracking of the design vehicle (see the AASHTO Green Book for the design of spiral and compound curves).
- If large vehicles need to encroach into an opposing travel lane, consider placing the stop line for opposing traffic further from the intersection.
- The designer must consider lane widths, curb radii, locations of parking spaces, grades and other factors in designing intersections. Designers are discouraged from using combinations of minimum dimensions unless the resulting design can be demonstrated to be operationally practical and safe.
- A curb return radius of 5 to 15 feet should be used where:
  1. High pedestrian volumes are present or reasonably anticipated;
  2. Volumes of turning vehicles are low;
  3. The width of the receiving intersection approach can accommodate a turning passenger vehicle without encroachment into the opposing lane;
  4. Large vehicles constitute a very low proportion of the turning vehicles;
  5. Bicycle and parking lanes create additional space to accommodate the “effective” turning radius of vehicles;
  6. Low turning speeds are required or desired; and
  7. Occasional encroachment of turning school bus, moving van, fire truck, or oversized delivery truck into an opposing lane is acceptable.
- Curb radii may need to be larger where:
  1. Occasional encroachment of a turning bus, school bus, moving van, fire truck, or oversized delivery truck into the opposing lane is not acceptable;
  2. Curb extensions are proposed or might be added in the future; and
  3. Receiving thoroughfare does not have parking or bicycle lanes and the receiving lane is less than 12 feet in width.

## Recommended Practice

Flexibility in the design of curb return radii revolves around the need to minimize pedestrian crossing distance, the choice of design vehicle, the combination of dimensions that make up the effective width of the approach and receiving lanes and the curb return radius itself. The practitioner needs to consider the trade-offs between the traffic safety and operational effects of infrequent large vehicles and the creation of a street crossing that is reasonable for pedestrians. The guidelines assume arterial and collector streets in urban contexts (C-3 to C-6) with turning speeds of city buses and large trucks of 5 to 10 mph. The guidance is not applicable to intersections without curbs.

Recommended practices include the following:

- In urban centers (C-5) and urban cores (C-6) at intersections with no vehicle turns, the minimum curb return radii should be 5 feet.

An alternative to increasing curb-return radii is setting back the stop line of the receiving street to allow large vehicles to swing into opposing lane as they turn. However, setbacks to accommodate right-turn encroachment need to be examined on a case-by-case basis since very tight right turns may require long setbacks.

## Recommendations for Curb Radii on Transit and Freight Routes

Truck routes should be designated outside of or on a minimum number of streets in walkable areas to reduce the impact of large turning radii. Where designated local or regional truck routes conflict

with high pedestrian volumes or activities, analyze freight movement needs and consider redesignation of local and regional truck routes to minimize such conflicts.

On bus and truck routes, the following guidelines should be considered:

- Curb-return radii design should be based on the effective turning radius of the prevailing design vehicle.
- Where the potential for conflicts with pedestrians is high and large vehicle turning movements necessitate curb radii exceeding 50 feet, evaluate installation of a channelized right-turn lane with a pedestrian refuge island (see the section on pedestrian refuge islands in Chapter 9 and the section on channelized right-turn lanes in Chapter 10). To better accommodate the path of large vehicles use a three-centered compound curve in the design of the island (see the AASHTO Green Book's Chapter 9 for design guidance).
- Where frequent turning of large vehicles takes place, avoid inadequate curb-return radii as they could potentially cause large vehicles to regularly travel across the curb and into the pedestrian waiting area of the streetside.

## Justification

Intersections designed for the largest turning vehicle traveling at significant speeds with no encroachment result in long pedestrian crossings and potentially high-conflict areas for pedestrians and bicyclists. Radii designed to accommodate the occasional large vehicle will allow passenger cars to turn at high speeds. In designing walkable urban thoroughfares, the selection of curb returns ranging from 5 to 25 feet in radius is preferable to shorten pedestrian crossings and slow vehicle-turning speeds to increase safety for all users.

# Channelized Right-Turns

## Background and Purpose

### Related Thoroughfare Design Elements

- Curb return radii
- Crosswalks
- Bicycle lanes at intersections
- Transit design

In urban contexts, high-speed channelized right turns are generally inappropriate because they create conflicts with pedestrians and bicyclists and also increase turning speeds. Under some of the circumstances described below, providing channelized right-turn lanes on one or more approaches at a signalized intersection can be beneficial, but unless designed correctly, these right-turn lanes can be undesirable for pedestrians. According to the *Oregon Bicycle and Pedestrian Plan* a well-designed channelization island can:

- Allow pedestrians to cross fewer lanes at a time and judge conflicts separately;
- Provide refuge for slower pedestrians;
- Improve accessibility to pedestrian push-buttons; and
- Reduce total crossing distance, which provides signal-timing benefits.

Right-turning drivers may not have to stop for the traffic signal when a channelized right-turn lane is provided. Even where pedestrian signal heads are provided at the intersection, pedestrians are usually expected to cross channelized right-turn lanes without the assistance of a traffic signal. Most channelized right-turn lanes consist of only one lane, and the crossing distance tends to be relatively short. However, drivers are usually looking to their left to merge into cross-street traffic and are not always attentive to the presence of pedestrians.



**Figure 10.10** A channelized right-turn lane typically provides a pedestrian refuge island and an uncontrolled crosswalk. Source: Dan Burden, walklive.org.

## General Principles and Considerations

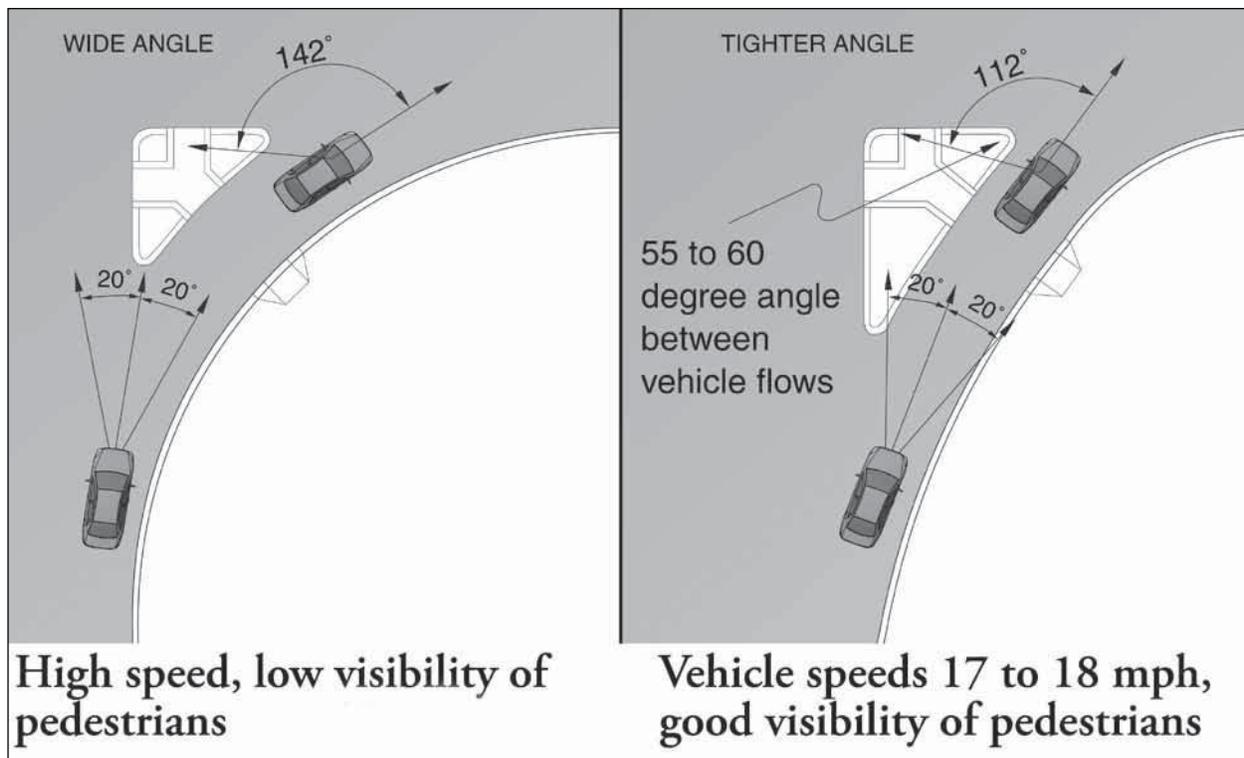
The general principles and considerations regarding channelized right turns include the following:

- Avoid using channelized right-turn lanes where pedestrian activity is or is expected to be significant. If a channelized right-turn lane is unavoidable, use design techniques described in this report to lessen the impact on pedestrians.
- Exclusive right-turn lanes should be limited. A right-turning volume threshold of 200–300 vehicles per hour is an acceptable range for the provision of right-turn lanes. Once determined that a right-turn lane is necessary, a well-designed channelization island can help slow down traffic and separate conflicts between right-turning vehicles and pedestrians (**Figure 10.10**).
- If channelized right-turn lane is justified, design it for low speeds (5 to 10 mph) and high-pedestrian visibility.
- For signalized intersections with significant pedestrian activity, it is highly desirable to have pedestrians cross fully under signal control. This minimizes vehicle-pedestrian conflicts and adds to the comfort of pedestrians walking in the area.

