An ITE Proposed Recommended Practice

Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities

Institute of Transportation Engineers

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This project was partially funded by a cooperative agreement from the Environmental Protection Agency's Development, Community and Environment Division.

RP-036

500/GP/JS/0306

Printed in the United States of America
ISBN No: 1-933452-11-0

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Preface and Acknowledgements

This report is published as a proposed recommended practice of the Institute of Transportation Engineers (ITE). As such, it is to be considered in its proposed form, but is subject to change after receipt and consideration of suggestions from those who have reviewed the report. Readers are encouraged to submit written suggestions for improving this report to:

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ITE wishes to thank the Federal Highway Administration's Office of Infrastructure, Office of Planning, Environment and Realty and the Environmental Protection Agency's Office of Policy, Economics and Innovation Development for financially supporting this work effort and providing leadership and guidance in the development of this report.

This report was developed through a partnership with ITE and the Congress for the New Urbanism (CNU) and is the result of several years of concerted effort by dedicated volunteers, including ITE and CNU members and many other interested parties. ITE wishes to thank the members of each of the following committees for their respective roles in the preparation of this report.

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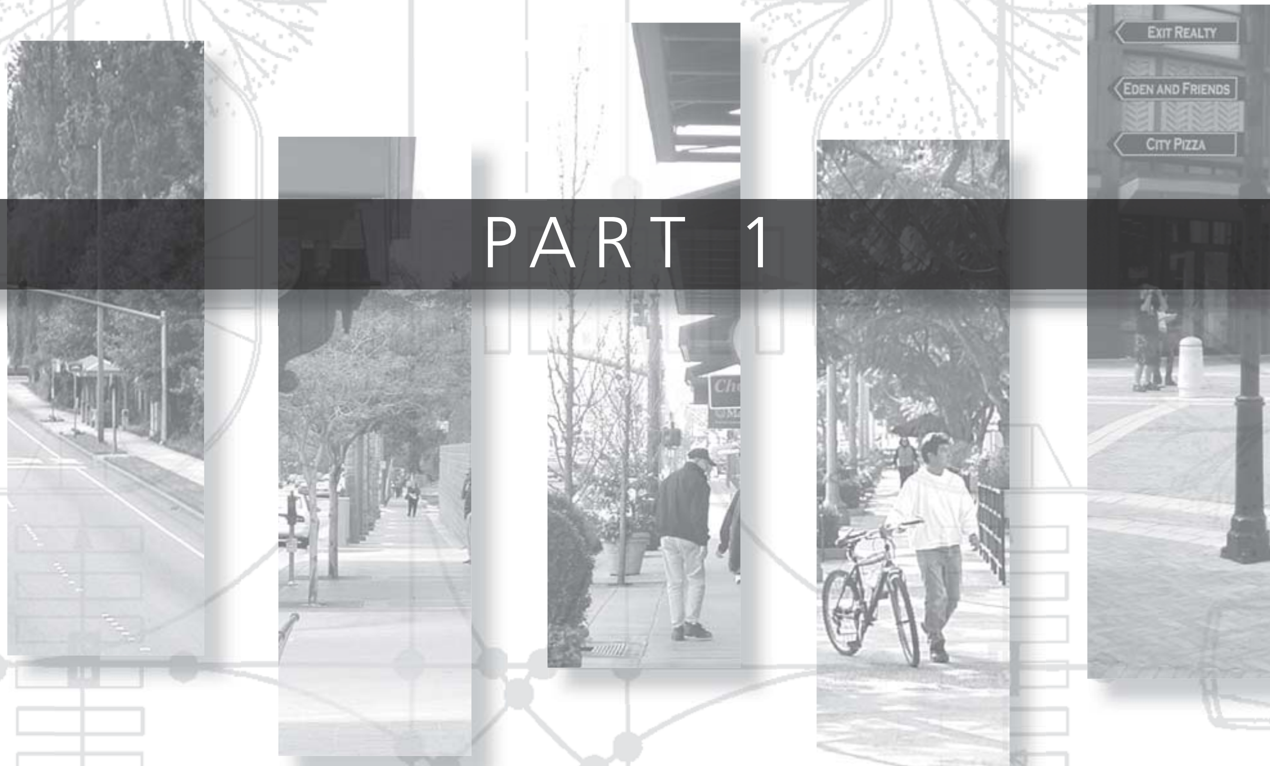
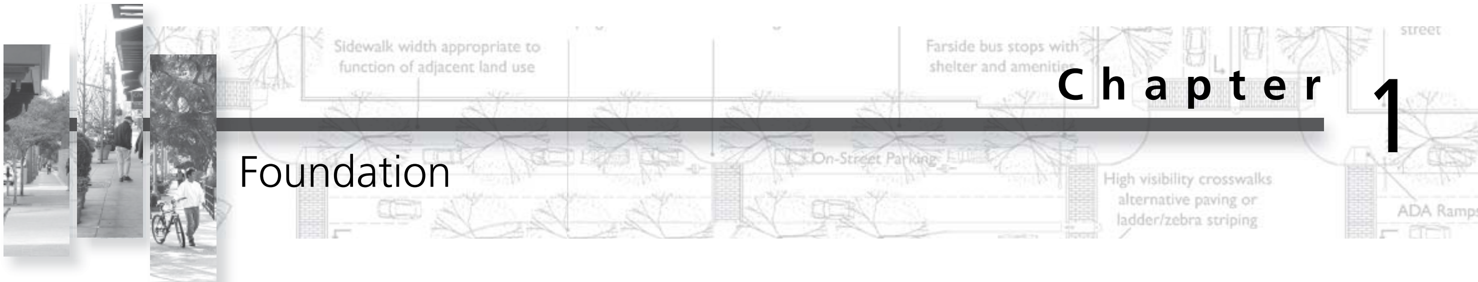


PART 1

Introduction



Chapter 1

Foundation

Purpose

This report advances the successful use of context sensitive solutions (CSS) in the planning and design of major urban thoroughfares for walkable communities. It provides guidance and demonstrates for practitioners how CSS concepts and principles may be applied in roadway improvement projects that are consistent with their physical settings.

CSS is the result of developing transportation projects that serve all users and are compatible with the surroundings through which they pass—the community and environment. Successful CSS results from a collaborative, multidisciplinary and holistic approach to transportation planning and project development. CSS in the transportation planning or project development process identifies objectives, issues and concerns based on stakeholder and community input at each level of planning and design (for example, network, corridor and project). This report provides guidance in how CSS principles may be considered and applied in the processes involved with planning and developing roadway improvements along urban thoroughfares.

As documented in *Context-Sensitive Design Around the Country* (TRB 2004), *A Guide to Best Practices for Achieving Context Sensitive Solutions* (TRB 2002) and other sources, the principles of CSS are successfully used in towns and cities as well as in rural areas. Agencies are transforming the current project development process to meet the expectations of all users and stakeholders. Integrating CSS principles into the project development process results in the consideration of a broad range of objectives and an attempt to balance these objectives based on the needs and conditions specific to each project and its context. The use of CSS principles in the project development process is resulting in community interests, user needs and environmental issues being considered early in the development of roadway improvement projects—specifically in defining the project's purpose and need, and as appropriate, in other decisions in each phase of the project.

Objectives

The objectives of this report are to:

1. Describe the principles of CSS and the benefits and importance of CSS in transportation projects;
2. Identify how CSS principles can be applied in the processes involved with planning and developing roadway improvement projects on major urban thoroughfares;
3. Describe the relationship, compatibility and tradeoffs that may be appropriate when balancing the needs of users, adjoining land uses, environment and community interests;
4. Present guidance on how to identify and select appropriate thoroughfare types and corresponding design parameters to best meet the needs of a particular context; and
5. Provide criteria for specific roadway elements along with guidance on balancing stakeholder, community and environmental needs and constraints in roadway improvement projects.

Focus of Report

This report provides guidance for the development of improvement projects on major urban thoroughfares, facilities that are typically classified as arterial and collector roadways in urbanized areas. While CSS is applicable to all types of transportation facilities, the guidelines in this report exclude high-speed limited access facilities (including freeways, expressways and parkways) and local streets. The report's chapters are focused on applying the principles of CSS in transportation planning and in the design of roadway improvement projects in places where community objectives support walkable communities—compact development, mixed land uses and support for pedestrians and bicyclists, whether it already exists or is a goal for the future. Many of the principles, concepts and design guidelines are directly applicable to urban thoroughfares in other contexts.

The principles, concepts and design criteria presented in this report are applicable to transportation planning as well as to thoroughfare design, and to construction and maintenance. The traditional term "thoroughfare" is used in this report instead of conventional names (street, roadway, or highway) to distinguish lower speed urban roadways from other types of roadways, and because some conventional names are used in this report to define different types of thoroughfares. For purposes of this report, lower speed is defined as a range of operating speeds from 25 to 35 mph, and higher speed is defined as 40 to 45 mph.

This report addresses the controlling elements of thoroughfare design, presents a context-based design process within the project development framework and provides specific design guidelines for the various elements that comprise the major urban thoroughfare.

Organization

This report is divided into three parts: introduction, planning and design. There are eleven chapters, with Chapter 1 being the introduction, Chapters 2 through 4 addressing CSS and the planning and project development process, and Chapters 5 through 11 addressing the thoroughfare design process and specific design criteria. Table 1.1 lists the chapters and provides an overview of the material that is addressed in each chapter.

Chapter 6 provides general design parameters and example designs for major urban thoroughfares with speeds up to 35 mph, in areas with high levels of pedestrian, bicycle and transit activity. Chapter 11 provides general design parameters for thoroughfares intended to operate at 40 to 45 mph in areas of lower multimodal activity. Design guidelines in Chapters 8 through 10 focus on the design of lower speed thoroughfares but much of this guidance is also applicable to the higher speed facilities addressed in Chapter 11.

Who Should Use Report

This report is for practitioners and stakeholders involved in the planning and design of major urban thoroughfares for walkable communities. Users are encouraged to consider the principles and guidelines in this report in conjunction with applicable local policies and standards. Table 1.2 presents many of the intended users and their responsibilities where CSS principles may be considered. Each user listed in Table 1.2 represents a different set of stakeholders, which brings different perspectives and responsibilities to the transportation planning and project development processes to best meet the needs of the stakeholders. However, all users may benefit from an understanding of CSS principles and how they might be integrated into their work.

Introduction to 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 is safe 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:[1]

- "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 an interdisciplinary team tailored to project needs;
- Address all modes of travel;
- Apply flexibility inherent in design standards; and
- Incorporate aesthetics as an integral part of good design."

1 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

Table 1.1 Contents of This Report

Chapter Title	Material that is Addressed
Part 1: Introduction	
1 – Foundation	The background behind this guidance, principles of CSS, definitions and an overview of the CSS process.
Part 2: Planning	
2 – Planning and Developing Context Sensitive Urban Thoroughfares	An overview of the transportation planning and project development process and how CSS is applied within these processes.
3 – Network and Corridor Planning	An overview of thoroughfare network types, characteristics of successful networks and network design guidelines. An overview of the corridor planning process and the role of CSS.
4 – A Framework for Urban Thoroughfare Design	An introduction into the design framework for context sensitive thoroughfare design, context zones, their characteristics and the features that create context, a description of thoroughfare types and their relationship with functional classifications, compatibility with context zones and general design parameters.
Part 3: Design	
5 – Thoroughfare Design Process	Process for using this report to design thoroughfares, how to design thoroughfares within constrained rights-of-way and flexibility in the application of design criteria.
6 – Typical Thoroughfare Designs	General design parameters for thoroughfare types, variations in the roadside and traveled way under varying conditions and example thoroughfare designs.
7 – Design Controls	A discussion of the engineering controls and level of flexibility critical in context sensitive design including design vehicle, roadway geometrics and design speed.
8 – Roadside Design Guidelines	General principles, design considerations and detailed guidance for the design of the elements that comprise the roadside.
9 – Traveled Way Design Guidelines	General principles, design considerations and detailed guidance for the design of the elements that comprise the traveled way.
10 – Intersection Design Guidelines	General principles, design considerations and detailed guidance for the design of the elements that comprise multimodal intersections.
11 – Thoroughfares in Vehicle Mobility Priority Areas	General design parameters for thoroughfare design in single use areas and areas where vehicular mobility is a priority and comparison of conventional and CSS cross-section determination in these areas.

Table 1.2 Intended Users and Responsibilities

User	Responsibilities
Transportation Planner	• Develops and evaluates long range transportation plans • Helps establish community vision and project goals and objectives • Develops and evaluates thoroughfare concepts, alternatives and impacts
Transportation/Civil Engineer	• Prepares purpose and need for transportation projects • Develops initial thoroughfare concepts and prepares detailed evaluation • Identifies design controls and parameters, constraints and tradeoffs • Works with public, stakeholders and interdisciplinary teams to resolve design challenges • Prepares preliminary and final engineering plans
Land Use Planner	• Develops long range land use plans • Helps establish community vision and goals and objectives for neighborhoods and corridors • Works with interdisciplinary team to establish and identify context • Formulates land use policy that affects thoroughfare design
Design Professional - Architect - Urban Designer - Landscape Architect	• Designs integral elements of the thoroughfare and its surrounding context including buildings, sites and streetscape features • Works with public, stakeholders and interdisciplinary teams to resolve design challenges
Stakeholders - Elected Officials - Appointed Commissioners - Developers - Local, Regional and State Agencies - Citizens	• Provide local and regional leadership • Provide funding and financing mechanisms for development of context and thoroughfares • Have jurisdiction and approval authority over plans and designs • Work closely with the general public to achieve community acceptance of projects

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 following quote from *A Guide to Achieving Flexibility in Highway Design* (American Association of State Highway and Transportation Officials):

"…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 come 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 spread 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;
- Interdisciplinary team approach to planning and design;
- Attention to community values and qualities including 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 and goals for the project, which generally relate to transportation issues (such as mobility, safety, 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 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 focuses on the solution or too narrowly constrains the range of alternatives (the purpose is to widen the highway).

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***

> ### 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

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.

Interdisciplinary team approach: An interdisciplinary 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. An interdisciplinary 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 engineers;
- Environmental scientists;
- Resource agency representatives;
- Land use planners;
- Urban designers, architects;
- Landscape architects, urban foresters;
- Property owners;
- Utility and transit owners/operators;
- Community leaders/representatives;
- Elected or appointed officials; and
- Fire, police and 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. 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 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 an interdisciplinary 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.

Principles of CSS

Principles of CSS address excellence in the transportation planning and design process. The qualities and characteristics listed below were developed at a conference in Maryland in 1998 entitled "Thinking Beyond the Pavement." These principles have become measures by which successful context sensitive solutions are judged. [2]

1. The project satisfies the purpose and needs as agreed to by a full range of stakeholders. This agreement is forged in the earliest phase of the project and amended as warranted as the project develops.
2. The project is a safe facility for both the user and the community.
3. The project is in harmony with the community, and it preserves environmental, scenic, aesthetic, historic and natural resource values of the area, in other words, exhibits context sensitive design.
4. The project exceeds the expectations of both designers and stakeholders and achieves a level of excellence in people's minds.
5. The project involves efficient and effective use of the resources (time, budget and community) of all involved parties.
6. The project is designed and built with minimal disruption to the community.
7. The project is seen as having added lasting value to the community.

While the principles listed focus on how CSS principles apply to the project development process, they also apply to other processes within an agency or in processes that involve multiple agencies. CSS prin-

2 Refer to the Maryland Department of Transportation's Web site (www.sha.state.md.us/events/oce/thinkingbeyondpavement.thinking_4.asp for a summary of the 1998 conference "Thinking Beyond the Pavement" and TRB 2002, 2004.

ciples should be recognized or integrated into agency policies including procedures (transportation planning or project development), programs, investment decisions (roadway improvement program decisions), staff training and design standards (such as state DOT design manuals). In fact, these principles have been integrated into the policies and mandates of many local and state agencies.

The "Thinking Beyond the Pavement" conference also identified how CSS can be integrated into the planning and design process. A successful CSS "process" can be defined by the following "Characteristics of the Process that will Yield Excellence in Transportation Design" (www.fhwa.dot.gov/csd/qualities.htm):

1. Communication with all stakeholders is open, honest, early and continuous.
2. A multidisciplinary team is established early, with disciplines based on the needs of the specific project, and with the inclusion of the public.
3. A full range of stakeholders is involved with transportation officials in the scoping phase. The purposes of the project are clearly defined and consensus on the scope is forged before proceeding.
4. The highway development process is tailored to meet the circumstances. This process should examine multiple alternatives that will result in a consensus of approach methods.
5. A commitment to the process from top agency officials and local leaders is secured.
6. The public involvement process, which includes informal meetings, is tailored to the project.
7. The landscape, the community and valued resources are understood before engineering design is started. A full range of tools for communication about project alternatives is used (visualization).

Principles for CSS in Urban Walkable Communities

This report provides guidance on how the above principles can be applied in the design of networks and major thoroughfares in places where the qualities of walkable communities are a high priority objective. This report supports excellence in transportation with additional principles specific to context sensitivity in these places. These principles are:

1. Urban circulation networks should accommodate pedestrians, bicycles, transit, freight and motor vehicles, with the allocation of right-of-way on individual streets determined through the CSS process.
2. The larger network, including key thoroughfares, should provide safe, continuous and well-designed multimodal facilities that capitalize on development patterns and densities that make walking, transit and bicycle travel efficient and enjoyable.
3. Thoroughfare design should complement urban buildings, public spaces and landscape, as well as support the human and economic activities associated with adjacent and surrounding land uses.
4. Safety is achieved through thoughtful consideration of users' needs and capabilities, through design consistency to meet user expectations and selection of appropriate speed and design elements.
5. Thoroughfare design should serve the activities generated by the adjacent context in terms of the mobility, safety, access and place-making functions of the public right-of-way. Context sensitivity sometimes requires that the design of the thoroughfare change as it passes through areas where a change in character is desired.
6. System-wide transportation capacity should be achieved using a high level of network connectivity and appropriately spaced and properly sized thoroughfares, along with capacity offered by multiple travel modes, rather than by increasing the capacity of individual thoroughfares.