## Recommended Practice

Recommended practices regarding channelized right-turn lanes include the following:

- The provision of a channelized right-turn lane is appropriate only on signalized approaches where right-turning volumes are high or large vehicles frequently turn and conflicting pedestrian volumes are low and are not expected to increase greatly.
- Where channelized right-turn lanes already exist at a high-pedestrian-activity signalized intersection, pedestrians can best be served by installing pedestrian signals to the right-turn lane crossing. This enables the pedestrian to cross the legs of the intersection fully under signalized control.
- Removing channelized right-turn lanes also makes it possible to use signing, such as NO TURN ON RED, turn-prohibition signs, or exclusive pedestrian signal phases to further assist pedestrians in safely crossing the street.
- When channelized right-turn lanes are justified for traffic capacity or large vehicle purposes, the following practices should be used:
  - Provide a low-angle right turn (about 112 degrees). This angle slows down the speed of right-turning vehicles and improves driver visibility of pedestrians within and approaching the crosswalk (**Figure 10.11**).
  - Use longitudinal crosswalk striping for visibility and place crosswalks so that a motorist has a clear view of pedestrians.
  - A well-illuminated crossing point should be placed where drivers and pedestrians have good sight distance and can see each other in advance of the crossing point. Unless no other choices are available, the crossing point should not be placed at the point where right-turning drivers must yield to other vehicles and therefore might not be watching for pedestrians.
  - Provide accessible islands. The island that forms the channelized right-turn lane must be a raised island of sufficient size (at least 120 square feet) for pedestrians to safely wait in a position where they are at least

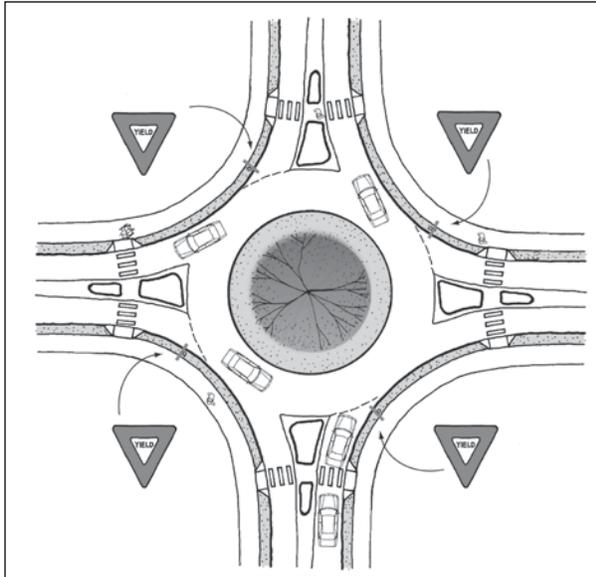


**Figure 10.11** The preferred design of a channelized right-turn lane uses an approach angle that results in a lower speed and improved visibility. Source: Kimley-Horn and Associates, Inc., adapted from an illustration by Dan Burden.

4 feet from the face of curb in all directions. A painted island is not satisfactory for pedestrians. The island also has to be large enough to accommodate accessible features, such as curb ramps (usually in three separate directions) or channels cut through the raised island that are flush with the surrounding pavement. If the crossing of the right-turn lane is signalized, the island needs to be large enough to contain pedestrian push buttons.

- Unless the turning radii of large vehicles, such as tractor-trailers or buses must be accommodated, the pavement in the channelized right-turn lane should be no wider than 16 feet. For any width right-turn lane, mark edge lines and cross-hatching to restrict the painted width of the travel way of the channelized right-turn lane to 12 feet to slow smaller vehicles.

- If vehicle-pedestrian conflicts are a significant problem in the channelized right-turn lane, it might be appropriate to provide signing to remind drivers of their legal obligation to yield to pedestrians crossing the lane in the marked crosswalk. Regulatory signs such as the TURNING TRAFFIC MUST YIELD TO PEDESTRIANS (R10-15) or warning signs such as the PEDESTRIAN CROSSING (W11-2) could be placed in advance of or at the crossing location.
- Signalize the channelized right-turn movement to eliminate significant vehicle-pedestrian conflicts. Signalization may be provided when there is/are (1) multiple right-turning lanes; (2) something inherently unsafe about the unsignalized crossing, such as poor sight distance or an extremely high volume of high-speed right-turning traffic; or (3) high pedestrian-vehicle crash experiences.



**Figure 10.12** A typical single-lane modern roundabout design provides yield control on all approaches and deflects approaching traffic to slow speeds. Source: Community, Design + Architecture, adapted from an illustration in *Roundabouts, An Informational Guide* (FHWA).

## Modern Roundabouts

### Background and Purpose

#### Related Thoroughfare Design Elements

- Pedestrian refuge islands
- Transit design
- Bicycle treatments at intersections
- Bus stops at intersections
- Bicycle lanes

Modern roundabouts are an alternative form of intersection control that is becoming more widely accepted in the United States. In the appropriate circumstances, significant benefits can be realized by converting stop-controlled and signalized intersections into modern roundabouts. These benefits include improved safety, speed reduction, reduction in certain types of vehicle crashes, opportunities for aesthetics and urban design, and operational functionality and capacity.

Studies conducted in the United States and published by the Federal Highway Administration in *Roundabouts: An Informational Guide* (2000) indicate that modern single-lane roundabouts in urban areas can result in up to a 61 percent reduction in all crashes and a 77 percent reduction in injury crashes when compared with stop-controlled intersections. When signalized intersections are replaced by modern single-lane roundabouts in urban areas, they have resulted in up to a 32 percent reduction in all crashes and up to a 68 percent reduction in injury crashes.

There remain some concerns regarding roundabouts and pedestrian and bicycle safety and how the disabled are accommodated. Care should be taken in areas with particularly high pedestrian volumes to provide adequate crosswalk widths and island dimensions to serve the volume of pedestrians moving around the roundabout. Double-lane roundabouts are of particular concern to pedestrians with visual impairments and bicyclists.

### General Principles and Considerations

The purpose of a modern roundabout is to increase vehicle capacity at the intersection, slow traffic and reduce the severity of collisions. They are not generally used to enhance pedestrian and bicycle safety. Roundabouts are not always the appropriate solution. General principles and considerations for the design of modern roundabouts include the following:

- The application of roundabouts requires close attention to a number of issues, including:
  - Type of design vehicle;
  - Use by disabled and visually impaired persons; and
  - Effects on pedestrian route directness.
- A modern roundabout should be designed to reduce the relative speeds between conflicting traffic streams and the absolute speed of vehicles to improve pedestrian safety. The curved path that vehicles must negotiate slows the traffic. Vehicles entering need to be properly deflected and yield to traffic already in the circulating roadway of the roundabout (**Figure 10.12**).

- Selecting a roundabout as the appropriate traffic control for an intersection requires location-specific analysis. Intersections with more than four legs are also good candidates for conversion to modern roundabouts, as are streets intersecting at acute angles.
- Locating pedestrian crossings at least 25 feet from the roundabout entry point.
- Accommodating bicyclists by (1) preferably mixing with the flow of vehicular traffic (but without pavement markings delineating a bicycle lane) or (2) alternatively, use of a slip ramp from the street to the sidewalk proceeding around the intersection along separate paths, which is usually combined with pedestrian facilities. This situation can create conflicts between bicyclists and pedestrians that must be addressed through good design and signage, and it is inconvenient for the bicyclist. To accommodate different ability levels of bicyclists, both options could be implemented at the same roundabout unless specific conditions warrant otherwise.
- Single-lane roundabouts (**Figure 10.13**) may typically accommodate up to 20,000 entering vehicles per day, depending on a location-specific analysis. A double-lane roundabout typically accommodates up to 40,000 vehicles per day. Capacity analyses should be conducted to determine peak hour operating conditions and levels of service. Specific dimensions need to accommodate such volumes, as are determined using roundabout analysis tools. Refer to *Roundabouts: An Informational Guide* (FHWA 2000) for more information.
- If considering a double-lane roundabout on a boulevard, carefully evaluate pedestrian crossings. It may be desirable to provide crosswalks at midblock locations away from the roundabout. Double-lane roundabouts are not recommended in areas with high levels of pedestrian and bicycle activity.
- Intersections near active railroad-grade crossings are typically not good candidates for roundabouts since traffic would be blocked in all directions when trains are present.



**Figure 10.13** Typical layout of a single lane modern roundabout. Source: Kimley-Horn and Associates, Inc.

- Sight distance for drivers entering the roundabout should be maintained to the left so that drivers are aware of vehicles and bicycles in the circle. Visibility across the center of the circle is not critical.
- Roundabouts provide an opportunity to visually enhance the area. Appropriate landscaping is encouraged, even in the center island. However, for safety, pedestrians are not permitted to walk to the center island. Thus, water features or features that might attract pedestrians to the center island should be discouraged.
- Proper signing and pavement markings should be designed for motorists, bicyclists and pedestrians in advance of and at the location of the roundabout. Consideration should be given to the use of a “yield line” where appropriate, as per Section 3B.16 of the *Manual on Uniform Traffic Control Devices* (MUTCD) (FHWA 2009).
- At some locations, pedestrian volumes may be high enough to warrant signal control of roundabout approaches to provide gaps for vehicles (since pedestrians have the right of way). Pedestrian-demand signals may be required at multilane roundabout crossings in order to create and identify gaps for some types of pedestrians: for example, children, the elderly and people who have visual or cognitive impairments.

## Recommended Practice

**Table 10.2** provides guidance for the selection of modern roundabouts for various thoroughfare types and presents general design parameters. There are three general roundabout design philosophies in use in the United States. First, many older traffic circles and rotaries are being eliminated or redesigned to modern roundabouts. Second, the Australian model of smaller-diameter and slower speed roundabouts is gaining popularity in the United States, as is the third, the British model of larger-diameter, multilane, higher-speed roundabouts. The designer should reference the planning

section of FHWA's informational guide to aid in the decision-making process.

## Justification

Roundabouts exist at more than 15,000 intersections in Europe and Australia, with decades of successful operation, research and improvements. Introduced into the United States in the 1990s, modern roundabouts are much improved over older American traffic circles and rotaries. Significant benefits related to crash and delay reduction are cited by researchers based on conversion of four-way stop-controlled and signal-controlled intersections in eight states.