CSS to Create Walkable Communities

Where a community has expressed a desire for walkable environments in transportation improvement projects, CSS principles are being applied to support and promote livable streets, neighborhoods and communities. This report provides guidance and examples of the use of CSS to plan and design major thoroughfares in urban environments where the community places a high priority on places with the following characteristics:

1. Mixed land uses in close proximity to one another;
2. Building entries that front directly onto the street without parking between entries and the public right-of-way;
3. Building, landscape and thoroughfare design that is pedestrian-scale, in other words, it provides architectural and urban design detail with size and design appreciated by persons who are traveling slowly and observing from the street level;
4. Relatively compact developments (both residential and commercial);
5. A highly-connected, multimodal circulation network, usually with a fine "grain" created by relatively small blocks; and
6. Thoroughfares and other public spaces that contribute to "placemaking"—the creation of unique locations that are compact, mixed-use and pedestrian- and transit-oriented and have a strong civic character with lasting economic value.

The above characteristics are the qualities found in urban places where development pattern, intensity and design character combine to make frequent walking and transit use attractive and efficient choices for many people, as well as provide for automobiles and convenient and accessible parking. An increasing number of communities are recognizing the value of these features and are embracing them in land use, urban design and transportation plans, often using techniques drawn from planning and design movements such as smart growth and new urbanism.

While CSS principles are applicable in all types of environments and for a wide range of transportation project types, this report provides examples of how the needs and issues of urban places can be considered in the design of CSS roadway improvement projects on urban thoroughfares.

Relationship to Other Guidance

This report supplements and expands on policies, guides and standards commonly used by state and local transportation, engineering and public works engineers and planners. Those publications include *A Policy on Geometric Design of Highways and Streets* (AASHTO 2004a); *Guide for the Planning, Design and Operation of Pedestrian Facilities* (AASHTO 2004b); *Guide for the Development of Bicycle Facilities* (AASHTO 1999); *Highway Safety Design and Operations Guide* (AASHTO 1997); *Roadside Design Guide* (AASHTO 2002); as well as state department of transportation design policies and manuals, local municipal street design standards, urban design guides, and guidances published by other standard setting organizations. This publication expands on information published by the Federal Highway Administration (FHWA) in *Flexibility in Highway Design* (1997) and the *Manual on Uniform Traffic Control Devices* (2003) and builds upon the considerations in developing context sensitive solutions described in *A Guide for Achieving Flexibility in Highway Design* (AASHTO 2004c). This report is not intended to supersede any state or local roadway design guidelines or standards, but rather to illustrate how established guidance can be applied to roadway improvement projects to make them more compatible with community objectives and context in urban areas.

The flexibility encouraged in this report is consistent with the policies and intent expressed in the American Association of State Highway and Transportation Officials' (AASHTO) *Policy on Geometric Design of Highways and Streets.* Most of the criteria in this report are based on AASHTO design criteria, and this report shows how the criteria can be applied to create context sensitive designs in places with the qualities of traditional urbanism. This report presents guidance from sources other than AASHTO, citing these sources at the end of each chapter. This report incorporates by reference consistency with guidelines and standards published in the latest version of the *Americans with Disabilities Act Accessibility Guidelines* (ADAAG), which can be found at www.access-board.gov. The appendix provides a bibliography of guidance documents and informational reports on matters related to thoroughfare design.

This document differs from the above resources by providing guidance on:

1. Applying CSS principles in the planning and design of urban thoroughfares;

2. How decisions in the planning and design of urban thoroughfares consider all factors and considerations;
3. The role of sites and buildings, and how context influences the design of the thoroughfare and vice versa; and
4. How thoroughfare design criteria should vary depending on the context through which the thoroughfare passes.

Key Terms and New Concepts

This and subsequent chapters introduce new concepts and terminology that may be unfamiliar to the first time user of this report. Table 1.3 defines key terms and new concepts that are used.

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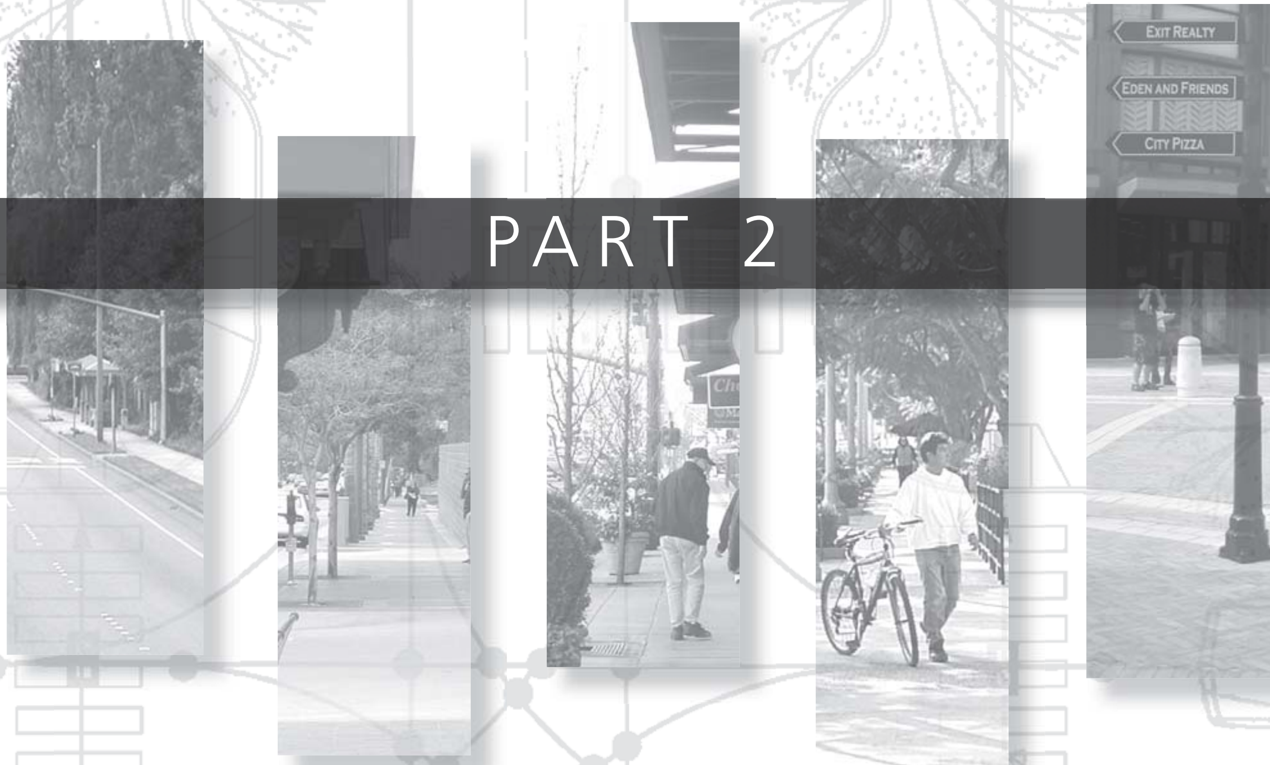
Table 1.3 Definition of Key Terms and New Concepts

Term or Concept	Definition
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 socio-economic structure, often defined by qualities including social traits, values, beliefs, culture, history, government structure, issues of concern and type of leadership.
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	Context sensitive solutions (CSS) is a 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 respect 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. Sources: Federal Highway Administration (www.fhwa.dot.gov/csd/index.htm) and Atlanta Regional Commission
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 (see Chapter 4). This report focuses on a set of four urban context zones for the purpose of CSS—suburban, general urban, urban center and urban core.
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 and sight distance are examples of design controls.
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.
Major 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 classes of arterials and collector streets. Thoroughfares are multi-modal in nature, and are designed to integrate with and serve the functions of the adjacent land uses.
New Urbanism	A multi-disciplinary movement dedicated to the restoring existing urban centers and towns within metropolitan regions, re-configuring 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)
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 and Chuck Bohl, "Placemaking")
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 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.

Table 1.3 Definition of Key Terms and New Concepts *(continued)*

Term or Concept	Definition
Smart Growth	A method of planning new development that serves the economy, the community and the environment. It changes the terms of the development debate away from the traditional growth or no growth to "how and where should new development be accommodated." Smart growth answers these questions by simultaneously achieving: • Healthy communities—that provide families with a clean environment. Smart growth balances development and environmental protection—accommodating growth while preserving open space and critical habitat, reusing land and protecting water supplies and air quality, • Economic development and jobs—that create business opportunities and improve local tax base; that provide neighborhood services and amenities; and that create economically competitive communities, • Strong neighborhoods—that provide a range of housing options, giving people the opportunity to choose housing that best suits them. It maintains and enhances the value of existing neighborhoods and creates a sense of community, and • Transportation choices—that give people the option to walk, ride a bike, take transit, or drive. (Source: U.S. Environmental Protection Agency) (www.epa.gov/ebtpages/envismartgrowth.html)
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.
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)
Walkable Communities	Walkable communities are desirable places to live, work, learn and play, and therefore a key component of smart growth. Their desirability comes from two factors. First, locating, within an easy and safe walk, 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)

PART 2



Planning

Chapter 2

Planning and Developing Context Sensitive Urban Thoroughfares

Purpose

This chapter describes, in general terms, the transportation planning and project development processes. It provides a broad overview of each stage of the processes and emphasizes that CSS principles can be applied at each stage. The transportation planning overview in this chapter provides the background for the practitioner to understand the principles and guidance on network and corridor planning presented in Chapter 3. Similarly, the overview of the project development process introduces the stages for planning and designing roadway improvement projects, which supports the information presented in Chapters 4 through 11.

Objectives

This chapter:

1. Broadly describes how CSS principles can be integrated into the transportation planning process; and
2. Describes how CSS can be integrated in the project development process and identifies the applicable steps.

CSS in the Transportation Planning Process

Transportation planning is a collaborative and participatory process involving agencies, organizations and the public in a comprehensive look at national, state, regional and community needs. It examines demographic characteristics and travel patterns for a given area, shows how these characteristics will change over a given period of time and evaluates alternative improvements for the transportation system. The transportation planning process is comprised of three basic tiers as described in Table 2.1, ranging from the national to the local agency level. Table 2.1 also summarizes how CSS can be applied in each of the planning tiers. The planning tiers are divided into three levels:

1. National—responsible for legislation, and oversight and development of policies and regulations, as well as providing funding for transportation projects at the state, regional and local level.
2. Regional/statewide—responsible for long and short-range transportation planning, development of transportation regulations and standards, oversight and development of transportation programs, and transportation funding; and
3. Local agency—responsible for local planning and project development, operations and maintenance of transportation facilities.

Different processes are followed for each of these tiers, but the basic transportation planning process is common to each tier. The difference between the tiers is in terms of the scale, timeframe, geographic scope and level of detail. Regardless of the tier, CSS principles should be incorporated into the transportation planning process that agencies may follow for specific applications. The integration of CSS principles can ensure that community values, urban, cultural, social, historic, scenic and environmental issues are considered and addressed in the planning process. The benefits of this include public support for transportation plans, savings of time and funds by minimizing contention and encouraging cooperation among agencies and fostering conservation of environmental and community resources. Working collaboratively with stakeholders produces a full range of options, an understanding of tradeoffs and consensus on key decisions, resulting in information that directly feeds into, and expedites, the project development process.

Without adoption and support of CSS principles by agencies (for example, polices, procedures, standards and programs) it will be challenging and difficult to apply CSS in either a transportation planning process or improvement project. If a regional long-range transportation plan or local corridor plan has not incorporated a process that considers CSS, it may limit the range of op-

Table 2.1 Transportation Planning Tiers and CSS Applications

Tier	Responsibilities	CSS Applications
National	• Authorizing legislation • Federal regulations • Federal policy • Research programs • Highway construction funding	• Interpreting legislation • Federal policy and regulations • Development of CSS and flexible design guidance • Demonstration projects • Research programs addressing design issues
Regional/Statewide	Regional Long-Range Planning (10 to 50 years) • Agency strategic plans • Regional transportation plans • Agency plans and programs Programs and System Plans (5 to 10 years) • System and corridor planning • Strategic system plans • Regional/agency operational programs and plans • Agency, regional, and state transportation improvement programs (STIP) • Highway construction funding	• Network design and connectivity plans • Multimodal and CSS policies • Public participation in CSD vision and plan development • Development of CSS and flexible design guidance • State design manual revisions • Context sensitive designs of highways and thoroughfares • Coordination with resource agencies • Demonstration programs • Staff and local agency training • CSS funding partnerships
Local Agency	• Operations, management strategies and plans • Roadway improvement projects • Planning, design, and enhancements • Support services • Capital improvement programs	• Local design manual/standards • Corridor plans • Thoroughfare plans • Multimodal and CSS policies in comprehensive plans • Integration of CSS into project development process (includes public participation)

Source: Adapted from "Freeway Management and Operations Handbook," Federal Highway Administration.

tions and the best overall solution. For example, changing the functional classification of a roadway to be more compatible with its surroundings should be considered at the level of the long-range transportation plan so that the change can be evaluated within the context of the entire network. Without a large-scale evaluation and adoption of the change in a plan, it will be difficult to change the functional classification at the project development stage, even if conditions justify the change.

The process usually involves the steps shown in Figure 2.1. The general process is introduced here to demonstrate how each stage provides an opportunity to integrate CSS principles, beginning with the first step in the process—the development of a vision, goals and policies. Below is a brief discussion of each step and the possible outcomes when CSS is part of the process.

Vision and Goals Applying CSS principles, at a policy level, helps establish the regional, local and neighborhood vision. CSS principles can result in compatibility between the facility and its surroundings so that the two are mutually supportive, whether in urban or rural settings. Possible outcomes of this step include:

- Long-range vision for the community and project;
- Community values and issues;
- Supporting data;
- Community and agency priorities;
- Development of an interdisciplinary team;
- Education of stakeholders regarding issues, process and constraints; and

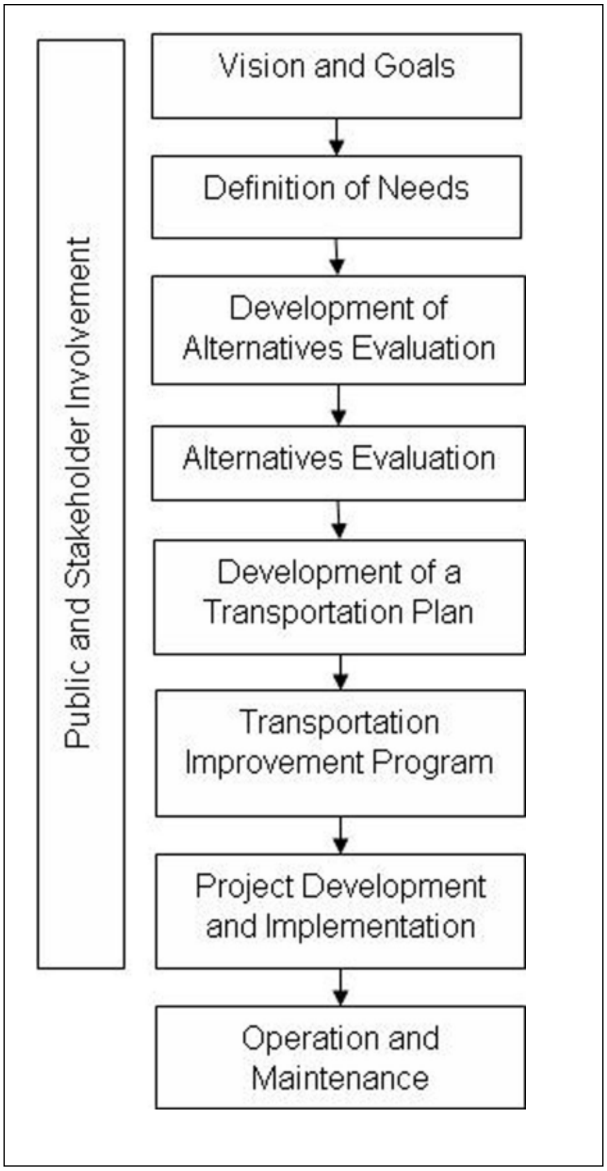


Figure 2.1 Transportation planning process. Source: Kimley-Horn and Associates Inc.

- Established planning process, which identifies decision points and stakeholder roles and responsibilities.

Definition of Needs A process that incorporates CSS, inclusive of all stakeholders, can help define the needs of the transportation plan or project based on the goals, objectives and visions established earlier. By proactively identifying stakeholder values, issues and concerns, CSS allows development of an inclusive problem/need statement. The possible outcomes of this step include:

- Acceptance of a problem statement that reflects community and agency perspectives;
- A broad and comprehensive needs statement reflecting community values as well as the transportation need; and
- Evaluation criteria and performance measures.

Development of Alternatives CSS encourages starting with a blank slate and developing a full range of options in a collaborative and participatory process, resulting in flexible and innovative solutions. Objectivity in developing the alternatives is critical. Infeasible options at first appearance can often be refined into workable solutions. The possible outcomes of this step include:

- Full range of alternatives that meet the needs statement;
- Avoidance of intentionally refutable (straw man) alternatives;
- Opportunities for enhancement and flexibility to modify alternatives;
- Consideration of all modes and all users;
- Consideration of innovative and feasible solutions; and
- Clear, understandable and graphical portrayal of alternatives.

Alternatives Evaluation CSS encourages objective evaluation of the tradeoffs between different alternatives, always relating back to evaluation criteria. As a result, stakeholders will be better able to support and endorse plans and designs. The possible outcomes of this step include:

- Participatory and transparent evaluation process;
- Clear assessment of tradeoffs;
- Equal level of assessment for accurate comparison;
- Information to assist decision-makers; and
- Clear reasoning behind rejection of alternatives.

Development of a Transportation Plan and TIP CSS principles can be integrated into the development of a long-term transportation network, with a goal of achieving increasingly diverse travel modes, and improving the overall operation of the transportation system. As a strategy that enhances safety and encourages all travel modes, CSS projects (transportation enhancements) may draw upon different funding sources than do conventional projects. The possible outcomes of this step include:

- Plan that reflects the vision, community values and meets the needs statement;
- Plan that identifies opportunities to enhance community resources;
- Plan that encompasses traditional and innovative solutions; and
- Community ownership and endorsement of the plan.

Public and Stakeholder Involvement CSS, by definition, is a process that involves, and attempts to build consensus among, a diverse group of stakeholders. The possible outcomes of this step include:

- Early involvement;
- Variety of traditional and innovative ways to engage the community (workshops, charrettes, newsletters, focus groups, Web sites, interviews);
- High level of agency credibility and public trust throughout the involvement process;
- Engagement of under-served and minority communities;
- Equal participation of stakeholders; and
- Education of the public regarding the planning and project development processes, constraints and agency perspectives.

Project Development and Implementation The integration of CSS principles can have the most profound effect on this step in the planning and design process as transportation projects are taken from the conceptual stage to implementation. The possible outcomes of this step include:

- Innovative solutions that meet project needs, reflect community values and enhance resources;
- Expedited approval of project through early and consistent stakeholder involvement;
- Application of design flexibility and documentation of design decisions;
- Continuation of stakeholder input through design and construction; and
- Assurance that commitments made in the planning process are honored through construction.

Transportation Visioning

Communities determine their own vision for transportation—describing an ideal that reflects their values, concerns and priorities. Below are examples of a transportation vision from two communities.

"Moving people and goods within and across the metropolitan boundaries safely, conveniently and reliably by providing an integrated and accessible transportation system comprised of a balanced range of travel options."
The Livable Metropolis, The Official Plan of the Municipality of Metropolitan Toronto,

"Traffic in the corridors will be calmed to foster a relaxed, accessible, outdoor-oriented, pedestrian-friendly urban village. The issues outlined below expand upon the vision statement and become a set of principles to guide future public and private investment and also create a "measuring stick" by which to evaluate consistency with the vision, and thereby appropriateness, of these future investments:

- Slow the traffic;
- Divert cut-through traffic around Upper Arlington;
- Build safe crosswalks;
- Build sidewalks and bikeways;
- Plant more street trees; and
- Encourage redevelopment that is scaled to encourage/foster street life.

Source:
"100-year lifespan vision of Upper Arlington Streets"
Lane Avenue and Tremont Road
Street Planning and Transportation Vision, City of Upper Arlington, Ohio

Operations and Maintenance The transportation planning and project development processes consider the effects of decisions on costs, liability risks and operations and maintenance. Application of CCS principles and design guidance can affect these considerations and need to be carefully considered. Examples include the need to maintain landscaping, the effects of CSS design on utility maintenance, liabilities associated with certain design elements and public places. The possible outcomes of this step include:

- Plan to monitor performance (particularly design exceptions) and receive feedback; and

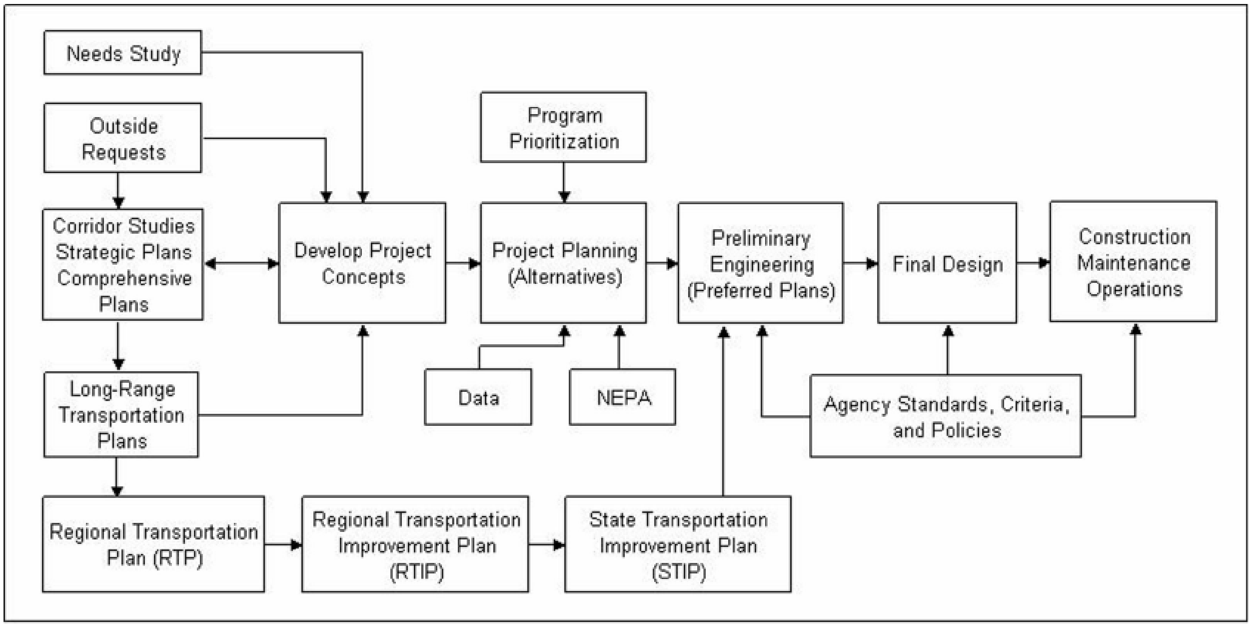


Figure 2.2 Transportation planning and project development processes. Source: Kimley-Horn and Associates Inc.

- Commitment to maintain facilities.

CSS in the Project Development Process

Figure 2.2 combines the basic phases of the transportation planning and project development processes for transportation facilities. This figure illustrates how the transportation planning process relates to the project development process. The figure is intended to show how information for transportation improvements to a thoroughfare developed in the transportation process provides input into the project development process. This type of information includes:

- Multimodal role of thoroughfares within the network;
- Relationship between land uses and the transportation system;
- Travel demand forecasts for various modes of travel;
- Performance measures and criteria used to evaluate individual transportation projects;
- Multimodal performance of the network and individual corridors;
- Identification of specific capital projects and funding sources;

Complete Streets

Some communities have adopted "complete streets" laws and policies to ensure that their roads and streets are routinely designed and operated to provide safe access for all users, including motorists, bicyclists, pedestrians and transit riders. In communities with complete streets policies, pedestrians, bicyclists, motorists and transit riders of all ages and abilities must be able to safely move along and across an urban street.

A complete streets policy creates a routine process for providing for all travel modes whenever a street is built or altered. Such policies have been adopted on the state level (Oregon, California, South Carolina, Virginia), by MPOs (Central Ohio, California Bay Area), and by local governments (Charlotte, NC; Sacramento, CA; Boulder, CO).

Complete streets projects will benefit greatly from the application of CSS principles. The recommendations of this report can help communities implement complete streets policies.

For more information on complete streets, visit www.completestreets.org.

- Goals and policies that provide direction for the development of individual transportation projects; and
- Prioritization of projects.

The information presented in this report requires an understanding of the existing and future context in urban areas. The application of CSS principles also requires one to know the ways to use the design of the thoroughfare itself to provide mutual support between the thoroughfare and existing and planned adjacent land uses and development patterns. CSS should be introduced at the earliest stage of project development—the needs study.

Integrating CSS in the project development process significantly influences the development of project concepts. Project concepts should emerge from a full understanding of the relationship between the thoroughfare, adjoining property and character of the broader urban area. Modal emphasis should be established in the early stages of project development, not addressed as an afterthought in preliminary engineering. In the project-planning step, which includes environmental review, all alternative analyses may incorporate the principles of CSS.

CSS highlights the need for context-sensitive performance measures and criteria for selecting the preferred alternative at this stage of project development. The project development process in Figure 2.2 is used as an icon in the following discussion to illustrate where the information in this report can be used in the process. The steps discussed are highlighted in the flowcharts below.

- **Long-Range Transportation Plan**: In this part of the process, the report's network planning and design guidelines (Chapter 3) can be used to help prepare long-range transportation plans and network connectivity supporting context-based thoroughfares. Additionally, the thoroughfare types described in Chapter 4 may be integrated into the development of long-range plans. The long-range transportation planning process provides an opportunity to identify those places where local agency land use and development policies can best support urban CSS, such as pedestrian scale districts, town center designs and transit corridors. These policy decisions can then be reflected in the development of thoroughfare classifications.

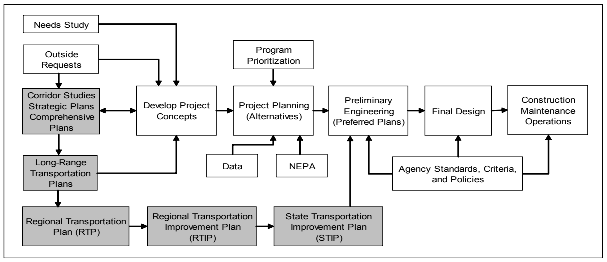
- **Needs Study and Project Concepts**: The fundamentals of urban context sensitive design, the design framework introduced in Chapter 3 and the thoroughfare design process and example thoroughfare designs (Chapters 5 and 6) are important tools in the needs study and development of project concepts.

  The project concept will emerge from an understanding of the relationships between thoroughfare types and context zones along with other unique project circumstances, values, or objectives. Additionally, a thoroughfare's modal emphasis should be clearly identified in the project concept phase. Chapters 3 and 5 provide the tools for corresponding specific thoroughfare types to various contexts and describe how to prioritize design elements and assemble the cross sections based on context and potentially constrained conditions. Data input to the project concept phase of project development should include information relating to land use development patterns and design features that support present conditions and, equally important, the vision for the future context.

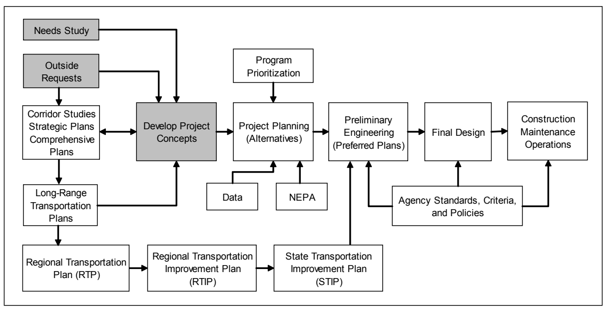
- **Project Planning and Alternatives Analysis**: Includes development and evaluation of alternatives and environmental review. The development of alternatives may use the techniques and design criteria presented in this report. Each alternative should incorporate the appropriate design characteristics compatible with the context.

- **Preliminary Engineering and Final Design:** All the Part 3 processes—thoroughfare design controls and detailed guidelines—are suitable tools for use in the preliminary engineering and final design phases of the project development process. These chapters provide information to establish an initial design for testing, identify tradeoffs and prepare a final concept for engineering.

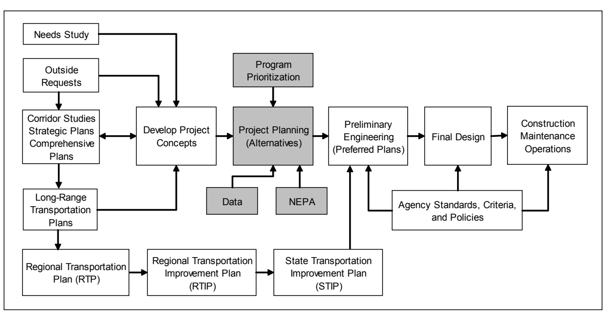
Applicable Steps in Process for Long-Range Transportation Plans (shown as highlighted boxes)



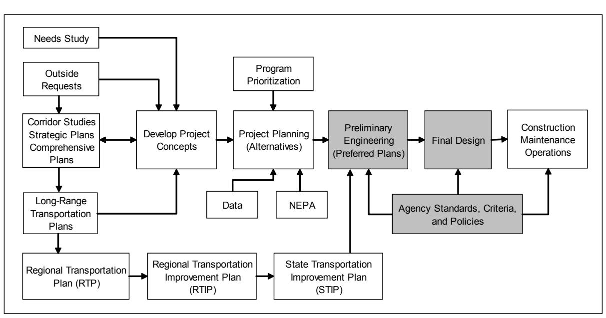
Applicable Steps in Process for Needs Study and development of Project Concepts (shown in highlighted boxes)



Applicable Steps in Process for Project Planning and Alternatives Analysis (shown in highlighted boxes)



Applicable Steps in Process for Preliminary Engineering and Final Design (shown in highlighted boxes)



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Chapter 3

Network and Corridor Planning

Purpose

This chapter describes the inter-relationship between the broader transportation network, corridors and individual thoroughfare segments. It presents how the principles of CSS can be used in the planning for urban thoroughfares at the network (or region) or corridor levels. The consideration of CSS principles in the network and corridor planning processes will contribute to the consideration of key issues and community objectives. This will result in a broader set of alternatives and improved flexibility when planning and developing roadway improvement projects.

This report emphasizes the introduction of CSS principles early in the planning process. Network and corridor planning is an early opportunity to establish a framework for integrating CSS into specific urban thoroughfare projects. This helps expedite the project development process by identifying and addressing key issues and community objectives early rather than for the first time during the planning and design of an individual roadway project. In summary, integrating CSS principles into the network and corridor planning process can:

- Determine how decisions for individual thoroughfare segments affect the corridor and network as a whole;
- Establish objectives, operational concepts, performance measures and thresholds, land uses, access control and functional classification for an entire network or corridor, which can be applied to individual thoroughfare segments in project development; and
- Allow for policy, political and public debate on issues that impact a broader area than an individual thoroughfare segment (regional, corridor, community).

The result of early integration of CSS principles is the ability to influence desired change systematically rather than a piecemeal process, meaning one improvement project at a time, where it may not be feasible or practical to make significant changes.

Objectives

This chapter:

1. Emphasizes that solutions may be found at the scale of the network and corridor rather than the individual thoroughfare (such as a denser network of streets or parallel facilities provide equivalent function and capacity to the alternative of widening an individual thoroughfare);
2. Provides CSS principles and considerations for planning and designing transportation networks and corridors;
3. Provides guidelines on how CSS principles can be applied and design issues addressed at the network or corridor planning level; and
4. Shows how the design of the network establishes the role of, and design parameters for, individual thoroughfare designs (for example, type of thoroughfare, modal requirements, type of traffic accommodated, design speed and number of lanes to accommodate projected traffic shared among the network's many individual links).

Introduction

Chapter 2 presented a broad overview of the transportation planning and project development processes and described how CSS principles can be applied in each step of the process. This chapter builds on Chapter 2 by describing the application of CSS principles and guidelines at the network and corridor scales.

Network, or "system," planning sets the strategic direction and framework around which the network and various components will eventually be constructed. It is the highest level of a series of incremental plans leading to the design of individual thoroughfare segments that is consistent with the framework of the network. Network planning defines goals and facilities for all modes of transportation in a specific area. These long-range plans typically contain a vision for the ultimate transportation system, goals and policies related to

> ### The Roles of Network and Corridor Plans
>
> **Network Plan:**
> - Links transportation system to other metropolitan functions such as land use, environment, economy, etc.
> - Integrates multimodal systems such as highways, streets, freight transit, bicycle and pedestrian.
> - Develops single mode networks such as a thoroughfare plan, rail system, bus system, or bicycle network.
>
> **Corridor Plan:**
> - Links corridor to surrounding metropolitan functions such as land use.
> - Coordinates and integrates multiple modes of transportation within the corridor.
> - Establishes the function and operation, and design criteria for the individual facilities in the corridor.

each mode of travel, technical information on travel patterns and forecasts, a capital program for individual projects as part of the transportation system and an action plan for implementing the plan over time.

The long-range transportation plan is comprised of an integrated transportation network and corridors. Corridors are transportation pathways that provide for the movement of people and goods between and within activity centers. A corridor encompasses a 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.

According to the New York Department of Transportation, corridor planning is the application of multiple strategies to achieve specific land use and transportation objectives along a transportation corridor, combining capital improvements and management strategies into a unified plan for the corridor.

CSS in Network Planning

Oftentimes the challenges encountered on an individual thoroughfare can be resolved at the scale of the network or the corridor. Network planning establishes a framework for the transportation system and distinguishes the functions, modal emphasis and operational features of individual segments. Alignment, spacing, functional classification, access control, determination of number of lanes and designation for major freight and transit routes are among the familiar characteristics addressed. Ideally, network planning takes place at the early stages of regional development and is integrated into a comprehensive planning process that concurrently addresses land use, transportation and environmental resource management. In practice, especially in areas with multiple jurisdictions, network planning is often conducted in a piecemeal manner by multiple agencies with different geographic jurisdictions, missions and powers. For the practitioner planning or designing a thoroughfare segment, considering network design and function can lead to solutions that balance between demands for vehicle throughput and support for adjacent development.

The design process—the subject of this report—needs to recognize the role of the thoroughfare as part of a large-scale, multimodal network. The designer, as well as stakeholders involved in the project development process, will need to weigh the regional, sub-regional and neighborhood functions of the thoroughfare in relation to urban form and character. The design of the individual thoroughfare, therefore, is linked to the performance of the network. This is the relationship between the network and the thoroughfare, and why network design is an important aspect of CSS.

Network characteristics have a very meaningful impact on urban development patterns. For example, compact, mixed-use areas are dependent on a pattern of highly-connected local and major thoroughfares. The high level of connectivity results in short blocks that provide many choices of routes to destinations, support a fine-grained urban lot pattern and provide direct access to many properties. Walkable suburban areas are similarly supported by a high level of street or path connectivity.