**Table 10.2 Recommended Practice for Modern Roundabouts**

Parameter	Minimum "Mini-Roundabout"	Urban Compact Roundabout	Urban Single-Lane Roundabout	Urban Double-Lane Roundabout*
Maximum Entry Speed (mph)	15	15	20	25
Design Vehicle	Bus and single-unit truck drive over apron	Bus and single-unit truck	Bus and single-unit truck WB-50 with lane encroachment on truck apron	WB-67 with lane encroachment on truck apron
Inscribed circle diameter (feet)	45 to 80	80 to 100	100 to 130	150 to 180
Maximum number of entering lanes	1	1	1	2
Typical capacity (vehicles per day entering from all approaches)	10,000	15,000	20,000	40,000
Applicability by Thoroughfare Type:				
Boulevard	Not Applicable	Not Applicable	Not Applicable	Applicable
Arterial Avenue	Not Applicable	Not Applicable	Applicable	Applicable
Collector Avenue	Applicable	Applicable	Applicable	Not Applicable
Street	Applicable	Applicable	Applicable	Not Applicable

\* Note the pedestrian and bicycle conflicts are inherent in multilane roundabouts unless they are signalized.

# Pedestrian Treatments at Intersections—Crosswalks

## Background and Purpose

### Related Thoroughfare Design Elements

- Midblock crossings
- Channelized right turns
- Curb extensions
- Curb-return radii
- Modern roundabouts
- Pedestrian refuge islands

Crosswalks are used to assist pedestrians in crossing streets. The definition provided in the MUTCD of an unmarked crosswalk makes it clear that unmarked crosswalks can exist only at intersections, whereas the definition of a marked crosswalk makes it clear that marked crosswalks can exist at intersections “or elsewhere.” Crosswalks also provide the visually impaired with cues and wayfinding, as long as they have appropriate contrast.

If sidewalks exist on one or more quadrants of the intersection at a signalized or unsignalized intersection, then crosswalks are legally present at the intersection whether they are marked or not. Even if sidewalks do not exist at the intersection, in some states crosswalks may be legally present.

Even if unmarked crosswalks legally exist at a signalized intersection, it is almost always beneficial to provide marked crosswalks from the perspective of pedestrian safety. Marked crosswalks alert drivers approaching and traveling through the intersection of the potential presence of pedestrians. Marked crosswalks also direct legal pedestrian movements to desirable crossing points.

If an unmarked crosswalk legally exists across a stop-controlled approach to an intersection, it is usually

not necessary to mark the crosswalk. However, if engineering judgment determines that pedestrian safety or the minimization of vehicle-pedestrian conflicts is especially important, then providing a marked crosswalk along with advanced warning signs and markings would be appropriate.

## General Principles and Considerations

In designing thoroughfares, the issue of crosswalks is not isolated to an individual intersection. The intent of CSS in walkable areas is to create an environment in which pedestrians and bicycles are expected and to support this expectation with consistent and uniform application of signing, markings and other visual cues for motorists and pedestrians. The following principles and considerations should help guide the planning or design of pedestrian crossings:

- Assume that pedestrians and bicyclists want and need safe access to all destinations that are accessible to motorists. Additionally, pedestrians will want to have access to destinations not accessible to motorists.
- Typical pedestrian and bicyclist generators and destinations include residential neighborhoods, schools, parks, shopping areas and employment centers. Most transit stops require that pedestrians be able to cross the street.
- Pedestrians need safe access at many uncontrolled locations, including intersections and midblock locations.
- Pedestrians must be able to cross streets at regular intervals. Unlike motor vehicles, pedestrians should not be expected to go more than 300 to 400 feet out of their way to take advantage of a controlled intersection.
- Intersections provide the best locations to control motorized traffic to permit pedestrian crossings.
- In order to effectively indicate to motorists that they are in, or approaching, a pedestrian area and that they should expect to encounter pedestrians crossing the street, the design of the crosswalk must be easily understood, clearly visible



**Figure 10.14** The three primary types of crosswalk markings (from left to right) are transverse, longitudinal and diagonal. Source: Kimley-Horn and Associates, Inc.



**Figure 10.15** Crosswalks with colored bricks contrast with concrete pavement. However, over time, colored bricks stain and lose contrast. Painted stripes marking brick or colored concrete crosswalks would increase their visibility. Otherwise use standard crosswalk markings for long-term visibility. Source: Kimley-Horn and Associates, Inc.

and incorporate realistic crossing opportunities for pedestrians.

- There are three primary marking options: transverse, longitudinal and diagonal (zebra) lines (**Figure 10.14**). The placement of lines for longitudinal markings should avoid normal wheel paths, and line spacing should not exceed 2.5 times the line width.
- At unsignalized or uncontrolled crossings, special emphasis longitudinal or diagonal markings should be used to increase visibility. High-contrast markings also aid people with vision impairments, but no MUTCD provisions for the use of high-contrast pavement markings has yet been developed.
- In highly urban areas (C-5 and C-6), at compact signalized intersections and at other locations with higher levels of pedestrian activity, pedestrian signals should automatically show the WALK sign without requiring activation.
- Although it is not a traffic control device, colored and textured crosswalk design treatments are sometimes used between transverse lines to further delineate the crosswalk, provide contrast for the visually impaired, provide tactile feedback to drivers and improve aesthetics (**Figure 10.15**).

Care should be taken to ensure that the material used in these crosswalks is smooth, nonslip and visible. Avoid using a paver system that may shift and/or settle or that induces a high degree of vibration in wheelchair wheels.

## Recommended Practice

The following practice is recommended:

- Provide marked crosswalks at urban signalized intersections for all legs of the intersection; and
- Provide a marked crosswalk across an approach controlled by a STOP sign where engineering judgment determines there is significant pedestrian activity and pedestrian safety or the minimization of vehicle-pedestrian conflicts is especially important at that particular location (also see section titled Design Elements for Intersections in Walkable Areas in this chapter).

## Justification

Marked crosswalks are one tool to get pedestrians safely across the street and they should be used in combination with other treatments (such as curb extensions, pedestrian refuge islands, proper light-

ing and so forth). In most cases, marked crosswalks alone (without other treatments) should not be installed within an uncontrolled environment when speeds are greater than 40 mph according to AASHTO's *Guide for the Planning, Design and Operation of Pedestrian Facilities* (2004b) and FHWA's *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations* (2002).

Pedestrians can legally cross the street at any intersection, whether a marked crosswalk exists or not. To enhance awareness by motorists, install crosswalks on all approaches of signalized intersections. If special circumstances make it unsafe to do so, attempt to mitigate the circumstance.

## Curb Extensions

### Background and Purpose

Curb extensions (also called nubs, bulb-outs, knuckles, or neck-downs) extend the line of the curb into the traveled way, reducing the width of the street. Curb extensions typically occur at intersections but can be used at midblock locations to shadow the width of a parking lane, bus stop, or loading zone. Curb extensions can provide the following benefits:

- Reduce pedestrian crossing distance and exposure to traffic;
- Improve driver and pedestrian visibility at intersections;
- Separate parking maneuvers from vehicles turning at the intersections;
- Visually and physically narrow the traveled way, resulting in a calming effect;
- Encourage and facilitate pedestrian crossing at preferred locations;
- Keep vehicles from parking too close to intersections and blocking crosswalks;
- Provide wider waiting areas at crosswalks and intersection bus stops;
- Reduce the effective curb-return radius and slow turning traffic;
- Provide space for level landings and clear space required at pedestrian push buttons, as well as

double perpendicular curb ramps with detectable warnings; and

- Provide space for streetscape elements if extended beyond crosswalks.

Curb extensions serve to better define and delineate the traveled way as being separate from the parking lane and streetside. They are used only where there is on-street parking and the distance between curbs is greater than what is needed for the vehicular traveled way.

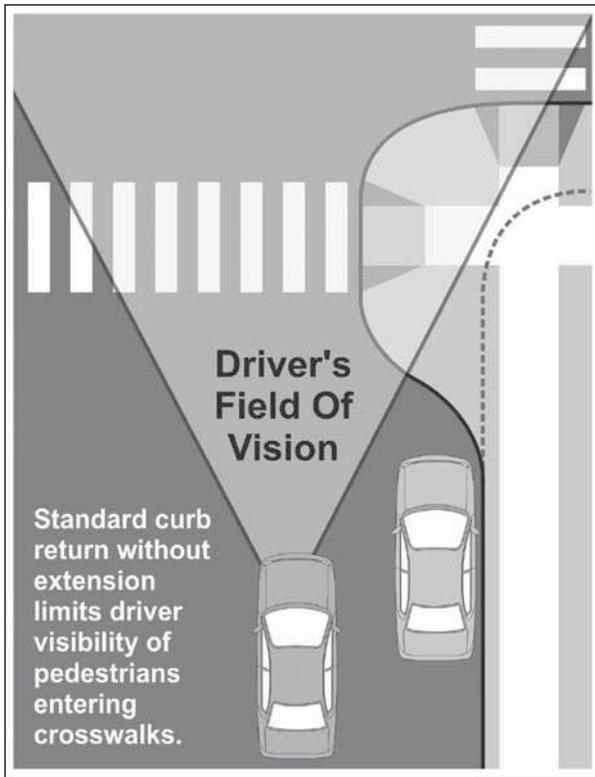
### Related Thoroughfare Design Elements

- Curb-return radii
- Channelized right turns
- Lane width
- Crosswalks
- Midblock crossings
- Bus stops at intersections
- Bus stops in the traveled way

### General Principles and Considerations

General principles and considerations regarding curb extensions include the following:

- Curb extensions may be used at intersections in any context zone but are emphasized in urban centers (C-5), urban cores (C-6) and other locations with high levels of pedestrian activity.
- Curb extensions help manage conflict between modes, particularly between vehicles and pedestrians. The curb extension is an effective measure to improve pedestrian safety and comfort and might contribute to slower vehicle speed.
- The design of the curb extension should create an additional pedestrian area in the driver's field of vision, thereby increasing the visibility of pedestrians as they wait to cross the street, as shown in **Figure 10.16**.



**Figure 10.16** Curb extensions can improve pedestrian visibility and reduce crossing distance. Source: Digital Media Productions.

- Curb extensions are used only where there is on-street parking and where only a small percentage of turning vehicles are larger than the design vehicle.
- Curb extensions are not applicable to intersections with exclusive right-turn lanes adjacent to

the curb, or intersections with a high volume of right-turning trucks or buses turning into narrow cross streets.

- Carefully consider drainage in the design of curb extensions to avoid interrupting the flow of water along the curb, thus pooling water at the crosswalk.
- Curb extensions work especially well with diagonal parking, shadowing the larger profile of the row of parking and providing large areas in the pedestrian realm.
- Adjusting the curb-return radius can accommodate emergency vehicles and large design vehicles. An “effective” radius can accommodate the design vehicle through the use of a mountable (or flush with pavement) extension with bollards to delineate the pedestrian area as shown in **Figures 10.17** and **10.18**. Flush curb extensions are frequently combined with raised intersections. However, care should be taken to provide adequate vehicle turning paths outside the designated pedestrian waiting area.
- Where bicycle lanes exist, the curb extension must be outside the width of the bicycle lane.
- Design curb-extension radii to allow street cleaning vehicles to reach and turn all inside and outside corners. Normally this requires a radius of 15 feet. This will also help stormwater flow in the gutters around corners.
- Ensure good street lighting not only for pedestrians but so that the extension is visible to drivers at night and in adverse weather.



**Figure 10.17** A mid block crossing with a flush curb in New Zealand. Pedestrians are separated from passing vehicles with bollards. Source: Community, Design + Architecture.



**Figure 10.18** Use of contrasting material and bollards to delineate the pedestrian and vehicle areas. Source: Kimley-Horn and Associates, Inc.

## Recommended Practice

The following practices are recommended when designing curb extensions on urban thoroughfares:

- Reduce crossing width at intersections by extending the curb line into the street by 6 feet for parallel parking and to within 1 foot of stall depth with angled parking. Ensure that the curb extension does not extend into travel or bicycle lanes.
- Apply the appropriate curb-return radius in the design of a curb extension. If necessary, use three-centered or asymmetric curb returns to accommodate design vehicles.
- Where buses stop in the travel lane, curb extensions can be used to define the location of the stop and create additional waiting areas and space for shelters, benches and other pedestrian facilities.
- When possible, allow water to drain away from the curb extension. In other cases a drainage inlet may need to be installed and connected to an existing underground storm-drain system.
- Curb extensions are usually constructed integral with the curb. In retrofit projects, curb extensions may be constructed away from the curb to allow drainage along the original flowline (Figure 10.19). Consider that this design might require additional maintenance to keep the flowline clear.
- When considering construction of curb extensions where an existing high road crown exists, reconstruction of the street might be necessary to avoid back draining the sidewalk toward abutting buildings. Slot drains along the sidewalk may provide an alternate solution.
- Sidewalks, ramps, curb extensions and crosswalks should all align with no unnecessary meandering.

## Justification

Curb extensions in unused or underutilized street space can be used to shorten pedestrian crossing distance, increase pedestrian visibility and provide additional space for pedestrian queuing and support activity. Extensions can increase safety, efficiency and attractiveness.



**Figure 10.19** Curb extensions may be used as landscaping or hardscape opportunities. This example shows a retrofit curb extension with drainage retained between the extension and the curb. Source: Community, Design + Architecture.

## Bicycle Lane Treatment at Intersections

### Background and Purpose

Selecting appropriate bicycle lane treatments at intersections requires providing uniformity in facility design, signs and pavement markings for bicyclists and motorist safety. The objective is to promote a clear

#### Related Thoroughfare Design Elements

- Bicycle lanes
- Curb extensions
- Right-turn channelization
- Lane width

understanding of safe paths through all intersection movements for bicyclists and motorists.

## General Principles and Considerations

General principles and considerations regarding bicycle lane treatment at intersections include the following:

- Since bicyclists ride on the right-hand side of adjacent motor vehicle traffic, bicyclists desiring to travel straight through an intersection conflict with motor vehicles that are making a right turn at the intersection. On intersection approaches that have a shared through/right-turn lane, bicyclists not turning right need to position themselves in the center of the through/right lane to safely traverse the intersection and avoid conflicts with right-turning vehicles. For this reason, the bike lane, if used, should be dashed on the approach to the intersection stop bar to indicate that the motorist should share the space with the bicyclists.
- Similarly, bicycle lanes should be dashed in bus stops to encourage buses to pull all the way to the curb.
- On intersection approaches that have an exclusive right-turn lane, the bicycle lane should be positioned to the left of the right-turn lane. Drivers of right-turning motor vehicles moving into the turn lane have an obligation to yield to any present bicyclists. The higher-speed motor vehicle is usually approaching the beginning of the turn lane from behind the bicyclist and has a better view of the potential conflict.
- A more complex situation exists when an exclusive right-turn lane is created by dropping a through lane. The bike lane can typically transition from the right of the right-turn lane to the left of the right-turn lane with a shift in alignment.
- Where there are numerous left-turning bicyclists, a left-turn bicycle lane may be provided on an intersection approach. This lane is located between the vehicular left-turn lane and the adjacent through lane so that bicyclists can keep to the outside as they turn left.

- On approaches to roundabout intersections, the bicycle lane needs to be terminated 100 feet before the crosswalk, yield line or limit of circulatory roadway and should not be provided on the circulatory roadway of the roundabout intersection.

## Recommended Practice

The recommended practice for bicycle lane treatment at intersections on urban thoroughfares is shown in **Table 10.3**.

## Justification

At intersections, bicyclists proceeding straight through and motorists turning right must cross paths unless the cyclist moves to the center of the through-right travel lane. Therefore, striping bike lanes up to the stop bar conflicts with this movement. Striping and signing configurations that encourage crossings in advance of the intersection in a weaving fashion reduce conflicts at the intersection and improve bicycle and motor vehicle safety. Similarly, modifications such as special sight distance considerations, wider roadways to accommodate on-street lanes, special lane markings to channelize and separate bicycles from right-turning vehicles, provisions for left-turn bicycle movements and special traffic signal designs (such as conveniently located push buttons at actuated signals or even separate signal indications for bicyclists) also improve safety and operations and balance the needs of both transportation modes when on-street bicycle lanes or off-street bicycle paths enter an intersection.

## Bus Stops at Intersections

### Background and Purpose

Walkable thoroughfare design for bus stops at intersections emphasizes an improved environment for pedestrians and techniques for efficient transit operations. Design considerations for buses are addressed in detail in the section on midblock bus stops in Chapter 9.

**Table 10.3 Recommended Practice for Bicycle Lane Treatment at Intersections on Walkable Urban Thoroughfares**

<b>Intersection Conditions and Related Recommendations</b>	
With pedestrian crosswalks	
	<ul style="list-style-type: none"> <li>• Bike lane striping should not be installed across any pedestrian crosswalks, and, in most cases, should not continue through any street intersections.</li> </ul>
With no pedestrian crosswalks	
	<ul style="list-style-type: none"> <li>• Bike lane striping should stop at the intersection stop line, or the near side cross street right-of-way line projection, and then resume at the far side right-of-way line projection.</li> <li>• Dash the bike lane prior to the stop line per MUTCD, to warn both motorists and cyclists of the need to prepare for right-turn movements at the intersection.</li> <li>• Bike lane striping may be extended through complex intersections with the use of dotted or skip lines.</li> </ul>
Parking considerations	
	<ul style="list-style-type: none"> <li>• The same bike lane striping criteria apply whether parking is permitted or prohibited in the vicinity of the intersection.</li> </ul>
Bus stop on near side of intersection or high right-turn volume at unsignalized minor intersections with no stop controls	
	<ul style="list-style-type: none"> <li>• A 6 to 8-inch solid line should be replaced with a dashed line with 2-foot dashes and 6-foot spaces for the length of the bus stop. Bike lane striping should resume at the outside line of the crosswalk on the far side of the intersection.</li> <li>• In the area of a shared through/right turn, the solid bike lane, if used, should be dashed to the stop bar to indicate that the right-turning motorist should share the space with bicyclists.</li> </ul>
Bus stop located on far side of the intersection	
	<ul style="list-style-type: none"> <li>• Solid white line should be replaced with a dashed line for a distance of at least 80 feet from the crosswalk on the far side of the intersection.</li> </ul>
T-intersections with no painted crosswalks	
	<ul style="list-style-type: none"> <li>• Bike lane striping on the far side across from the T-intersection should continue through the intersection area with no break. If there are painted crosswalks, bike lane striping on the side across from the T-intersection should be discontinued through the crosswalks.</li> </ul>
Pavement markings	
	<ul style="list-style-type: none"> <li>• Bike lane markings should be installed according to the provisions of Chapter 9C of the MUTCD.</li> <li>• The standard pavement symbols are one of two bicycle symbols (or the words "BIKE LANE") and an optional directional arrow as specified in the MUTCD. Symbols should be painted on the far side of each intersection. Pavement markings should be white and reflectorized.</li> </ul>
Signs	
	<ul style="list-style-type: none"> <li>• Bike lanes should be accompanied by appropriate signing at intersections to warn of conflicts (see Chapter 9B of the MUTCD).</li> </ul>
Actuation at Traffic Signals	
	<ul style="list-style-type: none"> <li>• If bike lane extends to the stop bar, provide a detector in the lane and appropriate pavement marking to indicate where the bicyclist should stop.</li> <li>• If the bicyclist shares a travel lane, provide a detector (and pavement marking) in the center of the lane.</li> <li>• If in-pavement or video detection is not possible, install a push-button on the curb accessible to the bicyclist.</li> </ul>

## Related Thoroughfare Design Elements

- Lane width.
- Curb extensions.
- Bus stops in the traveled way.
- Curb-return radius.
- Crosswalks.