One fundamental tension that is commonly encountered in the application of CSS principles is between the desire of local residents to emphasize character in thoroughfare design, and the desire of stakeholders from a range of broader interests to emphasize vehicle capacity or the ability to accommodate projected regional travel demand. The tension between these objectives is best addressed through consideration of the broader network and corridor in conjunction with the individual thoroughfare. Network characteristics are factors in providing opportunity for CSS. Connectivity, parallel routes and corridor capacity contribute to a transportation system that can accommodate projected demand by dispersing traffic, transit, freight and bicyclists across a system of parallel roadways.

This report addresses all major urban thoroughfares except limited access facilities and local streets. However, when considering network design, properly located express thoroughfares—freeways/tollways, expressways and parkways—supplement the urban arterial thoroughfare network by providing major increments of capacity for longer trips. High vehicular capacity facilities permit other major thoroughfares to balance the movement of traffic with other local objectives. If well connected to the larger thoroughfare network, local streets can also provide parallel capacity in the network to accommodate local, shorter trips.

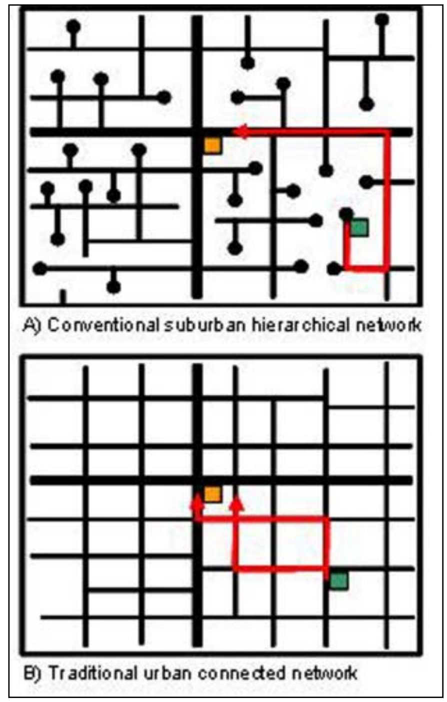

Figure 3.1 The collector in a typical hierarchical network (A) channels traffic from local streets to the arterial street system. A system of parallel connectors (B) provides multiple and direct routes between origins and destinations. Source: Kimley-Horn and Associates Inc.

Applying CSS in Network Planning

The following principles describe an approach to the planning and design of urban thoroughfare networks that are sensitive to community objectives and context. These principles should be applied together to create effective networks.

Network Planning

- Multimodal network planning should be integrated into long-range comprehensive plans that address land use, transportation and urban form.
- Network planning should address mobility and access needs associated with passenger travel, goods movement, utilities placement and emergency services.
- The reservation of right-of-way for the ultimate width of thoroughfares should be based on long-term needs defined by objectives for community character and mobility.
- Network planning should be refined and updated to define alignments and establish the role of thoroughfares as more detailed planning and development occurs.

Connectivity and Spacing

- Networks should provide a high level of connectivity so that drivers, pedestrians and transit users can choose the most direct routes and access urban properties. Connectivity should support the desired development patterns. Networks should provide intermodal connectivity to easily transfer between modes.
- Intersperse arterial thoroughfares with a system of intermediate collector thoroughfares serving local trips connecting neighborhood and sub-regional destinations.
- Expand the typical definition of collectors to recognize their role in connecting local origins and destinations in order to distribute trips efficiently, keep short local trips off the arterial system and provide a choice of routes for transit, pedestrians, drivers and bicyclists (Figure 3.1).
- Build network capacity and redundancy through a dense, connected network rather than through an emphasis on high levels of vehicle capacity on individual arterial facilities. This approach

Connectivity Index

A Connectivity Index can be used to quantify how well a roadway network connects destinations. Indices can be measured separately for motorized and non-motorized travel. Several methods can be used:

- The number of roadway links divided by the number of roadway nodes or intersections (Ewing, 1996). A higher index means that travelers have increased route choice, allowing more direct connections for access between any two locations.
- The ratio of intersections divided by the sum of intersections and dead-ends, expressed on scale from zero to 1.0 (USEPA, 2002). The closer the index is to 1.0, the more connected the network.
- The number of surface street intersections within a given area, such as a square mile, a measure of intersection density. The more intersections, the greater the degree of connectivity.
- An Accessibility Index as the ratio of direct travel distances to actual travel distances. Well connected streets result in a high index. Less connected streets with large blocks result in a lower index.

Source: Victoria Transport Policy Institute, www.vtpi.org

ensures that the network and thoroughfare facilities (in other words, more thoroughfares rather than wider thoroughfares) can support other objectives such as pedestrian activity, multimodal safety and support for adjacent development.

- Minimize property access directly onto arterials through design of a connected network of closely spaced arterial and collector thoroughfares and local street connections. With fewer driveway-type interruptions, arterial thoroughfares can perform more efficiently for vehicles and for pedestrians along their sidewalks. Thus, network connectivity can provide a foundation for access management and strategies to increase corridor capacity.

Performance Measures

- Select transportation performance measures that reflect stakeholder objectives and priorities for the system or facility being planned or designed.
- Use performance measures that recognize all modes.
- Performance measures can vary for different parts of the network as long as direct comparisons are made to the same measures.
- Performance measures could include conventional measures of vehicle congestion, such as capacity and speed, and could consider them at a network-wide or corridor-wide level.
- To reflect walkability and compact development, consider measures such as a connectivity index, intersection density measures and pedestrian environment measures.
- Choose performance measures that measure the mobility of all users.
- Selected performance measures should include measures of safety for all users.

CSS Considerations for Effective Network Planning

Network planning at the regional scale typically includes only highways, arterials and major collector systems. The planning of the finer grid of local residential and commercial streets is typically prepared at the county and/or city scale. As described above, regional network planning establishes the framework for the planning of county and citywide networks. County and citywide transportation plans establish a framework for planning and designing the local street system and individual thoroughfares. Finally, site planning and the project development process achieve the highest level of detail. The network types discussed below combine regional and local scales since later discussions on thoroughfare design are influenced by the pattern of fine grain networks.

Network Types

Urban network types are frequently characterized as either traditional (also called urban, pre-war, or connected) or conventional (also called suburban, post-

Figure 3.2 Example of a traditional network. Source: Data available from U.S. Geological Survey, EROS Data Center, Sioux Falls, SD.

war, hierarchical, or dendritic). Traditional networks (Figure 3.2) are typically characterized by a relatively non-hierarchical pattern of short blocks and straight streets with a high density of intersections. The typical conventional street network by contrast often includes a framework of widely-spaced arterial roads with limited connectivity provided by a system of large blocks, curving streets and a branching hierarchical pattern often terminating in cul-de-sacs (Figure 3.3). The prototypical traditional and conventional networks differ in three easily measurable respects: (1) block size, (2) degree of connectivity and (3) degree of curvature. While the last does not significantly impact network performance, block size and connectivity create very different characteristics.

Both network design types have advantages. Advantages of traditional grids include:

- Dispersion of traffic rather than concentrating it at a limited number of thoroughfares, which reduces the impacts of high traffic volumes on residential collectors;
- More direct routes, which generate fewer vehicle miles of travel (VMT) than contemporary suburban networks;
- Encouragement of walking and biking with direct routing and options to travel along high or low-volume streets and development patterns that can offer a variety of complementary destinations within close proximity;
- More transit-friendly systems because it offers users relatively direct walking routes to transit stops;
- A block structure where land use can evolve and adapt over time, providing development flexibility; and

Figure 3.3 Example of a conventional network. Source: Data available from U.S. Geological Survey, EROS Data Center, Sioux Falls, SD.

- Frequent traffic signals that can be synchronized to provide a consistent speed.

In contrast, conventional networks have some advantages over traditional urban grids. Advantages of conventional networks include:

- Reduction of through traffic in neighborhoods that results in lower traffic volumes on the local streets;
- Conventional networks, which can exhibit lower accident rates on the local streets because fewer intersections result in fewer conflict points; and
- Some very low volume local streets and cul-de-sacs, which are desirable to many residents.

Each network type has a primary disadvantage specifically related to the livability of residential streets within the network. The primary disadvantage of traditional grids results from the dispersion of traffic, resulting in some local residential streets experiencing higher traffic volumes than a similar street in a conventional network. The primary disadvantage of a hierarchy of streets in conventional networks is the channelization of traffic and associated impacts into a few residential collectors.

CSS Guidelines for Network Planning and Design

This section provides specific considerations and guidelines for implementing network design principles presented in the previous section. The guidelines provided in this section are applicable for:

1. Greenfield development—establishing, augmenting, or reconfiguring a system of major thoroughfares to serve an undeveloped, a newly developing area or long-range plans for future development.

2. Re-use and redevelopment—large projects in mature urban areas that permit reconfiguration or changes in function of adjacent or nearby thoroughfares. In these situations, the types of changes that might effect:
   - Surrounding land uses;
   - Thoroughfare alignment or the addition of new routes or connections;
   - Emphasis in mode (such as exclusive busways, wider roadsides to serve adjacent economic activities, addition of bike lanes);
   - Functional classifications; and
   - Modal split allowing reallocation of (network) right-of-way among modes.

3. Facility reconstruction—reconstruction of major sections of one or more thoroughfares provides an opportunity to make network changes more compatible with existing context/land uses, such as converting from a two-way thoroughfare to a one-way couplet (or vice versa), realigning a thoroughfare to improve accessibility to surrounding properties and reallocating right-of-way to better balance design elements among various modes of travel.

General Network Guidelines

- The system of multimodal thoroughfares may be organized by the context zones, functional classifications and thoroughfare types as described in Chapter 4.
- Every major thoroughfare should be designed to serve transit and pedestrians, as well as private and commercial vehicles.
- Design networks that concentrate longer distance through movements on limited access and arterial thoroughfares.
- Transit networks should focus on and take advantage of built or planned transit-oriented developments.
- Planning for right-of-way should consider needs based on network performance measures that are multimodal and that allow capacity and level-of-service to be considered in conjunction with other measures, both quantitative and qualitative. The CSS process should be open to the selection of decision criteria that balance community character and capacity enhancement or congestion relief.

Network Spacing Guidelines

- The basic form of the major thoroughfare system is shaped by the spacing and alignment of arterial thoroughfares. The system of arterials should be continuous and networked in a general rectilinear form. In lower density suburban and general urban areas, arterial spacing may need to be one-half mile or less. In denser urban centers and core areas, arterials may need to be spaced at one-quarter mile or less.

- In more conventional suburban areas that intend to remain so, arterial spacing of up to one mile may suffice if facilities of up to six lanes are acceptable to the community. The arterial thoroughfares should be supplemented by thoroughfares spaced at most one-quarter-mile apart. Such areas typically are interspersed with areas of mixed-use and walkable activity, such as commercial districts and activity centers. These centers require more frequent and connected networks of local streets.

- Closer spacing of thoroughfares (one-eighth mile for collectors) may be needed depending on pedestrian activity levels, desired block patterns and continuity. Natural features, preserved lands, or active agriculture may break up the pattern.

- Sketch planning demand estimation or travel forecasting models should be among the tools used to estimate the spacing and capacity needs for major urban thoroughfares within the minimum spacing described above.

- The network should include a system of bicycle facilities with parallel routes generally no more than one-half-mile apart, and with direct connections to major trip generators such as schools, retail districts and parks. Bicycle facilities may include on-street bike lanes, separated paths, or shared lanes on traffic-calmed streets with low motor vehicle volumes.

- Local streets should be configured in a fine-grained, multimodal network internally to the neighborhood, with multiple connections to the system of major thoroughfares. Where streets cannot be fully networked, they should be supplemented by pedestrian and/or bike-pedestrian facilities to provide the desired connectivity.

- Pedestrian facilities should be spaced so block lengths in less dense areas (suburban or general urban) do not exceed 600 ft. (preferably 200 to 400 ft.) and relatively direct routes are available. In the densest urban areas (urban centers and urban cores), block length should not exceed 400 ft. (preferably 200 to 300 ft.) to support higher densities and pedestrian activity.

Applying CSS in Urban Corridor Thoroughfare Planning

Corridors are transportation pathways that provide for the movement of people and goods between and within activity centers. A corridor encompasses a 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 (Figure 3.4).

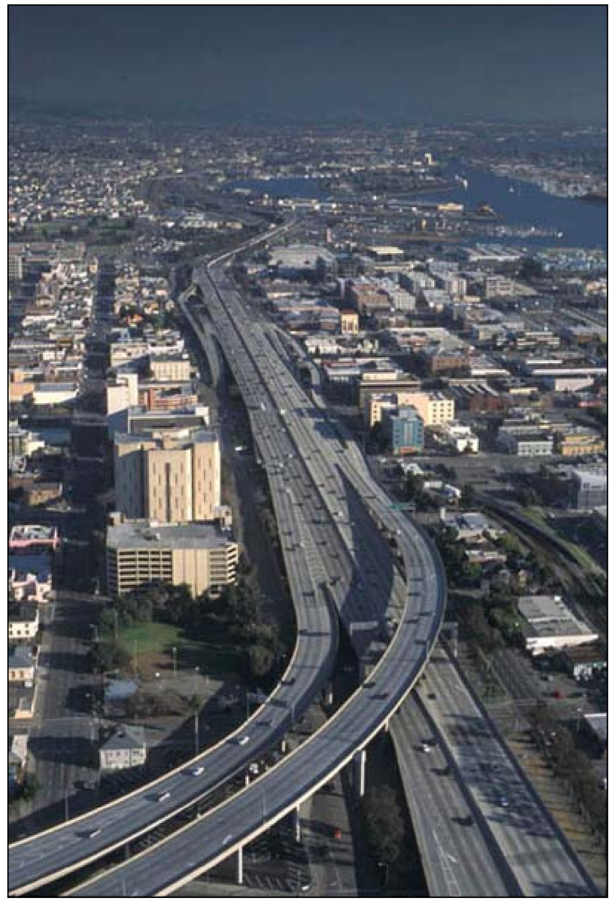

Figure 3.4 Corridors include multiple transportation facilities, adjacent land uses and connecting streets. Source: Kimley-Horn and Associates Inc.

Corridor planning is one of the incremental steps for network planning in the long-range transportation plan to thoroughfare design in the project development stage. The purpose of corridor planning is to comprehensively address future transportation needs and recommend a series of physical improvements and operational and management strategies within a corridor. Corridor planning fills the gap between long-range transportation planning and project development. It identifies and provides a link between corridor land-use planning and corridor transportation planning and provides an opportunity to direct future development within the corridor. An important benefit of corridor planning is that it addresses issues prior to project development for specific transportation improvements within the corridor. Finally, it promotes interagency cooperation and broad stakeholder and public involvement. Corridor plans should address the following: (ID DOT 1998)

- Long-range vision for the corridor;
- Existing conditions of the transportation system and analysis with regard to the performance objectives;
- Existing and future environmental, land-use and socio-economic conditions in the corridor area, including a community profile, current and planned land uses, historical and cultural buildings and sites, and key environmental resources and environmental issues;
- Public and stakeholder involvement strategy;
- Purpose, need and the relative importance of corridor needs through project goals and community objectives;
- Expected future multimodal travel demand and performance of existing and programmed transportation improvements;
- Identification of feasible alternatives by evaluating all options, and comparing costs, impacts

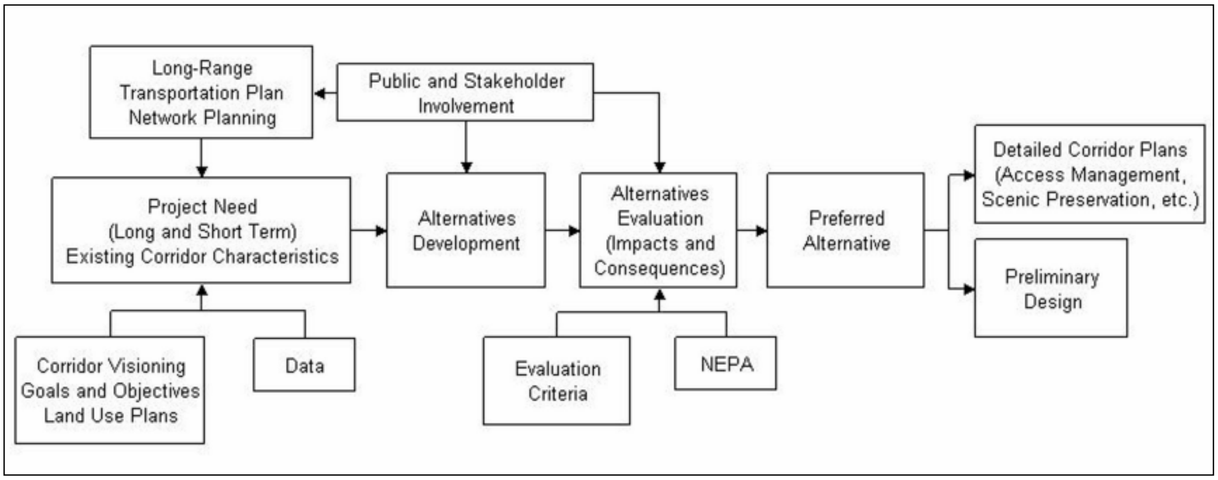

Figure 3.5 The Corridor Planning Process. Source: Kimley-Horn and Associates Inc.

and the degree to which the alternative meets the goals;

- Available and expected funding for transportation improvements in the corridor; and
- Long- and short-range recommendations.

The corridor planning process generally mirrors the transportation planning process in its fundamental steps of a needs study, alternatives development, alternatives evaluation and selection of a preferred alternative, which leads to either the development of a detailed plan or implementation of the project development process (preliminary design).

Integrating CSS in urban corridor thoroughfare planning requires stakeholders to consider the economic, social, and environmental consequences of alternatives. It defines the short- and long-term needs of the corridor, develops goals and objectives that will achieve the vision of the corridor and evaluates feasible multimodal alternatives.