## Recommended Practice

### Placement of Bus Stops at Intersections

The preferred location for bus stops is the near side or far side of an intersection. This location provides the best pedestrian accessibility from both sides of the street and connection to intersecting bus routes. While not preferred, bus stops on long blocks may be placed at a midblock location or to serve a major transit generator (See Chapter 9). Guidance and considerations related to bus stops at intersections include the following:

- Consider a near-side stop on two-lane thoroughfares where vehicles cannot pass a stopped bus.
- Consider a far-side stop on thoroughfares with multiple lanes where vehicular traffic may pass uncontrolled around the bus.
- On thoroughfares where vehicular traffic is controlled by a signal, the bus stop may be located either near side or far side, but far side is preferable.
- Where it is not desirable to stop the bus in a travel lane and a bus pullout is warranted, a far side or midblock stop is generally preferred. As with other elements of the roadway, consistency of stop placement lessens the potential for operator and passenger confusion.
- When locating a bus stop in the vicinity of a driveway, consider issues related to sight distance, blocking access to development and potential conflicts between automobiles and buses.
- The approach to a bus stop from the sidewalk to the bus must be fully accessible as defined by the U.S. Access Board. Bus stop access must in every case include a safe and accessible street crossing.

It must also contain a loading area of at least 5 feet by 8 feet for wheelchairs to board. (see Chapter 9)

The placement of bus stops at intersections varies from site to site. However, general considerations for the placement of bus stops at intersections include the following:

- When the route alignment requires a left turn, the preferred location for the bus stop is on the far side of the intersection after the left turn is completed.
- When the route alignment requires a left turn and it is infeasible or undesirable to locate a bus stop far side of the intersection after the left turn, a midblock location is preferred. A midblock bus stop should be located far enough upstream from the intersection so a bus can maneuver into the proper lane to turn left.
- If there is a high volume of right turns at an intersection or when the transit route turns right at an intersection, the preferred location for a stop is on the far side of the intersection.
- In circumstances where the accumulation of buses at a far-side stop would spill over into the intersection and additional length is not available, the stop should be placed on the near side of the intersection.
- At complex intersections with dual right- or left-turn lanes, far-side stops are preferred because they remove the buses from the area of complicated traffic movements.
- When there is substantial transfer activity between two bus routes on opposite sides of the street, placing one stop near side and one at the adjacent far-side location can minimize the number of crossings required to transfer between buses.

**Table 10.4** summarizes the advantages and disadvantages of far-side and near-side bus stop placements.

### Curb Extension Bus Stops (Bus Bulbs)

A curb extension may be constructed along streets with on-street parking. Curb extensions may be designed in conjunction with bus stops to facilitate bus operations and passenger access. The placement of a

**Table 10.4 Advantages and Disadvantages of Far side and Near side Bus Stops**

<b>Far Side Bus Stops</b>	
<b>Advantages</b>	<b>Disadvantages</b>
<ul style="list-style-type: none"> <li>• Minimizes conflict between buses and right turning vehicles traveling in the same direction</li> <li>• Minimizes sight distance problems on approaches to the intersection</li> <li>• Encourages pedestrians to cross behind the bus</li> <li>• Minimizes area needed for curbside bus zone</li> <li>• If placed just beyond a signalized intersection in a bus turnout, buses may more easily re-enter the traffic stream</li> <li>• If a turnout is provided, vehicle capacity through intersection is unaffected</li> <li>• Can better take advantage of traffic signal priority for buses</li> </ul>	<ul style="list-style-type: none"> <li>• If bus stops in travel lane, could result in traffic queued into intersection behind the bus (turnout will allow traffic to pass around the stopped bus)</li> <li>• If bus stops in travel lane, could result in rear-end accidents as motorists fail to anticipate stopped traffic</li> <li>• May cause passengers to access buses further from crosswalk</li> <li>• May interfere with right turn movement from cross street</li> <li>• May obscure sight distance for crossing vehicles</li> <li>• If signal priority not in use, bus may have to stop twice, once at signal and then at bus stop</li> </ul>
<b>Near Side Bus Stops</b>	
<b>Advantages</b>	<b>Disadvantages</b>
<ul style="list-style-type: none"> <li>• Minimizes interference when traffic is heavy on the far side of an intersection</li> <li>• Allows passengers to access buses close to crosswalk</li> <li>• Driver may use the width of the intersection to pull away from the curb</li> <li>• Allows passengers to board and alight when the bus is stopped for a red light</li> <li>• Provides the driver with the opportunity to look for oncoming traffic, including other buses with potential passengers</li> </ul>	<ul style="list-style-type: none"> <li>• Stopped bus interferes with right turns</li> <li>• May cause sight distance problem for approaching traffic, cross-street traffic and pedestrians</li> <li>• If located in a pullout or shoulder or at a signalized intersection, a traffic queue may make it difficult for buses to re-enter the traffic stream</li> <li>• Prohibits through traffic movement with green light, similar to far side stop without a bus turnout</li> <li>• May cause pedestrians to cross in front of the bus at intersections</li> <li>• Limits use of traffic signal priorities</li> </ul>

Source: *Bus Stop Safety and Design Guidelines Manual*, Orange County Transportation Authority and Kimley-Horn and Associates, Inc.

bus stop on a curb extension should follow the same guidelines as those previously stated (a near-side stop is preferred on two-lane streets where vehicles cannot pass a stopped bus; in the case of a street with multiple lanes where vehicular traffic may pass uncontrolled around the bus, a far-side stop is preferred for sight distance issues).

A bus stop on the near side of a single-lane approach of an uncontrolled intersection should completely obstruct the traffic behind it. Where it is not acceptable to have stopped buses obstruct a lane of traffic and a bus turnout is justified according to the criteria presented in Chapter 9 (section on midblock bus stops), a bus stop may be placed on the far side in the parking lane just beyond the curb extension. It might be appropriate to place a bus stop on a far-side curb extension at

an uncontrolled intersection if the warrants for a bus pullout are not met and its placement will not create a traffic hazard.

Near-side curb extensions are usually about 6 feet in width and of sufficient length to allow passengers to use the front and back doors of a bus. A near-side curb extension bus stop is shown in **Figure 10.20**.

Besides reducing the pedestrian crossing distances, curb extensions with near-side bus stops can reduce the impact to parking (compared to typical bus zones), mitigate traffic conflicts with autos for buses merging back into the traffic stream, make crossing pedestrians more visible to drivers and create additional space for passenger queuing and amenities, such as a shelter and/or a bench.



**Figure 10.20** A near-side curb extension bus stop. Source: Kimley-Horn and Associates, Inc.

In areas where curb extensions are desired, but it is not acceptable to have the bus stop in the travel lane, a far-side pullout area can be created in the parking lane. This location and design eliminates the safety hazard of vehicles passing the bus prior to entering the intersection. However, bus stop length will likely be increased over the normal far-side length because of the need to add an approach taper to the stop downstream from the curb extension.

### **Queue Jumpers**

Queue jumpers provide priority treatment for buses along arterial streets by allowing buses to bypass traffic queued at congested intersections. Queue jumpers evolved from the need to reduce bus delays at intersections or other congested locations. In the past, traffic engineers constructed bus turnouts to move buses out of the traffic stream while they are stopped for passengers. Bus turnouts introduce significant travel time penalties to bus patrons because buses are delayed while attempting to reenter the traffic stream. Queue jumpers provide the double benefit of removing stopped buses from the traffic stream to benefit the general traffic and getting buses through congested intersections so as to benefit bus operations.

Queue jumpers consist of a near-side right-turn lane (buses excepted) and a far-side bus stop and/or acceleration lane. Buses are allowed to use the right-turn lane to bypass traffic congestion and proceed through the intersection. Additional enhancements to queue jumpers could include an exclusive bus-only lane upstream from the traffic signal, extension of the right-turn lane to bypass traffic queued at the intersection, or advanced green indication allowing the bus to pass through the intersection before general traffic does.

### **Queue Jumper With an Acceleration Lane**

This option includes a near-side right-turn lane (buses excepted), near-side bus stop and acceleration lane for buses with a taper back to the general purpose lanes on the far-side of the intersection.

### **Queue Jumper With a Far-Side Bus Stop**

This option may be used when there is a heavy directional transfer to an intersecting transit route. Buses can bypass queues either using a right-turn lane (buses excepted) or an exclusive bus queue jump lane. Since the bus stop is located on the far side, a standard transition can be used for buses to reenter the traffic

stream. Queue jumpers at urban thoroughfare intersections should be considered when:

1. High-frequency bus routes have an average headway of 15 minutes or less;
2. Forecasted traffic volumes exceed 500 vehicles per hour in the curb lane during the peak hour and right-turn volumes exceed 250 vehicles per hour during the peak hour; and
3. Intersection operates at an unacceptable level of service (defined by the local jurisdiction).

## Works Cited

American Association of State Highway and Transportation Officials. 2004a. *A Policy on Geometric Design of Highways and Streets*. Washington, DC: AASHTO.

American Association of State Highway and Transportation Officials. 2004b. *Guide for the Planning, Design and Operation of Pedestrian Facilities*. Washington, DC: AASHTO.

Federal Highway Administration. 2009. *Manual on Uniform Traffic Control Devices*. Washington, DC: FHWA.

Federal Highway Administration. 2000. *Roundabouts: An Informational Guide*. Washington, DC: FHWA.

Federal Highway Administration. 2002. *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations*. Washington, DC: FHWA.

Oregon DOT. *Oregon Bicycle and Pedestrian Plan*.

Transportation Research Board. 2006. *Improving Pedestrian Safety at Unsignalized Crossings, NCHRP Report 562*. Washington, DC.

Federal Highway Administration. 2005. *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations*. FHWA Publication #: HRT-04-100. Washington, DC: FHWA.

United States Access Board. *Accessible Public Rights-of-Way*. Accessible via [www.access-board.gov/prowac/](http://www.access-board.gov/prowac/)

## Sources of Additional Information

American Association of State Highway and Transportation Officials. *A Guide to Achieving Flexibility in Highway Design*. Washington, DC: AASHTO, May 2004.

American Association of State Highway and Transportation Officials. *Guide for the Development of Bicycle Facilities*. Washington, DC: AASHTO, 1999.

American Planning Association. *Bicycle Facility Planning*. Chicago, IL: APA, 1995.

Congress for the New Urbanism. *Codifying New Urbanism*. Chicago, IL: American Planning Association, May 2004.

Federal Highway Administration. *Flexibility in Highway Design*. Washington, DC: FHWA, 1997.

Institute of Transportation Engineers. *Innovative Bicycle Treatments*. Washington, DC: ITE, 2002.

Insurance Institute for Highway Safety/Ryerson Polytechnic University. *Crash Reductions Following Installation of Roundabouts in the United States*. March 2000.

Jacobs, Allan. *Great Streets*. Cambridge, MA: MIT Press, 1995.

Leisch, Joel P. *Freeway and Interchange Geometric Design Handbook*. Washington, DC: ITE, 2005.

Oregon Department of Transportation. *Main Street—When a Highway Runs Through It, A Handbook for Oregon Communities*. Oregon Department of Transportation, November 1999.

Transportation Research Board. NCHRP Report 330: *Effective Utilization of Street Width on Urban Arterials*. Washington, DC: TRB, 1990.

Transportation Research Board. *NCHRP Report 500, Volume 3: A Guide for Addressing Collisions with Trees in Hazardous Locations*. Washington, DC: TRB, 2003.

Transportation Research Board. *NCHRP Report 524: Safety of U-Turns at Unsignalized Median Openings*. Washington, DC: TRB, 2004.

Public Rights-of-Way Access Advisory Committee (PROWAAC). *Special Report: Accessible Public Rights-of-Way: Planning and Designing for Alterations*. 2007.

## Key Terms and New Concepts

**Accessibility**—A term describing the degree to which something is accessible by as many people as possible. In transportation design, accessibility is often used to focus on people with disabilities and their right of access to thoroughfares, buildings and public transportation. Accessibility also refers to transportation facilities that comply with *Public Rights-of-Way Accessibility Guidelines* (PROWAG).

**Access Management**—Access management is defined as the management of the interference with through traffic caused by traffic entering, leaving and crossing thoroughfares. It is also the control and regulation of the spacing and design of driveways, medians, median openings, traffic signals and intersections on arterial streets to improve safe and efficient traffic flow on the road system.

**Arterial**—A street that typically emphasizes a high level of traffic mobility and a low level of property access. Arterials accommodate relatively high levels of traffic at higher speeds than other functional classes and serve longer distance trips. Arterial streets serve major centers of activity of a metropolitan area and carry a high proportion of the total urban area travel. Arterials also serve significant intra-area travel, such as between central business districts and outlying residential areas, between major inner city communities or major suburban centers. Arterial streets carry important intra-urban as well as intercity bus routes.

**Articulation**—An architectural term that refers to dividing building facades into distinct parts that reduce the appearance of the building's mass adjacent to the sidewalk, identify building entrances and minimize uninviting blank walls.

**Bicycle Boulevard**—A roadway that motorists may use that prioritizes bicycle traffic through the use of various treatments. Through motor vehicle traffic is discouraged by periodically diverting it off the street. Remaining traffic is slowed to approximately the same speed as bicyclists. STOP signs and signals on

the bicycle boulevard are limited to the greatest extent possible, except when aiding bicyclists in crossing busy streets.

**Collector**—A street that typically balances traffic mobility and property access. Collector streets provide land access and traffic circulation within residential neighborhoods, commercial and industrial areas. Collector streets pass through residential neighborhoods, distributing trips from the arterials through the area to the ultimate destination. Collector streets also collect traffic from local streets in residential neighborhoods and channel it into the arterial system. In the central business district, and in other areas of like development and traffic density, the collector system may include the street grid that forms a logical entry for traffic circulation.

**Community**—A group of people living within a defined geographic area or political boundary such as a neighborhood, district, town, city, or region. It is both a physical place of streets, buildings, schools and parks and a socioeconomic structure, often defined by qualities including social traits, values, beliefs, culture, history, government structure, issues of concern and type of leadership.

**Community Livability**—Refers to the environmental and social quality of an area as perceived by residents, employees, customers and visitors, including safety and health, local environmental conditions, quality of social interactions, opportunities for recreation and entertainment, aesthetics and existence of unique cultural and environmental resources.

**Context**—The nature of the natural or built environment created by the land, topography, natural features, buildings and associated features, land use types and activities on property adjacent to streets and on sidewalks and a broader area created by the surrounding neighborhood, district, or community. Context also refers to the diversity of users of the environment.

**Context Sensitive Solutions (CSS)**—Collaborative, interdisciplinary process that involves all stakeholders to design a transportation facility that fits its applicable setting and preserves scenic, aesthetic, historic and environmental resources while maintaining safety and mobility. CSS respects design objectives for safety, efficiency, capacity and maintenance while integrating community objectives and values relating to compatibility, livability, sense of place, urban design, cost and environmental impacts.

**Context Zone**—One of a set of categories used to describe the overall character of the built and natural environment, building from the concept of the “transect”—a geographical cross section through a sequence ranging from the natural to the highly urbanized built environment. There are six context zones plus special districts describing the range of environments including four urban context zones for the purpose of CSS—suburban, general urban, urban center and urban core.

**Control Vehicle**—A vehicle that infrequently uses a facility and must be accommodated, but encroachment into the opposing traffic lanes, multiple-point turns, or minor encroachment into the roadside is acceptable. A condition that uses the control vehicle concept arises where occasional large vehicles turn at an intersection with low opposing traffic volumes (e.g., a moving van in a residential neighborhood or once per week delivery at a business) or where large vehicles rarely turn at an intersection with moderate to high opposing traffic volumes (e.g., emergency vehicles).

**Corridor**—A transportation pathway that provides for the movement of people and goods between and within activity centers. A corridor encompasses single or multiple transportation routes or facilities (such as thoroughfares, public transit, railroads, highways, bikeways, etc.), the adjacent land uses and the connecting network of streets.

**Corridor Plan**—Document that defines a comprehensive package of recommendations for managing and improving the transportation system within and along a specific corridor, based upon a 20-year planning horizon. Recommendations may include any effective mix of strategies and improvements for many modes.

**Corridor Planning**—Process that is collaborative with local governments and includes extensive public participation opportunities. A corridor may be divided into logical, manageable smaller areas for the purpose of corridor planning.

**Design Control**—Factors, physical and operational characteristics, and properties that control or significantly influence the selection of certain geometric design criteria and dimensions. Design speed, traffic and pedestrian volumes, location and sight distance are examples of design controls.

**Design Vehicle**—Vehicle that must be regularly accommodated without encroachment into the opposing traffic lanes. A condition that uses the design vehicle arises where large vehicles regularly turn at an intersection with high volumes of opposing traffic (e.g., a bus route).

**Edge Zone**—The area between the face of curb and furnishing zone, an area of required clearance between parked vehicles or traveled way and appurtenances or landscaping.

**Environment**—The natural and built places within or surrounding a community. The natural environment includes the topography, natural landscape, flora and fauna, streams, lakes and watersheds, and other natural resources, while the human/built environment includes the physical infrastructure of the community, as well as its institutions, neighborhoods, districts, and historical and cultural resources.

**Frontage Zone**—The distance between the throughway and the building front or private property line that is used to buffer pedestrians from window shoppers, appurtenances and doorways. It contains private street furniture, private signage, merchandise displays, etc. The frontage zone can also be used for street cafes. This zone is sometimes referred to as the “shy” zone.

**Functional Classification**—A system in which streets and highways are grouped into classes according to the character of service they intended to provide.

**Furnishings Zone**—The area of the roadside that provides a buffer between pedestrians and vehicles. It

contains landscaping, public street furniture, transit stops, public signage, utilities, etc.

**Human Scale**—How humans perceive the size of their surroundings and their comfort with the elements of the natural and built environment relative to their own size. In urban areas, human scale represents features and characteristics of buildings that can be observed within a short distance and at the speed of a pedestrian, and sites and districts that are walkable. In contrast, auto scale represents a built environment where buildings, sites, signs, etc. are designed to be observed and reached at the speed of an automobile.

**Intermodal**—Refers to the connections between transportation modes.

**Intersection**—Where two or more public streets meet. They are characterized by a high level of activity and shared use, multi-modal conflicts, complex movements and special design treatments.

**Local Street**—Streets with a low level of traffic mobility and a high level of land access, serving residential, commercial and industrial areas. Local governments typically have jurisdiction for these streets.

**Major Thoroughfare**—As defined for this report, major streets (and rights-of-way, including improvements between the pavement edge and right-of-way line) in urban areas that fall under the conventional functional classes of arterials and collector streets. Thoroughfares are multimodal in nature and are designed to integrate with and serve the functions of the adjacent land uses.

**Mixed-Use**—The combining of, or zoning for, retail/commercial and/or service uses with residential or office use in the same building or on the same site either vertically (with different uses stacked upon each other in a building) or horizontally (with different uses adjacent to each other or within close proximity).

**Mixed-use Area**—Areas comprised of a mix of land uses, scales and densities that provide some level of internal pedestrian connectivity. The Urban Land Institute (ULI) defines mixed-use as “three or more significant revenue producing uses with significant functional and physical integration of the different uses that conform to a coherent plan.”

**Mobility**—The movement of people or goods within the transportation system.

**Multimodal**—Refers to the availability of transportation options within a system or corridor whether it be walking, bicycling, driving, or transit.

**Multi-use Area**—Areas containing two or more land uses that may or may not be complementary and interactive, but that have little or no internal connectivity by any travel mode, and have little or no shared access or shared parking. Nearly all interaction between buildings in this type of area is by motor vehicle travelling on public streets rather than within large parking areas.

**New Urbanism**—A multidisciplinary movement dedicated to the restoring of existing urban centers and towns within metropolitan regions, reconfiguring sprawling suburbs into real neighborhoods and diverse districts, conserving natural environments and preserving a community’s built legacy. The new urbanist vision is to transform sprawl and establish compact, walkable, sustainable neighborhoods, streets, and towns.

*(Source: Charter of the New Urbanism and [www.cnu.org](http://www.cnu.org))*

**Place/Placemaking**—A holistic and community-based approach to the development and revitalization of cities and neighborhoods. Placemaking creates unique places with lasting value that are compact, mixed-use, and pedestrian and transit oriented, and that have a strong civic character.

*(Source: [www.placemakers.com](http://www.placemakers.com) and Chuck Bohl, “Placemaking”)*

**Public Participation**—A collaborative process that encourages stakeholders to participate in the formation, evaluation and conclusion of a plan or transportation improvement project.