The outcome of CSS in urban corridor thoroughfare planning goes beyond just street improvements. Corridor planning integrally addresses transportation improvement, land development and redevelopment, economic development, scenic and historic preservation, community character and environmental enhancement. Because urban corridor thoroughfare planning affects a broad spectrum of the community, public and stakeholder involvement is a central element of the process. The basic steps in the planning process include:

- Corridor vision;
- Project needs;
- Alternatives development;
- Alternatives evaluation; and
- Selection of preferred alternative.

In some cases, urban corridor thoroughfare planning may be integral with environmental studies leading to a National Environmental Policy Act document (www.epa.gov/compliance/nepa) or other environmental impact assessment. Figure 3.5 illustrates the steps in the corridor planning process and identifies the type of input needed at various stages in the process.

The basic steps in the process, and how CSS principles can be integrated, are described below:

Corridor Vision: Similar to any application of CSS principles, the process begins with a vision for the corridor. A vision is a corridor-wide expression of how the corridor will be viewed in the future. Goals for the corridor expand on the vision by identifying the achievements that will implement the corridor's plan. Developing objectives and a vision for a corridor can occur as part of a long-range transportation plan or as part of the corridor planning process. Public and stakeholder input and involvement are critical inputs when developing a vision, because the vision needs to reflect the goals and objectives of the community and address more than the transportation function of the corridor. The

Corridor Vision and Needs

CSS Approach:
- Public and stakeholder input
- Corridor and context characteristics
- Identify values and issues

CSS Outcome:
- Inclusive problem statement
- Corridor vision
- Goals and objectives

Alternatives Development

CSS Approach:
- Interactive and participatory process
- Alternatives address problem statement and reflect objectives

CSS Outcome:
- Broad range of solutions derived from collaboration
- Innovation and flexibility

corridor vision feeds directly into the project needs step.

Needs: Like developing a vision, the needs for the project may be developed in a long-range transportation plan if there is one, or may be developed as part of the corridor planning process. The project needs include a problem statement that reflects the needs of all users. The needs reflect the corridor's existing (and future) context and characteristics. Stakeholder input is necessary to identify values, issues, priorities and goals and objectives. Much of this same input will help form criteria for assessing alternatives in the next phase.

Alternatives Development: The corridor planning process includes a participatory public process to define and develop alternatives. The alternatives need to address the problem statement identified in the project needs step and also reflect the community vision and objectives. Stakeholder input is necessary to identify values, issues, priorities and criteria for assessing alternatives. The CSS outcome of this step is an inclusive problem statement, a short and long-range vision for the corridor and goals and objectives that will direct the development of alternatives.

With a CSS approach, the needs may be stated in terms of context, economic, or other community aspects, as well as mobility needs. The CSS outcome of this step is to provide decision-makers with a wide range of choices, derived in a collaborative and participatory process. The alternatives should be competitive in that they address as many of the goals and objectives as possible. Solutions should be innovative and flexible in the application of design guidance. The solutions should include ways to enhance and meet the needs of the context, activities generated by adjacent and nearby land uses and objectives that are part of the community vision for the corridor.

To the extent not already included in the community vision, consideration should also be given to potential environmental consequences when developing the corridor alternatives. Alternatives may include different alignments and parallel routes, cross-sections, modal combinations, roadside treatments, interaction with adjacent development, streetscape approaches, business and community activity and support infrastructure. The important thing to remember is that the alternatives in CSS are developed to meet the full range of a specific community or neighborhood's objectives.

Alternatives Evaluation: The goal of the alternatives evaluation is to provide an objective and balanced assessment of impacts, trade-offs and benefits of each alternative (Figure 3.6). This requires careful selection of, and stakeholder agreement on, evaluation criteria. The criteria need to reflect not just transportation objectives, but the community and environmental objectives as well. Examples of evaluation criteria categories include:

Mobility: travel demand, roadway capacity, level of service, travel time, connectivity, circula-

Alternatives Evaluation

CSS Approach:
- Public and stakeholder input
- Evaluation criteria that reflects community, environmental and transportation objectives and concerns

CSS Outcome:
- Clear assessment of trade-offs
- Participatory process

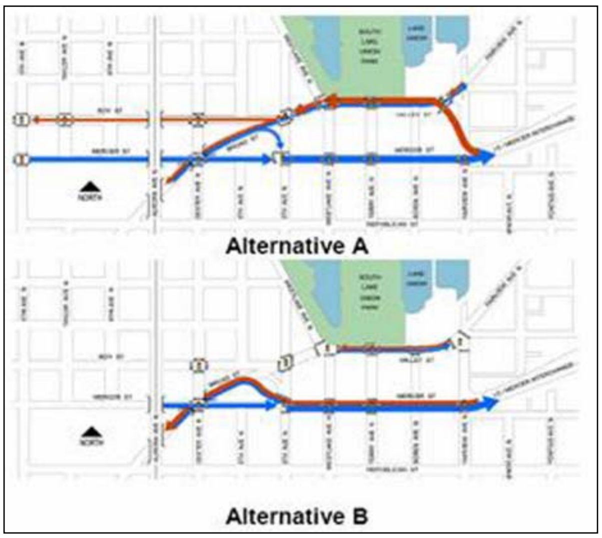

Figure 3.6 Corridor planning involves the consideration of trade-offs between alternatives. In this example different alignments and reconfiguration of streets are evaluated and compared. Source: City of Seattle, CHM2HILL, South Lake Union Transportation Study, Mercer Corridor Project.

tion, access, truck movement, access to multiple travel modes, etc.

Social and Economic Effects: socioeconomic and cultural environment (historic, cultural and archaeological resources; residential and business displacement/dislocation; socioeconomics and equity; neighborhood integrity and cohesion; economic development; place making qualities; etc.).

Environmental Effects: positive and negative effects of natural environment (air quality,

Selection of Preferred Alternatives

CSS Approach:
- Participatory process, using workshops or charrettes to refine concepts
- Consensus building

CSS Outcome:
- Alternative fits within the context
- Composite solution for all modes and users
- Preferred alternative that balances across objectives and evaluation criteria

noise, energy consumption, water quality and quantity, vegetation, wildlife, soils, open space, park lands, ecologically significant areas, drainage/flooding aesthetics and visual quality); land use (residential patterns, compatible uses, development suitability according to community values, etc.).

Cost-effectiveness and Affordability: capital costs, operations and maintenance costs, achievement of benefits commensurate with resource commitment, sufficiency of revenues, etc.

Other Factors: compatibility with local and regional plans and policies, constructability, construction effects, etc.

The alternatives evaluation step includes a comprehensive evaluation of applicable issues and options using selected criteria such as those described above (such as, modal capacity; alignment; design concept; costs; right-of-way; environmental, social and economic impacts; operations; safety; etc.). Alternatives can be a combination of capital improvements and management and operations strategies. The outcome of this step is the clear communication of trade-offs to the public, stakeholders and decision-makers, developed and discussed in a transparent and participatory process.

- **Selection of Preferred Alternative:** The selection of a preferred alternative is a consensus-based process. Consensus building in this step

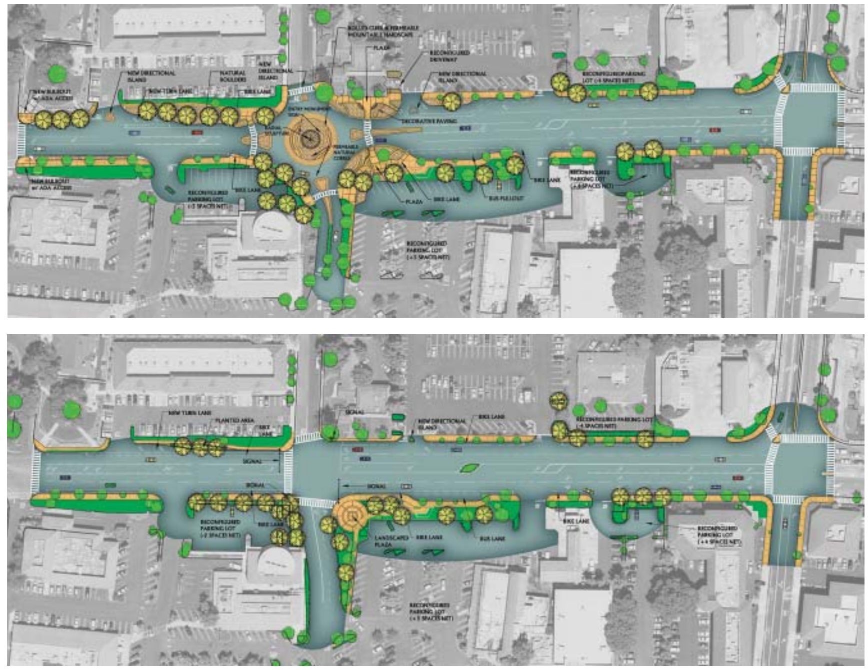

Figure 3.7 Corridor planning results range from broad policies to detailed concepts for corridor segments. Source: Contra Costa County Deptartment of Public Works and Whitlock & Weinberger Transportation Inc.

engenders community ownership in the selected alternative and helps achieve a commitment towards implementation of the plan or project. The CSS process uses an array of tools for selecting, refining and building consensus on alternatives. A successful selection of a preferred alternative is one that is compatible with the context(s), reflects the needs of all users, and best achieves the objectives and vision established for the corridor.

The selection of a preferred alternative leads to either the development of a detailed corridor plan, such as a thoroughfare plan, access management plan, scenic preservation plan, streetscape plan, or economic vitalization plan, or it can lead to the preliminary design of an individual thoroughfare, network of thoroughfares, or multimodal transportation corridor with parallel thoroughfares, rail, transit, highway and bikeway systems.

Corridor planning varies in level of effort ranging from large-scale planning efforts for corridors in newly developing areas to small-scale planning of segments of individual thoroughfares within constrained rights-of-way. The outcome of corridor planning ranges from broad policies to statewide and regional long-range transportation plans to multimodal systems plans, and to local thoroughfare plans and individual segment concepts and designs (Figure 3.7). CSS plays a role in any type of corridor planning. The remainder of this report focuses on the detailed design of thoroughfares.

CSS Example in Corridor Planning – Developing Evaluation Criteria

SR 179 Corridor Plan

The Arizona Department of Transportation (ADOT) worked with the community of the greater Sedona area in the Coconino National Forest to design and construct improvements to the 9-mile stretch of SR 179. This road carries millions of tourists each year through one of the most pristine and unique areas of the world. The road is also the only route connecting the business and residential communities of the greater Sedona area. While there have been improvements to SR 179, continuing traffic build-up will continue to exacerbate the capacity and safety issues of the road during the next 20 years.

This example addresses the selection of evaluation criteria for rural scenic segments and urban segments of the corridor. It is an exemplary example of a process that

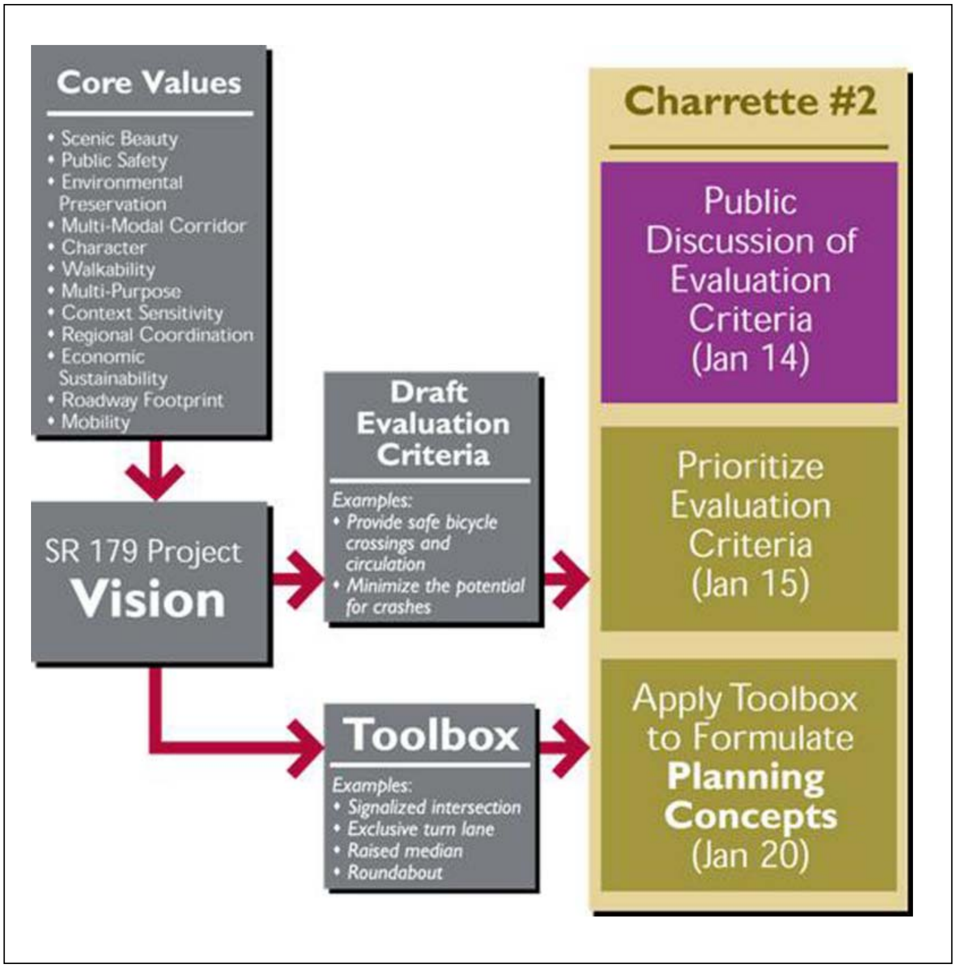

Figure 3.8 The needs based implementation plan included a community-based process to develop criteria to evaluate corridor alternatives. Source: Arizona Department of Transportation, DMJM+Harris.

integrates CSS principles to work with stakeholders to evaluate corridor alternatives. The evaluation process could be used to evaluate projects in any context.

The goal of the project was to develop a transportation corridor that addressed safety, mobility and the preservation of scenic, aesthetic, historic, environmental and other community values, and to reach consensus on the planning, design and construction of SR 179.

The SR 179 project is an exemplary example of a CSS corridor plan involving the public. The collaborative community-based process used an innovative process called the needs based implementation plan (NBIP). This process depended on the community to actively participate and provide input throughout the process.

Developing Evaluation Criteria

A unique aspect of the SR 179 Corridor project was the process used to develop and select the preferred planning concepts, particularly the evaluation criteria. The process is illustrated in Figure 3.8. The development of evaluation criteria began with working with the community to identify tits core values for the corridor. The core values are also components of the vision for the corridor. Core values include in priority order:

- Scenic beauty—preservation of scenic features and viewpoints;
- Public safety—preventing crashes and providing efficient emergency services;
- Environmental preservation—maintaining the natural and physical environment;
- Multi-modal—provisions for modes of travel that include bicycles and transit;
- Character—the unique look and feel of the corridor;
- Walkability—ability of pedestrians to circulate in the corridor and reach points within the corridor;

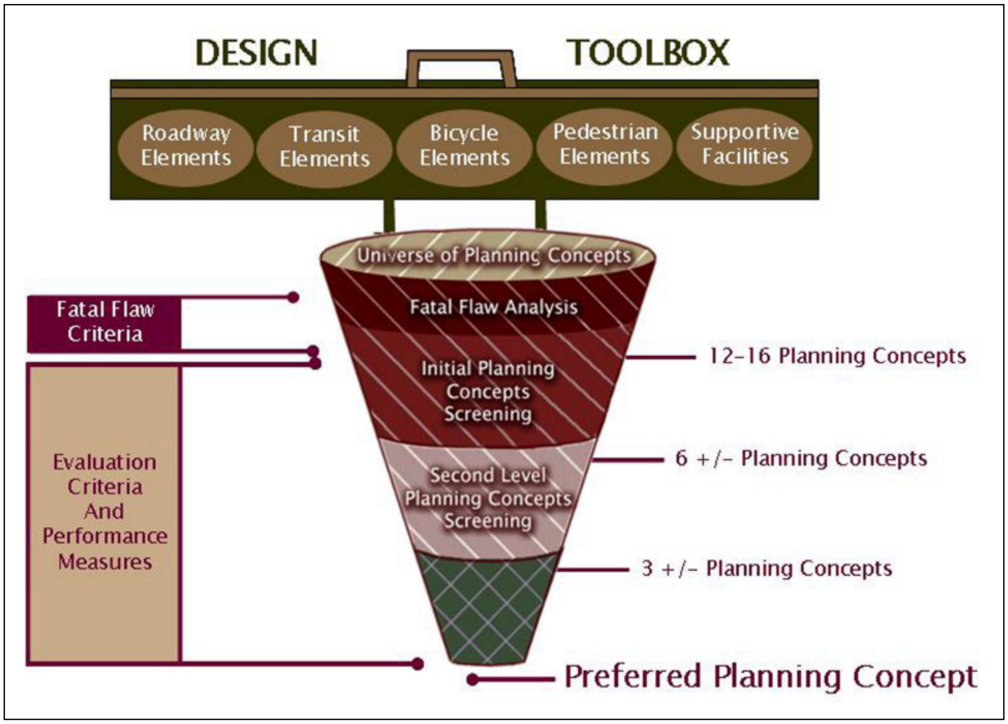

Figure 3.9 The screening process started with a wide range of alternatives and used public participation and evaluation criteria to narrow alternatives to a preferred planning concept. Source: Arizona Department of Transportation, DMJM+Harris.

- Multi-purpose—a corridor that serves many needs including commuting, shopping, tourism and social trips;
- Context sensitivity—compatibility with the unique context of the SR 179 corridor;
- Regional coordination—a process involving stakeholders throughout the region;
- Economic sustainability—contribution to the economic vitality of the area;
- Roadway footprint—the width and cross-section of the corridor; and
- Mobility—ability to provide efficient and reliable transportation services.

Using the core values as a base, the project team worked with the community to develop, prioritize and build consensus on criteria for evaluating corridor alternatives. The evaluation criteria and performance measures were used in a screening process to narrow the alternatives to a preferred planning concept for each segment of the corridor. Figure 3.9 illustrates the screening process. Figure 3.10 presents a sample of the evaluation criteria and associated performance measures.

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Corridor Evaluation Criteria and Performance Measures	
Evaluation Criterion	**Performance Measures**
Retain and enhance the natural appearance of the landscape, and the ability to enjoy scenic views from the corridor.	Number of sensitively placed scenic pullouts
	Number of new scenic vistas available
	Appropriate scenic viewing opportunity potential
Provide a distinctive corridor identity and unique experience for the user.	Opportunity for artistic and landscape amenities
	Opportunity to preserve and interpret architectural and cultural themes of the Sedona/Red Rock area
	Opportunity for design creativity to contribute to the corridor identity
Provide safe and attractive wayfinding aids (signage and informational features) for tourists and others who may be relatively unfamiliar with the corridor.	Total number of sites for wayfinding information
	Opportunities for context-sensitive wayfinding signage visible from the roadway and pathways
	Opportunities to provide access to new Forest Service Ranger District Office and other connecting facilities
Provide safe vehicular and emergency access to, from and across the corridor.	Number of new safe crossings (signals or roundabouts)
	Number of locations on the mainline with left turn storage lane or roundabout
	Number of acceleration and deceleration lanes
	Number of "right-in, right-out" ingress/egress locations
	Number of mainline entry locations
Provide safe pedestrian crossings and circulation.	Number of new safe pedestrian crossings
	Opportunities for pedestrian amenities and enhancements at intersections
	Square feet of pathways/sidewalks
	Number of trailheads directly accessible on foot from the corridor
	Number of key destinations in the corridor accessible via a connected pedestrian system

Figure 3.10 Example evaluation criteria and performance measures excerpted from the SR 179 Corridor Plan. Extracted from: Arizona Department of Transportation, DMJM+Harris.

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Chapter 4

A Framework for Urban Thoroughfare Design

Purpose

This chapter describes a set of tools for use by practitioners developing CSS for major urban thoroughfares in walkable communities. It introduces and explains a design framework that uses the concept of context zones and a set of thoroughfare types that respond to the challenges of implementing CSS in urban areas.

The functional classification system classifies context as either rural or urban. In this report, the definition and description of the urban context is expanded to provide more detailed descriptions of adjacent surroundings, and uses context as a criterion in the selection of thoroughfare type and design criteria. Context zones are used to categorize urban contexts into discrete types, ranging from lower to higher density and intensity of development.

Thoroughfare types are used as an addition to functional classifications to provide a broader range of thoroughfare design choices. The use of thoroughfare types restores the former practice of distinguishing facility types by design characteristics in addition to functional classifications.

This chapter describes the relationship between context and thoroughfares.

Objectives

This chapter:

1. Defines "context" as used in urban thoroughfare design and explains the features of urban areas that create and shape context;
2. Introduces the concept of "context zones" and provides guidance to help practitioners identify context zones;
3. Describes the different types of thoroughfares, their relationship to functional classifications; and
4. Describes features of thoroughfare types and context zones that result in compatibility.

Introduction

The CSS process in the urban environment demands special tools. While it is possible to "feel" the character of an urban area, it can be hard to define and describe the specific features that collectively give shape and character to a particular urban setting, whether it is a small town, suburban center, main street, or high-density regional downtown.

The design of the thoroughfare itself helps to define context as much as adjacent buildings define context. The standard thoroughfare design process generally emphasizes vehicular capacity and the provision of automobile access to adjoining land uses, primarily using the functional classification, traffic volume and design speed as the determinants for design parameters. CSS has expanded the process to integrate thoroughfares into its surroundings. The result in many communities is a new emphasis on urban thoroughfares with features that emphasize multimodal safety and mobility, and support for the activities of the adjacent land uses. Context sensitive urban thoroughfares might include public spaces designed into the roadside such as plazas, small parks and sidewalk width for outdoor cafes.

The design of the thoroughfare should change as context changes. For example, additional lanes may be needed as speed is reduced and intersections are controlled when a highway enters a downtown. In this context the highway often functions as a main street; curb-and-gutter drainage, on-street parking, wide sidewalks, pedestrian-scaled lighting and trees in planters may be added. Outside of downtown the highway might traverse a residential area where sidewalks narrow, planted buffer strips are added and slower speeds are maintained. When the thoroughfare again enters the rural environment, speed increases, shoulders replace on-street parking, sidewalks might be eliminated and landscaping is set back further from the traveled way. It is the change in context that determines the need for transitions and change in thoroughfare design parameters.

For all major thoroughfares practitioners need to evaluate capacity, connectivity and safety considerations in combination with meeting local objectives for urban character. The selection of appropriate design controls and performance measures, discussed further in Chapter 7, is a key step in developing suitable design solutions. The design scenarios presented in Chapter 6 provide illustrations of how context sensitive objectives can be evaluated under alternative designs and integrated into a preferred alternative.

Features that Create Context

Land Use

Land use is a common criterion for characterizing urban development and estimating vehicle trip generation, particularly in single-use, vehicle-dominated locations. The design framework in this report identifies land use as an important contributor to context and major factor in the selection of design criteria, assembly of the cross-section components and allocation of the width of the right-of-way.

In addition to having a fundamental impact on travel demand, variations in adjacent land use affect the width and design of the roadside, the part of the thoroughfare between the curb and edge of right-of-way including sidewalks. As detailed in Chapter 8, residential uses have less need for sidewalk space than mixed-use blocks with ground floor commercial uses, where space for window shopping, outdoor dining, newspaper racks, etc. adds to the sidewalk width. Commercial uses generate higher volumes of pedestrian travel and business activities that use the roadside. With respect to the traveled way, the part of the thoroughfare between curbs, variations between residential and commercial areas include parking- and travel-lane width, and operating and design speeds. Commercial areas typically have a higher volume of large vehicles such as delivery trucks and buses, and have a higher turnover of on-street parking than residential areas. Thus, a predominantly commercial thoroughfare often requires a wider traveled way. Commercial areas usually generate more traffic than residential areas, which affects decisions related to the number of lanes, access control and intersection design.

Site Design

The ways in which buildings, circulation, parking and landscape are arranged on a site create either a vehicle-dominated location or pedestrian-oriented one. The specific elements of site design that contribute to defining contexts, ranging from suburban to highly urban, include:

- *Building orientation and setback*. In an auto-dominated place, typical buildings are set back into private property. By contrast, a context with traditional urban character will have buildings oriented toward and often adjacent to the thoroughfare. The directness of the pedestrian connection to the building entry from the thoroughfare, and whether the building itself is integrated into the thoroughfare's roadside with stoops, arcades, cafes, etc. distinguishes a context with traditional urban character. In these locations, buildings may form a continuous built edge, or street wall (a row of buildings that have no side yards and consistent setback at the thoroughfare edge).
- *Parking type and orientation*. Parking provided in adjacent surface lots between buildings and thoroughfares with driveway connections to the thoroughfare generally defines a vehicle-dominated context. On-street parking, and parking under or behind buildings and accessed by alleys is an urban characteristic.
- *Block length*. Development patterns with traditional urban qualities usually have short block lengths with a system of highly connected major thoroughfares, local streets and alleys. Vehicle-dominated contexts have larger blocks, less complete street connectivity and usually no alleys.

Building Design

The design of buildings is a significant contributor to context. Building height, density and floor-area ratio, architectural elements, mass and scale, relationship to adjacent buildings and thoroughfares, orientation of the entry, and the design and type of ground floor land uses can help shape context.

Development in vehicle-dominated contexts generally has lower height, density and lot coverage (often

Figure 4.1 Pedestrian-scaled architectural elements. Source: Community, Design + Architecture.

represented as floor-area ratio). In these locations, buildings will be one to three stories in height, isolated from other buildings and may be surrounded by surface parking.

Buildings in locations with traditional urban character are typically taller, attached or very close to adjacent buildings and have higher floor-area ratios. Buildings may form a street wall on thoroughfares. Ground floor uses in urban buildings are usually oriented to the pedestrian passing on the adjacent sidewalk, incorporating architectural elements that are interesting, attractive and scaled to the pedestrian (Figure 4.1). Some aspects of how building design helps define urban context include:

- *Building height and thoroughfare enclosure*. Buildings are the primary feature of urban contexts that create a sense of definition and enclosure on a thoroughfare—an important urban design element that helps create the experience of being in a city and in a place that is comfortable for pedestrians. The threshold when pedestrians first perceive enclosure is a 1:4 ratio of building height to thoroughfare width—typical of low-density suburban environments. In denser urban contexts, height-to-width ratios between 1:3 and 1:2 create an appropriate enclosure on a thoroughfare (Figure 4.2).
- *Building width*. Building width, like building height, contributes to the sense of enclosure of the thoroughfare. There are three elements of width: (1) percentage of a building's width fronting the street should range from about 70 percent in suburban environments to nearly 100 percent in urban environments; (2) distance between buildings or building separation should range from 0 to 30 ft.; and (3) articulation of buildings (an architectural term that refers to dividing building facades into distinct parts to reduce the appearance of the building's mass

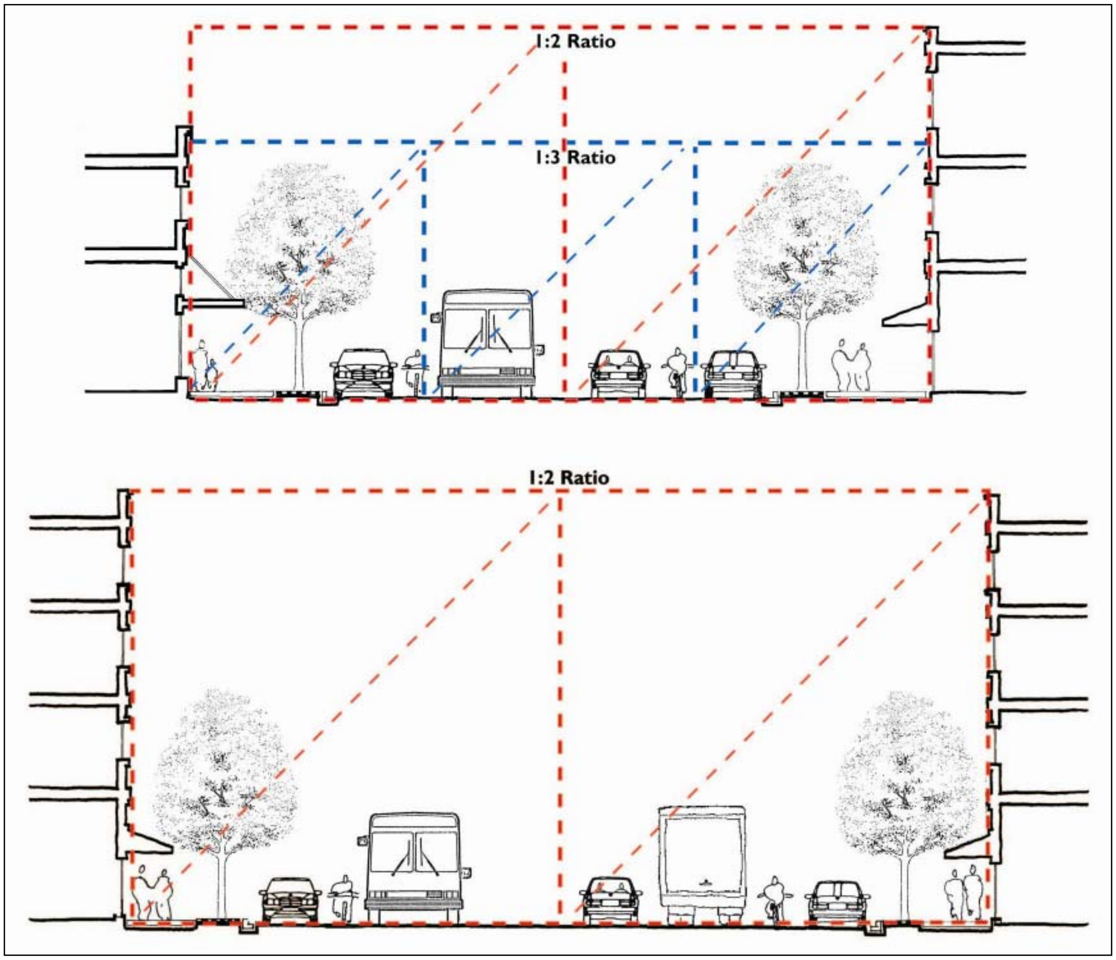

Figure 4.2 Illustration of height to width ratios that create a scale on thoroughfares that is comfortable to people and encourage walking (human scale). Human scale ratios fall between 1:3 and 1:2 as measured from the building fronts. Source: Community, Design + Architecture.

adjacent to the sidewalk, identify building entrances, and minimize uninviting blank walls) resulting in a scale of building that is comfortable to a person walking adjacent to it and adds architectural diversity and interest (Figure 4.3).

- *Building scale and variety.* This helps define the context and character of a thoroughfare and encourages walking by providing visual interest to the thoroughfare. The scale and variety of buildings should help define the scale of the pedestrian environment. Vehicle-oriented building scale maximizes physical and visual accessibility by drivers and auto passengers contributing to contexts that discourage walking.
- *Building entries.* Building entries are important in making buildings accessible and interesting for pedestrians. To maintain or create traditional urban character, buildings should have frequent entries directly from adjacent thoroughfares to improve connectivity and break down the scale of the building. Frequent entries from parking lots and secondary thoroughfares should be provided as well. Primary entries are encouraged at street corners to define intersections, increase the accessibility of buildings and reduce walking distance.

Figure 4.3 The frequency of articulation of a building facade contributes to a scale that is comfortable to pedestrians. Source: Community, Design + Architecture.

Context Zones

As described above, a wide variety of factors create context in the urban environment. Every thoroughfare has an immediate physical context created by buildings and activities on adjacent properties, and is part of a broader context created by the surrounding neighborhood or district. While the elements of context relating to buildings, landscape, land uses and public facilities can combine in almost infinite varieties, this report presents a set of four context zones for the purpose of CSS in urban areas. The four context zones are a subset of a more inclusive system of contexts that can be used to describe the full range of environments, from natural to highly urbanized (Duany 2000, 2002). Figure 4.4 illustrates this concept. Although the diagram graphically represents context zones as a linear continuum, from most natural to most urban, the zones are most frequently found arranged in mosaic-like patterns reflecting the complexity of metropolitan regions.

Many communities have found that context zones are useful in presenting information to the public. Local illustration of context zone examples can offer useful models that aid stakeholders in expressing their desires to create distinctive parts of their communi-

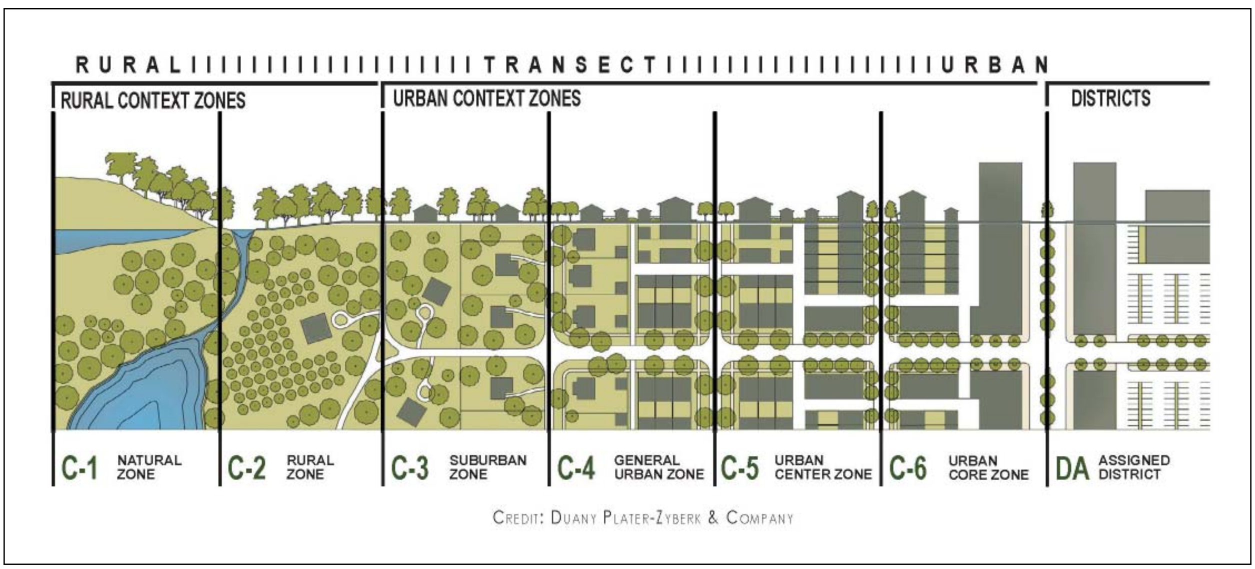

Figure 4.4 Illustration of a gradient of development patterns ranging from rural in Context Zone 1 (C-1) to the most urban in C-6. Source: Duany Plater-Zyberk and Company.

ties. Both professionals and stakeholders can use the context zones during the CSS process, ideally after calibrating the zone descriptions to reflect the range of height, intensity and building features in their own communities.

Selecting a Context Zone in Thoroughfare Design

The design process presented in this report uses context zones as a primary consideration in selecting the design parameters of urban thoroughfares. Much like the "rural" and "urban" classifications that are critical in selecting design criteria in *A Policy on the Geometric Design of Highways and Streets* (AASHTO 2004), context zones are an important determinant of basic design criteria in traditional urban thoroughfares. This chapter helps the practitioner identify and select context zones as one of the first steps in the design process.