**Right of way**—The publicly owned land within which a thoroughfare can be constructed. Outside of the right-of-way the land is privately owned and cannot be assumed to be available for thoroughfare construction without acquiring the land through dedication or purchase.

**Safety**—A condition of being safe, free from danger, risk, or injury. In traffic engineering, safety involves reducing the occurrences of crashes, reducing the severity of crashes, improving crash survivability, developing programmatic safety programs and applying appropriate design elements in transportation improvement projects.

**Sight Distance**—Distance that a driver can see ahead in order to observe and successfully react to a hazard, obstruction, decision point, or maneuver.

**Single-use Area**—Single-use areas may be corridors or districts which are predominantly comprised of a single type of land use. Often the scale of single-use areas, their lack of a mix of uses and their associated roadway networks tend not to be conducive to walking. Transportation in single-use areas is primarily by motor vehicles, although transit and bicycling can be viable modes. Single-use areas might contain large tracts of housing such as subdivisions or commercial, or industrial uses that rely on freight movement and therefore need to accommodate significant numbers of large vehicles.

**Smart Growth**—Land use development practices that create more resource efficient and livable communities, with accessible land use patterns. It is an alternative to sprawl development patterns.

**Stakeholders**—Groups or individuals that have an interest (stake) in the outcome of the planning or project development process. Typical stakeholders include elected officials, appointed commissioners, metropolitan planning organizations, state and local departments of transportation, transit authorities, utility companies, business interests, neighborhood associations and the general public.

**Streetside**—The public right-of-way, which typically includes the planting area and sidewalk, from the back of the curb to the front property line of adjoining parcels. The roadside is further divided into a series of zones that emphasize different functions including the frontage, throughway, furnishings and edge zones. Transportation facilities, including bus shelters, waiting areas and bicycle parking, may be part of the roadside.

**Thoroughfare**—As defined for this report, major streets (and their rights-of-way, including improvements between pavement edge and right-of-way line) in urban areas that fall under the conventional functional classifications of arterials and collector streets excluding limited-access facilities. Thoroughfares are multi-modal in nature, and are designed to integrate with and serve the functions of the adjacent land uses.

**Throughway Zone**—The walking zone that must remain clear both horizontally and vertically for the movement of pedestrians.

**Traditional Urban Environments**—Places with development pattern, intensity and design characteristics that combine to make frequent walking and transit use attractive and efficient choices, as well as provide for automobiles and convenient and accessible parking. Traditional urban environments typically have mixed land uses in close proximity to one another, building entries that front directly on the street, building, landscape and thoroughfare design that is pedestrian-scale, relatively compact development, a highly-connected, multimodal circulation network, usually with a fine “grain” created by relatively small blocks, thoroughfares and other public spaces that contribute to “placemaking” (the creation of unique locations that are compact, mixed-use, and pedestrian and transit oriented, that have a strong civic character and with lasting economic value).

**Transect**—A continuum of contexts ranging from the natural and agricultural (parks, open space, farmland) to varying intensities of urbanism (from suburban to urban core). The transect is the basis for the four urban context zones used in this guidance.

**Transitions**—A change in thoroughfare type, context (e.g., rural to urban), right-of-way width, number of lanes, or neighborhood or district. Geometrically, transitions refer to the provision of a proper smooth taper where lanes or shoulders change width, lanes diverge or merge, or lanes have been added or dropped.

**Traveled Way**—The public right-of-way between curbs, including parking lanes, and the travel lanes for private vehicles, goods movement, transit vehicles and bicycles. Medians, turn lanes, transit stops and exclusive transit lanes, curb and gutter, and loading/unloading zones are included in the traveled way.

**Traversable Community**—Denotes the ability to travel within an area based on the area’s size, network connectivity, availability of multimodal facilities, and mix of uses that elicit the need to travel within the area. Large and predominantly single-use districts are most easily traversed by automobile; whereas compact mixed-use districts can be viably traversed by walking or bicycling.

**Urban Area**—As defined by federal-aid highway law (Section 101 of Title 23, U.S. Code) urban area means an urbanized area as an urban place as designated by the Bureau of the Census having a population of 5,000 or more.

**Values**—Attributes and characteristics regarded by a community as having ultimate importance, significance, or worth. Community values encompass the natural and built environment, its social structure, people and institutions. The term often refers to a set of principles, standards, or beliefs concerning the elements of the community that are of ultimate importance.

**Vision**—Part of the process of planning a community that involves residents looking into the future, thinking creatively and establishing what they want their community to be in a 20- or 50-year planning horizon. A vision describes an ideal picture and guides goal-setting, policies and actions by helping to understand community concerns, prioritize issues, determine necessary actions and identify indicators to measure progress. Successful visions include a future that:

- Balances economic, environmental and social needs from a long-term perspective in terms of decades or generations instead of years;
- Incorporates the views of a wide cross-section of the community; and
- Tracks its progress in reaching the future.

(Source: [www.communitiescommittee.org](http://www.communitiescommittee.org))

**Walkable**—Streets and places designed or reconstructed to provide safe and comfortable facilities for pedestrians, and are safe and easy to cross for people of all ages and abilities. Walkable streets and places provide a comfortable, attractive and efficient environment for the pedestrian including an appropriate separation from passing traffic, adequate width of roadside

to accommodate necessary functions, pedestrian-scaled lighting, well-marked crossings, protection from the elements (e.g., street trees for shade, awnings, or arcades to block rain), direct connections to destinations in a relatively compact area, facilities such as benches, attractive places to gather or rest such as plazas and visually interesting elements (e.g., urban design, streetscapes, architecture of adjacent buildings).

**Walkable Communities**—Walkable communities possess these two attributes: first, by location, in a mixed-use area within an easy and safe walk of goods (such as housing, offices, and retail) and services (such as transportation, schools, libraries) that a community resident or employee needs on a regular basis. Second, by definition, walkable communities make pedestrian activity possible, thus expanding transportation options, and creating a streetscape that better serves a range of users—pedestrians, bicyclists, transit riders and automobiles. To foster walkability, communities must mix land uses and build compactly, and ensure safe and inviting pedestrian corridors.

(Source: [www.smartgrowth.org](http://www.smartgrowth.org))

## Additional Sources of Definitions

Victoria Transport Policy Institute. TDM Encyclopedia Glossary. May 10, 2005. [www.vtpi.org/tdm/tdm61.htm](http://www.vtpi.org/tdm/tdm61.htm).

Federal Highway Administration. FHWA Functional Classification Guidelines, Section II. Concepts, Definitions, and System Characteristics. April 2000. [www.fhwa.dot.gov/planning/fcsec2\\_1.htm](http://www.fhwa.dot.gov/planning/fcsec2_1.htm).

Metropolitan Transportation Commission (San Francisco Bay Area). Arterial Operations Program Ped/Bike Safety Toolbox. April 2003. [www.bayareatraffic-signals.org/toolbox/Tools/BikeBlvd.html](http://www.bayareatraffic-signals.org/toolbox/Tools/BikeBlvd.html)





## Introduction to Context Sensitive Solutions (CSS)

### What is CSS?

CSS is a different way to approach the planning and design of transportation projects. It is a process of balancing the competing needs of many stakeholders starting in the earliest stages of project development. It is also flexibility in the application of design controls, guidelines and standards to design a facility that works for all users regardless of the mode of travel they choose.

There are many definitions of CSS (see sidebar for example definitions from state DOTs) but they share a common set of tenets:<sup>1</sup>

- “Balance safety, mobility, community and environmental goals in all projects;
- Involve the public and stakeholders early and continuously throughout the planning and project development process;
- Use a multidisciplinary team tailored to project needs;
- Address all modes of travel including pedestrians, transit/paratransit, bicycles, private motor vehicles and freight;
- Accommodate all types of travelers including young, old and disabled, as well as able bodied adults safely, conveniently and comfortably on all thoroughfares;
- Apply flexibility inherent in applying design guidelines and standards; and
- Incorporate aesthetics and accessibility as an integral part of good design.”

These tenets can be applied to the planning and design of any type of transportation project in any context, the result of which is aptly summarized in the

1. Expanded from a list of Principles from the Minnesota Department of Transportation as published on the University of Minnesota’s Center for Transportation Studies Web site [www.cts.umn.edu/education/csd/index.html](http://www.cts.umn.edu/education/csd/index.html)

### CSS as Defined by State Departments of Transportation

“Context sensitive solutions use innovative and inclusive approaches that integrate and balance community, aesthetic, historic and environmental values with transportation safety, maintenance and performance goals. Context sensitive solutions are reached through a collaborative, interdisciplinary approach involving all stakeholders.”

#### California Department of Transportation

“Context Sensitive Solutions (CSS) is a philosophy wherein safe transportation solutions are designed in harmony with the community. CSS strives to balance environmental, scenic, aesthetic, cultural and natural resources, as well as community and transportation service needs. Context sensitive projects recognize community goals, and are designed, built and maintained to be sustainable while minimizing disruption to the community and environment.”

#### New York State Department of Transportation

“The essence of CSS is that a proposed transportation project must be planned not only for its physical aspects as a facility serving specific transportation objectives, but also for its effects on the aesthetic, social, economic and environmental values, needs, constraints and opportunities in a larger community setting. WSDOT endorses the CSS approach for all projects, large and small, from early planning through construction and eventual operation. CSS is a process that places a high value on seeking and, if possible, achieving consensus. WSDOT’s belief is that consensus is highly advantageous to all parties and may help avoid delay and other costly obstacles to project implementation.”

#### Washington State Department of Transportation

following quote from *A Guide to Achieving Flexibility in Highway Design* (AASHTO 2004):

“...a highway or transportation project that reflects a community consensus regarding purpose and need, with the features of the project developed to produce an overall solution that balances safety, mobility and preservation of scenic, aesthetic, historic and environmental resources.”