As Table 4.1 shows, context is defined by multiple parameters, including land use, density and design features. Table 4.1 presents the full range of context zones, but this report focuses on the suburban through urban core contexts (C-3 through C-6). The "distinguishing characteristics" column in the table, for example, describes the overall relationship between buildings and landscape that contribute to context. In addition to the distinguishing characteristics and general character, four attributes assist the practitioner in identifying a context zone: (1) building placement—how buildings are oriented and set back in relation to the thoroughfare; (2) frontage type—what part of the site or building fronts onto the thoroughfare; (3) typical building height; and (4) type of public open space.

Guidelines for identifying and selecting a context zone include the following.

1. Consider both the existing conditions and the plans for the future, recognizing that thoroughfares often last longer than adjacent buildings.
2. Assess area plans and review general, comprehensive and specific plans, zoning codes and community goals and objectives. These often provide detailed guidance on the vision for the area.
3. Compare the area's predominant land use patterns, building types and land uses to the characteristics presented in Table 4.1.
4. Pay particular attention to residential densities, commercial floor-area ratios and building heights.
5. Consider dividing the area into two or more context zones if an area or corridor has a diversity of characteristics that could fall under multiple context zones.
6. Identify current levels of pedestrian and transit activity or estimate future levels based on the type, mix and proximity of land uses. This is a strong indicator of urban context.
7. Consider the area's existing and future characteristics beyond the thoroughfare design, possibly extending consideration to include entire neighborhoods or districts.

Thoroughfare Types

The design process in this report refers to both functional classification and thoroughfare type to classify streets and highways. This report further divides major urban thoroughfares into two distinct design classifications: thoroughfares in areas with traditional urban qualities serving compact, walkable mixed-use environments (as defined in Chapter 1), and vehicle mobility priority thoroughfares serving single-use areas or districts, or any area where the movement of vehicular traffic is a high priority.

The design of thoroughfares in vehicle mobility priority areas is governed by functional classification and surrounding context (retail commercial, business park, industrial, residential). Design guidance for these thoroughfares is provided in Chapter 11. The design of thoroughfares in areas with traditional urban qualities is governed by both function class and thoroughfare type. Design guidance for these thoroughfares, the focus of this report, is provided in Chapters 5 through 10.

The purpose of each classification as used in CSS applications for areas with traditional urban qualities is described below.

Table 4.1 Context Zone Characteristics

Context Zone	Distinguishing Characteristics	General Character	Building Placement	Frontage Types	Typical Building Height	Type of Public Open Space
C-1 Natural	Natural landscape	Natural features	Not applicable	Not applicable	Not applicable	Natural open space
C-2 Rural	Agricultural with scattered development	Agricultural activity and natural features	Large setbacks	Not applicable	Not applicable	Agricultural and natural
C-3 Suburban	Primarily single family residential with walkable development pattern and pedestrian facilities, dominant landscape character	Detached buildings with landscaped yards	Varying front and side yard setbacks	Lawns, porches, fences, naturalistic tree planting	1 to 2 story with some 3 story	Parks, greenbelts
C-4 General Urban	Mix of housing types including attached units, with a range of commercial and civic activity at the neighborhood and community scale	Predominantly detached buildings, balance between landscape and buildings, presence of pedestrians	Shallow to medium front and side yard setbacks	Porches, fences	2 to 3 story with some variation and few taller workplace buildings	Parks, greenbelts
C-5 Urban Center	Attached housing types such as townhouses and apartments mixed with retail, workplace, and civic activities at the community or sub-regional scale.	Predominantly attached buildings landscaping within the public right-of-way, substantial pedestrian activity	Small or no setbacks, buildings oriented to street with placement and character defining a street wall	Stoops, dooryards, storefronts, arcaded walkways	3 to 5 story with some variation	Parks, plazas and squares, boulevard median landscaping
C-6 Urban Core	Highest-intensity areas in sub-region or region, with high-density residential and workplace uses, entertainment, civic and cultural uses	Attached buildings forming sense of enclosure and continuous street wall landscaping within the public right-of-way, highest pedestrian and transit activity	Small or no setbacks, building oriented to street, placed at front property line	Stoops, dooryards, forecourts, storefronts, arcaded walkways	4+ story with a few shorter buildings	Parks, plazas, and squares, boulevard median landscaping
Districts	To be designated and described locally, districts are areas that are single-use or multi-use with low-density development pattern and vehicle mobility priority thoroughfares. These may be large facilities such as airports, business parks and industrial areas.					

(Based on transect zone descriptions in SmartCode V-6.5, Spring 2005 Credit: Duany Plater-Zyberk & Company.)

Shaded cells represent context zones that are not addressed in this report.

- Functional classification—defines a thoroughfare's function and role in the network, in addition to governing the selection of certain design controls. The practitioner may use functional class to determine:

  - Continuity of the thoroughfare through a region and the types of places it connects (such as major activity centers);
  - Purpose and lengths of trips accommodated by the thoroughfare;
  - Level of land access;
  - Type of freight service; and
  - Types of public transit services (for example, bus rapid transit)

  Use functional classification to determine the following design controls:

  - Design speed; and
  - Sight distance.

- Thoroughfare type—governs the selection of the thoroughfare's design criteria and, along with the surrounding context, is used to determine the physical configuration of the thoroughfare. Design criteria and physical configuration address which elements are included in the design and selection of dimensions. Use thoroughfare types, along with context zones, to develop designs for:

  - Roadside (sidewalks, planting strips);
  - Traveled way (lanes, medians, on-street parking, bicycle lanes); and
  - Intersections.

Table 4.2 shows eight specific thoroughfare types that are commonly used in the United States and gives a general description of each type. This report focuses on major urban thoroughfares—only four of the types in Table 4.2 fall into this category: high- and low-speed boulevards, avenues and streets. These thoroughfare types typically serve a mix of modes including pedestrian, bicycle users, private motor vehicles (for passenger and freight) and transit. Boulevards are typically larger thoroughfares with medians. The multiway boulevard is a variant of a boulevard that contains separated roadways for through and local access traffic. Boulevards serve a mix of regional and local traffic and carry the most important transit routes. Avenues and streets are similar to each other in form but avenues can be up to four lanes with a median. Streets are generally two lanes and serve predominantly local traffic.

Table 4.3 shows the relationship between thoroughfare types and functional classification. In general, boulevards serve an arterial function, avenues may be arterials or collectors and streets typically serve a collector or local function in the highway network.

More detailed description of the general design parameters and desired operating characteristics of the thoroughfare types are given in Table 4.4. As mentioned above, this document focuses on the three thoroughfare types in the table that can be considered to be major urban thoroughfare types: boulevards, avenues and streets. Those thoroughfare types serving areas with traditional urban qualities are suitable for the four urban context zones C-3, C-4, C-5 and C-6. Chapter 6 provides design parameters and criteria for each thoroughfare type based on a combination of functional class, context zone and whether the surrounding land use is predominantly commercial or residential.

Multiway boulevards may be considered when balancing the needs of abutting land uses (curb parking, pedestrian facilities, land access, fronting buildings) with arterial functions. The design of multiway boulevards, particularly intersections, is complex and sophisticated and beyond the scope of the guidance in this report. Vehicle mobility priority thoroughfares are suitable for single-use districts comprised of auto-oriented commercial/employment, strip commercial/shopping centers, business parks/office campuses, industrial/manufacturing and single-use residential areas as described in Chapter 11.

Table 4.2 Thoroughfare Type Descriptions

Thoroughfare Type	Functional Definition
Freeway/Expressway/ Parkway	Freeways are high speed (50 mph +), controlled-access thoroughfares with grade-separated interchanges and no pedestrian access. Includes tollways. Expressways and parkways are high- or medium-speed (45 mph +), limited-access thoroughfares with some at-grade intersections. On parkways, landscaping is generally located on each side and has a landscaped median. Truck access on parkways may be limited.
Rural Highway	High speed (45 mph +) thoroughfare designed to carry both traffic and to provide access to abutting property in rural areas. Intersections are generally at grade.
High Speed Boulevard (see Chapter 11 for design guidance)	High speed (40 to 45 mph) divided arterial thoroughfare in urban and suburban environments designed to carry primarily higher speed, long distance traffic and serve large tracts of separated single land uses (for example, residential subdivisions, shopping centers, industrial areas and business parks). High speed boulevards may be long corridors, typically 4 to 8 or more lanes and provide very limited access to land. May be transit corridors and accommodate pedestrians with sidewalks or separated paths, but some high speed boulevards may not provide any pedestrian facilities. These boulevards emphasize traffic movement, and signalized pedestrian crossings and cross-streets may be widely spaced. Bicycles may be accommodated with bike lanes or on separate paths. Buildings or parking lots adjacent to boulevards typically have large landscaped setbacks. They are primary goods movement and emergency response routes and widely use access management techniques.
Low Speed Boulevard (see Chapters 8, 9 and 10 for design guidance)	Walkable, low speed (35 mph or less) divided arterial thoroughfare in urban environments designed to carry both through and local traffic, pedestrians and bicyclists. Boulevards may be long corridors, typically 4 lanes but sometimes wider, serve longer trips and provide limited access to land. Boulevards may be high ridership transit corridors. Boulevards are primary goods movement and emergency response routes and use access management techniques. Curb parking may be allowed on boulevards. Multiway boulevards are a variation of the boulevard characterized by a central roadway for through traffic and parallel roadways for access to abutting property, parking and pedestrian and bicycle facilities. Parallel roadways are separated from the through lanes by curbed islands with landscaping; these islands may provide transit stops and pedestrian facilities. Multiway boulevards often require significant right-of-way.
Avenue (see Chapters 8, 9 and 10 for design guidance)	Walkable, low-to-medium speed (30 to 35 mph) urban arterial or collector thoroughfare, generally shorter in length than boulevards, serving access to abutting land. Avenues serve as primary pedestrian and bicycle routes and may serve local transit routes. Avenues do not exceed 4 lanes and access to land is a primary function. Goods movement is typically limited to local routes and deliveries. Some avenues feature a raised landscaped median. Avenues may serve commercial or mixed-use sectors and usually provide curb parking.
Street (see Chapters 8, 9 and 10 for design guidance)	Walkable, low speed (25 mph) thoroughfare in urban areas primarily serving abutting property. A street is designed to connect residential neighborhoods with each other, connect neighborhoods with commercial and other districts, and connect local streets to arterials. Streets may serve as the main street of commercial or mixed-use sectors and emphasize curb parking. Goods movements is restricted to local deliveries only.
Rural Road	Low speed (25-30 mph) thoroughfare in rural areas primarily serving abutting property.
Alley/Rear Lane	Very low-speed (5-10 mph) vehicular driveway located to the rear of properties, providing access to parking, service areas and rear uses such as secondary units, as well as an easement for utilities.

Shaded cells represent thoroughfare types that are not addressed in this report.

Table 4.3 Relationship Between Functional Classification and Thoroughfare Type

Functional Classification	Thoroughfare Types						
	Freeway/expressway/ Parkway	Rural Highway	Boulevard	Avenue	Street	Rural Road	Alley/rear Lane
Principal Arterial	■	■	■	■			
Minor Arterial		■	■	■	■		
Collector				■	■	■	
Local					■	■	■

■ Correspondence between Functional Class and Thoroughfare Type.
Shaded cells represent thoroughfare types that are not addressed in this report.

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Table 4.4 Urban Thoroughfare Characteristics

Urban Thoroughfare Type	Number of Through Lanes	Design Speed (mph)	Operating Speed (mph)	Intersection Spacing [1]	Transit Service Emphasis	Median	Driveway Access	Curb Parking	Pedestrian Facilities [2]	Bicycle Facilities	Freight Mvmt. [3]
FREEWAY	4 to 6+	50-70	45-65	1 to 2 miles	Express	Required	No	No	No	Optional Separated Pathway	Regional Truck Route
EXPRESSWAY/PARKWAY	4 to 6	50-60	45-55	1/2 to 1 mile	Express	Required	No	No	Optional Separated Pathway	Optional Separated Pathway	Regional Truck Route
BOULEVARD	4 to 6	35-40	30-35	660 to 1,320 ft.	Express and Local	Required	Limited	Optional	Sidewalk	Bike Lanes or Parallel Route	Regional Truck Route
MULTIWAY BOULEVARD	4 to 6	30-40 (20 in access lanes)	25-35	660 to 1,320 ft. (400 to 660 ft. for access lanes)	Express and Local	Required	Yes from access lane	Yes on access roadway	Sidewalk		Regional Route/Local deliveries only on access roadway
AVENUE	2 to 4	30-35	25-30	300 to 660 ft.	Local	Optional	Yes	Yes	Sidewalk		Local Truck Route
STREET	2	30	25	300 to 660 ft.	Local	Optional	Yes	Yes	Sidewalk		Local Deliveries Only
ALLEY/REAR LANE	1	10	5	Not Applicable	None	No	Yes	No	Shared	Shared	Local Deliveries Only

Shaded cells represent thoroughfare types that are not addressed in this report.

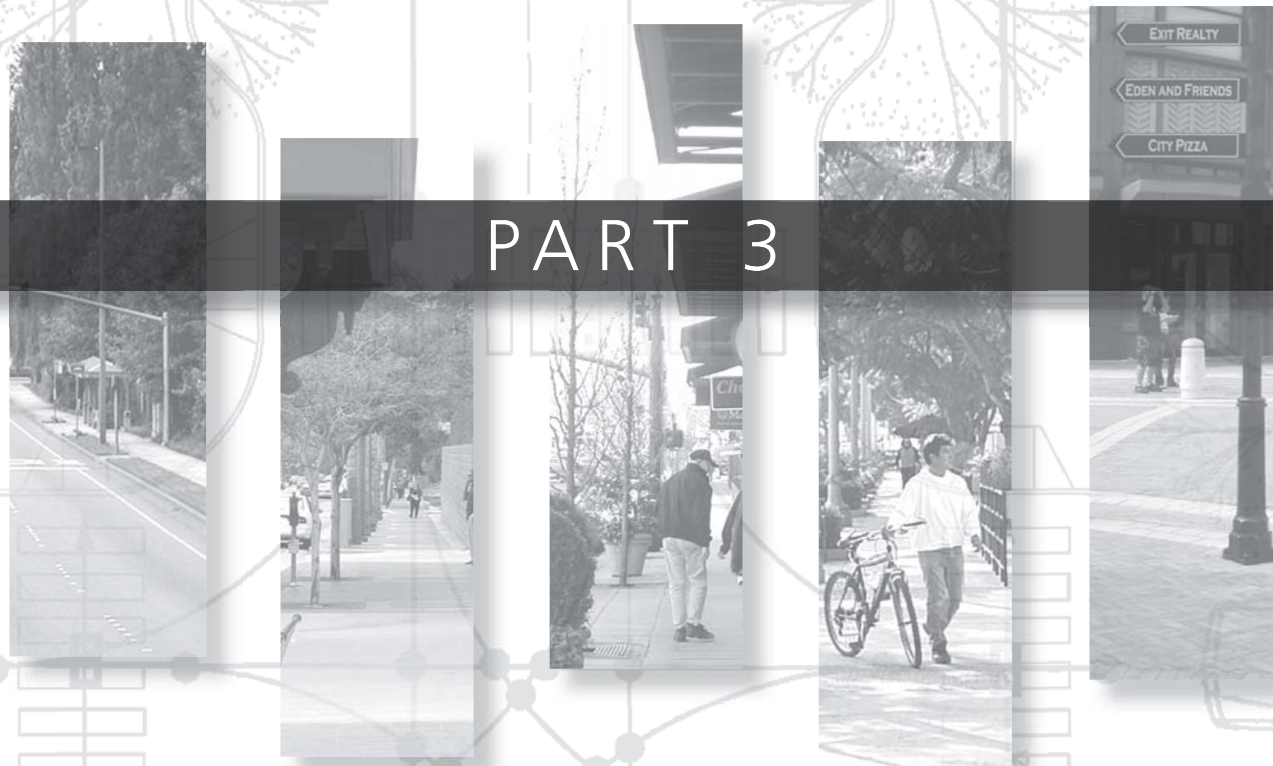
Notes:

[1] Spacing for freeways and expressways/parkways reflect grade-separated interchanges or major at-grade intersection spacing. Spacing for boulevards, multiway boulevards, avenues and streets depends on the context zone. Spacing shown represents signalized intersection spacing. Spacing for streets reflect driveway spacing.

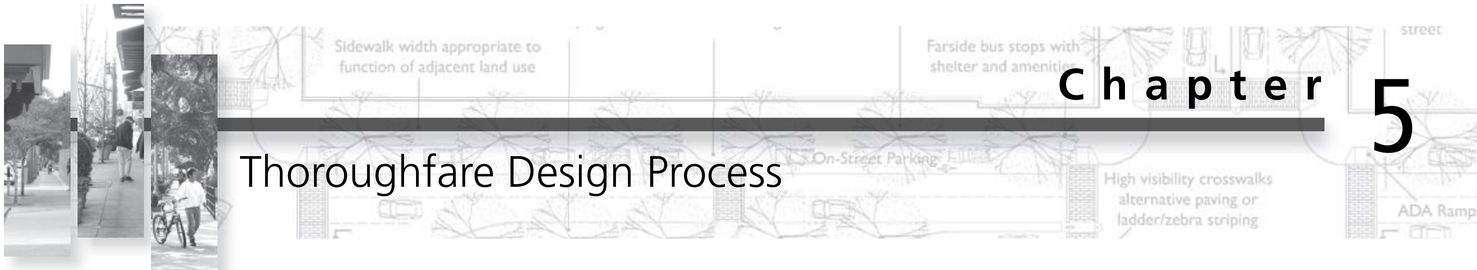
[2] Boulevard, avenue and street thoroughfare types have sidewalks on both sides. Sidewalk width varies as a function of context zone, fronting land use and other factors.

[3] Freight movement is divided into three categories: 1) regional truck route, 2) local truck route and 3) local deliveries only. Cells show highest order of truck movement allowed.