## Why CSS is Important

CSS principles applied to the planning and design of a transportation project can make the difference between a successful project valued by the community or an embattled project taking years or even decades to complete, if ever. There are numerous examples of transportation projects that have ground to a halt or that have been held up in the courts long before final design is ever reached. Why? One common theme in these unsuccessful projects is not just contention over the project, but a lack of understanding of what the community values and a failure to address stakeholder issues and concerns. Some common issues that affect transportation projects include:

- Real or perceived incompatibility with surroundings;
- Community impacts;
- Emphasis on mobility without consideration of other community values;
- Disproportionate distribution of benefits or impacts (environmental justice); and
- Lack of stakeholder education and participation throughout the planning and design processes.

A CSS approach to the planning and design of a transportation project (otherwise referred to as a CSS process) cannot guarantee resolution of issues or even alleviate all contention. It can, however, minimize problems and delays by ensuring stakeholder involvement, identification of issues and community values and evaluation of alternative solutions that meet the needs and purpose of the project and address issues to the extent possible. A successful CSS process builds consensus on the best possible solution and promotes community ownership in the results.

## Elements of Effective CSS

An effective CSS approach to transportation planning and project development can take many different forms, but should include the following key elements:

- A common understanding of the purpose and need of the transportation project;
- Stakeholder involvement at critical points in the project;

## Benefits of CSS

“As an approach to transportation, CSS has spread rapidly since 1998. In large part this is because CSS practitioners and advocates understand and embrace its many important benefits:

- CSS solves the right problem by broadening the definition of “the problem” that a project should solve, and by reaching consensus with all stakeholders before the design process begins.
- CSS conserves environmental and community resources. CSS facilitates and streamlines the process of NEPA compliance.
- CSS saves time. It shortens the project development process by gaining consensus early, thereby minimizing litigation and redesign and expediting permit approvals.
- CSS saves money. Shortening the project development process and eliminating obstacles save money and time.
- CSS builds support from the public and the regulators. By partnering and planning a project with the transportation agency, these parties bring full cooperation, and often additional resources as well.
- CSS helps prioritize and allocate scarce transportation funds in a cost-effective way, at a time when needs far exceed resources.
- Group decisions are generally better than individual decisions. Research supports the conclusion that decisions are more accepted and mutually satisfactory when made by all who must live with them.
- CSS is the right thing to do. It serves the public interest, helps build communities and leaves a better place behind.”

Source: [www.contextsensitivesolutions.org](http://www.contextsensitivesolutions.org)

- Multidisciplinary team approach to planning and design;
- Attention to community values and qualities including accessibility, environment, scenic, aesthetic, historic and natural resources, as well as safety and mobility; and

- Objective evaluation of a full range of alternatives.

**Purpose and need:** Understanding the purpose and need of the project includes developing an inclusive problem definition/statement that represents a common viewpoint of the problem among the stakeholders. According to the Federal Highway Administration (2005), “the purpose and need is the foundation of the decision-making process, influencing the rest of the project development process, including the range of alternatives studied and, ultimately, the selected alternative.” The generally accepted characteristics of an effective purpose and need statement include:

- The statement should be concise, easy-to-read and readily understandable.
- It should focus on essential needs, goals and policies for the project, which generally relate to transportation issues (such as mobility, safety, accessibility and reliability); it should be careful to delineate other desirable elements (environmental protection, scenic improvements) as separate from the purpose and need.
- It should be supported by data and policy that justify the need.
- It should focus on the problems that need to be addressed, and for which a proposed project is being considered, (for example, the purpose is to improve safety along a highway segment that has a high accident rate), and should not be written in a way that prematurely focuses on a specific solution or too narrowly constrains the range of alternatives (e.g., the purpose is to widen the highway).

**Stakeholder involvement:** Stakeholders are agencies, organizations, or individuals who have some level of authority over, an interest in, or may be potentially impacted by a transportation project. An effective CSS approach allows for meaningful stakeholder participation—meaning that stakeholders have an opportunity to participate in decisions or contribute in a way that can influence decisions. The CSS process can range from information dissemination, education and the provision of stakeholder input and comments to proactive hands-on involvement through town meetings, workshops, charrettes and advisory committees.

**Multidisciplinary team approach:** A multidisciplinary approach to planning and design incorporates the viewpoints of the various agencies, stakeholders and professionals who have roles or areas of concern in the transportation project. The different viewpoints allow coordination between different activities and resolution of competing interests. A multidisciplinary team approach can also result in a broader range of potential alternatives that meet multiple objectives. The makeup of planning and design teams can vary significantly depending on the nature of the project and can include anyone or any organization connected with the project, including, but not limited to, the following:

- Transportation planners;
- Highway/traffic and transit engineers;
- Environmental scientists;
- Resource agency representatives;
- Land use planners;
- Urban designers, architects;
- Landscape architects, urban foresters;
- Property owners;
- Users;
- Utility and transit owners/operators;
- Community and interest group leaders/representatives;
- Elected or appointed officials; and
- Fire, police, highway maintenance representatives.

**Attention to community values and important qualities:** Citizens value specific attributes of their community, whether it is the economic vitality of their downtown, their history, ease of mobility and safe streets, the quality of schools, natural resources, scenic qualities, or their system of parks. These important values can be overlooked in the evaluation process. The CSS approach works with stakeholders and the community to identify their values. It strives to integrate these values into evaluation criteria, and develop alternatives to preserve and enhance community attributes and address concerns.

**Objective evaluation of a full range of alternatives:** At a minimum, the development of alternatives must meet the purpose and need of the project. Ideally,

alternatives developed in a CSS approach meet the purpose and need, preserve and enhance community values and address stakeholder concerns. They also educate the design professional about factors that are important for project success and acceptance. Objectivity is important and all possibilities should be screened in a process that involves the stakeholders. The development, evaluation and screening of alternatives are opportunities to educate non-technical stakeholders.

For a more detailed discussion of the elements of an effective CSS process refer to *NCHRP Report 480: A Guide to Best Practices in Achieving Context Sensitive Solutions* (TRB 2002).

## Conventional Process Versus CSS

There are fundamental differences in the approaches to design that can result in different outcomes. Conventional thoroughfare design is frequently driven by traffic demand and level of service objectives. The first two design elements of a thoroughfare are typically determined in the transportation planning process—functional classification and number of lanes. The outcome of this vehicle mobility-focused process influences the rest of the design process, from working with stakeholders to the final design. A pre-determined outcome can be a source of conflict with stakeholders that delays or even stops projects because the thoroughfare design may not be considered compatible with its surroundings or does not address the critical concerns of the community.

CSS-inspired thoroughfare design also begins the transportation planning process with an emphasis on identifying critical factors and issues before establishing design criteria. Certainly functional classification, travel forecasts and levels of service are factors to consider in CSS, and may be a high priority objective under many circumstances. Through a multidisciplinary approach, including a full range of stakeholders, the process seeks to identify the core issues/problems, develop a spectrum of alternatives and reach consensus on the best solution. The process may determine that level of service needs to be balanced along with environmental, historic preservation, or economic development objectives in the community. This process

results in a well thought out and rationalized design tradeoff—the fundamental basis of CSS.

An inclusive process is not a guarantee of success, but it often results in early acceptance and community ownership of transportation projects. The tenets of CSS in thoroughfare design are summarized in the principles described in the next section.

## CSS Principles, Processes and Outcomes

The qualities and characteristics of a transportation project were originally developed at a conference in Maryland in 1998 entitled “Thinking Beyond the Pavement.” In 2007, at a meeting of the AASHTO Standing Committee on Highways, a group of FHWA, state department of transportation and institutional representatives refined the definition and principles of CSS resulting in a list of process characteristics and outcomes. These process characteristics and outcomes have become measures by which successful context sensitive solutions are judged.<sup>2</sup>

Based on the refined definition, context sensitive solutions is guided by a process which:

- Establishes an interdisciplinary team early, including a full range of stakeholders, with skills based on the needs of the transportation activity.
- Seeks to understand the landscape, the community, valued resources and the role of all appropriate modes of transportation in each unique context before developing engineering solutions.
- Communicates early and continuously with all stakeholders in an open, honest and respectful manner, and tailors public involvement to the context and phase.
- Utilizes a clearly defined decision-making process.

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<sup>2</sup> Refer to “Results of Joint AASHTO/FHWA Context Sensitive Solutions Strategic Planning Process, Summary Report, March 2007”. Prepared by the Center for Transportation and the Environment at North Carolina State University. The document can be found at [www.contextsensitivesolutions.org](http://www.contextsensitivesolutions.org).

- Tracks and honors commitments through the life cycle of projects.
- Involves a full range of stakeholders (including transportation officials) in all phases of a transportation program.
- Clearly defines the purpose and seeks consensus on the shared stakeholder vision and scope of projects and activities, while incorporating transportation, community and environmental elements.
- Secures commitments to the process from local leaders.
- Tailors the transportation development process to the circumstances and uses a process that examines multiple alternatives, including all appropriate modes of transportation, and results in consensus.
- Encourages agency and stakeholder participants to jointly monitor how well the agreed-upon process is working, to improve it as needed, and when completed, to identify any lessons learned.
- Encourages mutually supportive and coordinated multimodal transportation and land-use decisions.
- Draws upon a full range of communication and visualization tools to better inform stakeholders, encourage dialogue and increase credibility of the process.

Context sensitive solutions lead to outcomes that:

- Are in harmony with the community and preserve the environmental, scenic, aesthetic, historic, and natural resource values of the area.
- Are safe for all users.
- Solve problems that are agreed upon by a full range of stakeholders.
- Meet or exceed the expectations of both designers and stakeholders, thereby adding lasting value to the community, the environment and the transportation system.
- Demonstrate effective and efficient use of resources (people, time and budget,) among all parties.





Institute of Transportation Engineers

1099 14th Street, NW  
Suite 300 West  
Washington, DC 20005-3438  
USA

[www.ite.org](http://www.ite.org)

CONGRESS  
FOR THE  
NEW  
URBANISM

The Marquette Building  
140 S. Dearborn Street, Suite 404  
Chicago, IL 60603  
USA

[www.cnu.org](http://www.cnu.org)