PART 3



Design



Chapter 5

Thoroughfare Design Process

PART 3: DESIGN

Purpose

This chapter outlines a five-stage process for designing thoroughfares in walkable urban contexts where the community has determined that the character of the thoroughfare and its integration with its surroundings are a high priority. It also presents an approach to design thoroughfares within constrained rights-of-way and discusses the flexibility the designer has in applying the design parameters presented to urban thoroughfares.

Objectives

This chapter:

1. Describes the various components of the thoroughfare and describes fundamental features of CSS in thoroughfare design;
2. Defines terms that are used in the thoroughfare design process;
3. Provides an overview and describes the five stages of the thoroughfare design process; and
4. Outlines a process for designing thoroughfares in constrained rights-of-way.

Definitions

Urban thoroughfare design requires attention to many elements of the public right-of-way and how these elements integrate with adjoining properties. To assist the designer in successfully assembling the elements of the thoroughfare, this report organizes definitions, design principles and criteria into four sections corresponding to the components of a thoroughfare. The three components that comprise the cross-section of the thoroughfare are illustrated in Figure 5.1 (context, roadside, traveled way), while the fourth component, intersections, is discussed below.

Figure 5.2 illustrates many of the fundamental elements of a context sensitive thoroughfare design, including elements in the traveled way and roadside, and as part of the context.

Each of the components can be described as follows.

- Context—Encompasses a broad spectrum of environmental, social, economic and historical aspects of a community and its people. All of these aspects are important in developing CSS. Thus, context can be the built or is part of the natural environment. The built environment consists of properties and activities within and adjacent to the public right-of-way and the thoroughfare itself, with surroundings that contribute to characteristics that define the context zone. Buildings, landscaping, land-use mix, site access and public and semi-public open spaces are the primary shaping elements of the context. The natural environment includes features such as water or topography. In both environments, context can reflect historic or other protected resources. An urban thoroughfare will often pass through both built and natural environments as it changes from one context zone to another.

- Roadside—The public right-of-way typically includes 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 frontage, throughway, furnishings and edge zones (Table 5.1 and Chapter 8 provide detailed descriptions). The function of roadside zones and the level of pedestrian use of the roadside are directly related to the activities generated by the adjacent context.

- Traveled Way—The public right-of-way is between curbs and includes parking lanes, and the travel lanes for private vehicles, goods move-

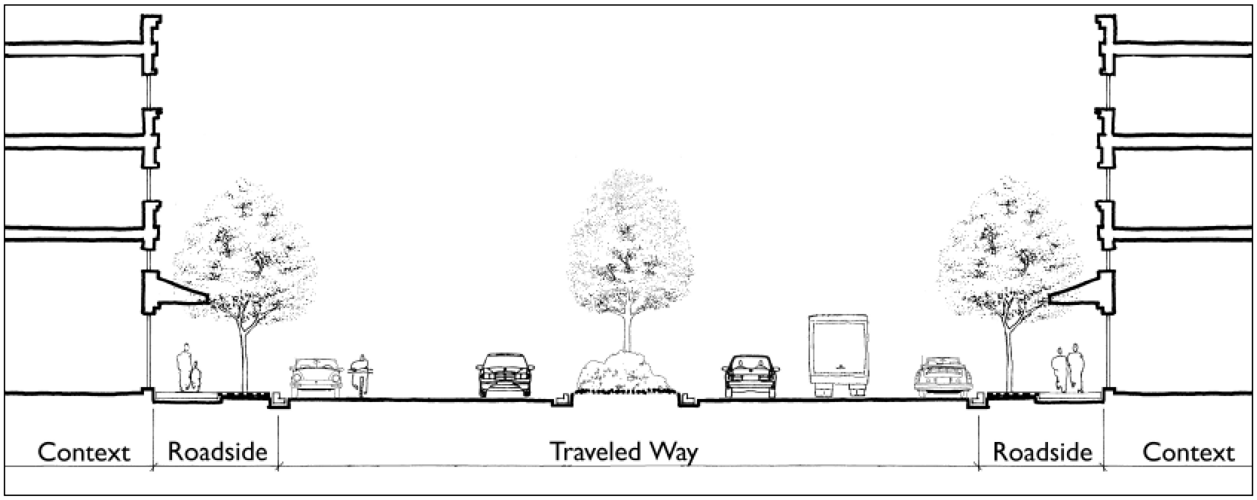


Figure 5.1 Components of an urban thoroughfare. Source: Community, Design + Architecture.

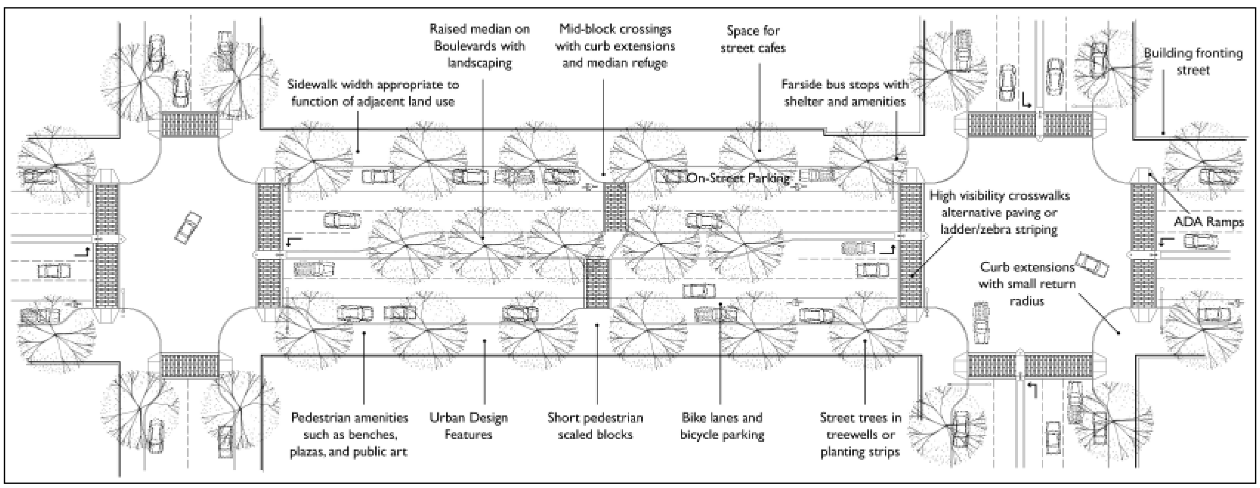


Figure 5.2 An illustration of the elements of a context sensitive thoroughfare. Community, Design + Architecture.

ment, 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 (see Chapter 9 for detailed descriptions).

- Intersections—Are defined as where two or more public streets meet. Intersections are characterized by a high level of activity and shared use, multi-modal conflicts, complex movements and special design treatments (Chapter 10 contains detailed descriptions).

This chapter uses terms that are commonly used in transportation planning and engineering and introduces new terms and concepts that require definition. Both common and new terms and concepts as they are related to the design process are defined in Table 5.1.

Table 5.1 Definition of Terms and Concepts in Chapter 5

Term or Concept	Definiton
Frontage Zone	One of the zones comprising the roadside, the frontage zone is the space between the pedestrian travel way and building faces or private property. At a minimum it provides a buffer distance from vertical surfaces or walls and allows people to window shop or enter/exit buildings without interfering with moving pedestrians. The frontage zone provides width for overhanging elements of adjacent buildings such as awnings, store signage, bay windows, etc. If appropriate width is provided, the frontage zone may accommodate a variety of activities associated with adjacent uses, such as outdoor seating, or merchant displays.
Throughway Zone	The roadside zone in which pedestrians travel. The throughway must provide a minimum horizontal and vertical clear area in compliance with ADA requirements.
Furnishings Zone	The furnishings zone is a multi-purpose area of the roadside. It serves as a buffer between the pedestrian travel way and the vehicular area of the thoroughfare within the curbs, and it provides space for roadside appurtenances such as street trees, planting strips, street furniture, utility poles, sidewalk cafes, sign poles, signal and electrical cabinets, phone booths, fire hydrants, bicycle racks and bus shelters.
Edge Zone	The edge zone, sometimes also referred to as the "curb zone," is the transition area between the thoroughfare traveled way and the furnishings zone of the roadside and provides space for the door swing from vehicles in the parking lane, for parking meters and for the overhang of diagonally parked vehicles.
Right-of-way	Right-of-way is 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.

(See Chapters 8 and 9 for further definitions and design guidelines for the components of the roadside and the traveled way.)

Overview of the Design Process

The context-based thoroughfare design process presented encompasses the project development steps from developing project concepts to final design. Briefly introduced in Chapter 2, the design process is comprised of the five stages shown in Figure 5.3. While this report presents the process in five discrete stages for simplicity, the thoroughfare design process is an iterative process that requires collaboration with the public, stakeholders and an interdisciplinary team of professionals.

Stage 1: Review or develop an area transportation plan.

The transportation plan entails development of land use and travel demand forecasts and testing of network alternatives. Often this stage is already available and serves as a direction or resource for the thoroughfare designer. This first stage provides the overall basis for thoroughfare design. The transportation plan establishes guiding principles and policies for the broader community and region. It develops and evaluates the network to ensure the transportation system accommodates projected land use growth. The plan should identify performance measures for each mode of transportation at the intersection, corridor and network level and identify how the network supports the community's key goals. The plan should identify and prioritize discrete thoroughfare projects from which the project development process begins. If an area transportation plan has not been prepared, one should be pre-

An area transportation plan is a long-range plan based on a public/stakeholder process that establishes goals and objectives for the area, town, or region. The plan results in the pattern of the thoroughfare network, the initial sizing of individual thoroughfares and prioritization of transportation improvements.

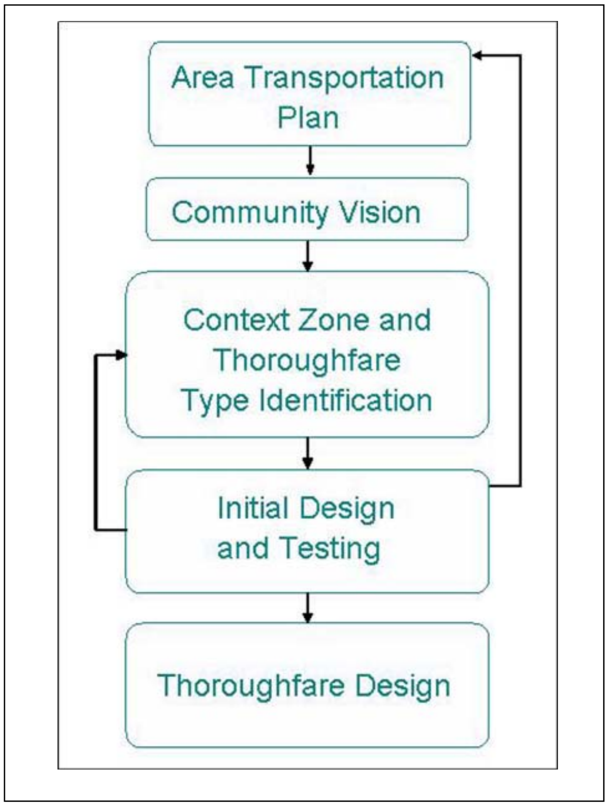


Figure 5.3 Thoroughfare design stages. Source: Kimley-Horn and Associates Inc.

pared as part of the thoroughfare design process. Area transportation plans can be in the form of regional transportation plans, comprehensive or general plans, or focused district, area, or specific plans. Chapter 3 provides background and guidance on network systems and design.

Stage 2: Understand community vision for context and thoroughfare.

In this stage, the designer collaborates with the public, stakeholders and interdisciplinary team to develop goals and objectives for the project.

If the community in which the project is located has developed a vision and established goals and objectives, this stage entails a thorough knowledge and understanding to ensure that the project achieves the vision. This stage requires review of planning documents, transportation and circulation plans, and land use and zoning codes. Through the community vision, the designer can determine both the existing and future context for the area served by the thoroughfare. It is the future context that defines the long-term transportation and placemaking function of the thoroughfare.

Understanding the vision, goals and objectives of the place a thoroughfare serves is a critical step. This includes understanding the context as well as the thoroughfare's role in the transportation system. Context sensitive thoroughfare design considers today's conditions, but also reflects plans for the future.

If the community lacks a vision, desires a change, or requires further detail in the project area, this is an opportunity to use a public and/or stakeholder process to develop a vision. Frequently, it is desirable to use a participatory process to develop concepts and alternatives even if a vision exists. This establishes public ownership in the project and helps meet the requirements of National Environmental Policy Act.

The process for working with the public and stakeholders to develop a vision is outside the scope of this report. However, there are resources available to explain the process such as *Public Involvement Techniques for Transportation Decision-Making* by the U.S. DOT Federal Transit Administration.

Stage 3: Identify compatible thoroughfare types and context zones.

This report provides the tools for this stage in Chapter 4—a framework for urban thoroughfare design. Stage 3 relies on an understanding of the existing and future context identified in Stage 2. Stages will result in the identification of opportunities, design controls and constraints that will dictate thoroughfare design elements and project phasing.

Chapter 4 guides the thoroughfare designer through the process of identifying context and alternative thoroughfare types best suited for the identified context zone. The initial relationship between the context zone and the thoroughfare is tentative, leading to Stage 4 of the process.

Stage 3 determines the compatibility between the existing and future context and the appropriate thoroughfare type. It considers land use and transportation integration, modal requirements, place-making objectives and the functional roles of the adjacent land use and street.

Stage 3 entails close examination of modal requirements (such as transit, bicycle, pedestrian and freight needs) and establishment of design controls such as traffic volumes, speed, corridor wide operations, right-of-way constraints and other fundamental engineering controls (Chapter 7 provides additional information). This stage might be an iterative process that compares needs with constraints, identifies trade-offs and establishes priorities. Specific steps in this stage include:

1. Determine the context zone(s) within which the thoroughfare is located. The context zones, whether existing or projected, are determined from a community or regional comprehensive plan if one is available. In the absence of such a plan, the context zones can be derived from the description of the function, configuration, the type of the buildings fronting the thoroughfare and whether the context is predominantly residential or commercial. Note that the context zone will change throughout the length of a corridor, requiring the thoroughfare to be divided into segments that may have varying design parameters and elements. Table 4.1 in Chapter 4 can assist in identifying context zones.

2. Select the appropriate thoroughfare type based on context zone and purpose of the thoroughfare as determined from the area plan, including its functional classification designation.

   Tables 4.2, 4.3 and 4.4 assist the designer in developing the character and general design parameters of the thoroughfare. The thoroughfare's functional classification establishes the role of the thoroughfare in the transportation network and helps determine certain design controls such as target and design speed. Thoroughfare type establishes the physical design of the thoroughfare and the design elements that serve the activities of the adjacent uses. For urban thoroughfares in walkable communities, the combination of thoroughfare type, functional classification and context zone is used to select the appropriate general design parameters presented in Chapter 6, and the roadside, traveled way and intersection design guidelines presented in Chapters 8 through 10, respectively.

Stage 4: Develop and test the initial thoroughfare concept.

In Stage 4, initial thoroughfare concepts are developed by establishing vital parameters such as functional class, speed, number of lanes, right-of-way and other design parameters. In this stage, the thoroughfare's function beyond the limits of the project are considered along with its multimodal and place-making functions to ensure both the community vision and the overall network operates as planned.

Understanding the balance between the regional functions and local needs of the thoroughfare is key to select the appropriate design criteria and prepare the initial thoroughfare concept. Stage 4 determines whether the boulevard, avenue, or street concept of initial width is appropriate. This step in the process feeds back into the previous stages if the evaluation of the concept results in the need to change the initial thoroughfare type or modify the system design. In this stage the practitioner uses the design parameters identified by the context zone/thoroughfare type combination selected in Stage 3 (Tables 6.1 and 6.2 in Chapter 6) to determine the basic elements of the thoroughfare that impact its width, including on-street parking, bicycle lanes, number and width of travel lanes, median and general configuration of the roadside.

The practitioner then tests and validates the initial concept at the corridor and network level of performance. A successful urban thoroughfare concept is one that, when viewed as part of an overall system, maintains acceptable system-wide performance even though the individual thoroughfare intersections may experience congestion. Network performance should include multimodal performance measures. Chapter 3 describes the role of the thoroughfare in the network and references network connectivity guidelines.

Evaluation of the thoroughfare at the corridor and network level will either validate the initial concept or indicate the need to revisit the context zone/thoroughfare type relationship or modify the design parameters. The evaluation might even indicate the need to revise regional or sub-regional land use and circulation plans.

Stage 5: Develop a detailed thoroughfare design.

The evaluation and initial designs in the previous stages lead to refinements and development of a detailed thoroughfare design that reflects the project objectives. This step culminates in final engineering design and environmental approvals.

Once a successful initial concept has been developed and validated, the process leads to the final step of detailing the thoroughfare design. Stage 5 involves using the guidance to integrate the design of the street components, context, roadside, travelway and intersections. As with any design process, this stage is iterative, resulting in a thoroughfare plan and cross-sections. This stage then leads into preliminary and final engineering. Specific steps in this stage include:

1. Identify available right-of-way and other constraints.

   In new developments, this step establishes the necessary right-of-way to accommodate the thoroughfare type and its desirable elements. In existing built areas, this step identifies the available right-of-way as an input to the thoroughfare design process. It is important to identify any other constraints that will affect the design, such as utility placement.

   In existing areas, an initial cross-section of the desirable roadside and traveled way elements is prepared (see design examples in Chapter 6) and compared with the available right-of-way. If the collective width of the desirable design elements exceeds the right-of-way, determine the feasibility of acquiring the necessary right-of-way or eliminating or reducing non-vital elements.

2. Design the traveled way elements.

   First identify and select the design controls appropriate for the thoroughfare type and context zone identified in Stage 3. These controls include target and design speed (affects sight distance and alignment), control/design vehicle (affects lane width and intersection design), and modal requirements, such as level of pedestrian activity, parking, bike routes, primary freight routes, or transit corridor, etc. A trade-offs evaluation may be necessary if right-of-way is constrained. The design controls and context, along with the available right-of-way, assist in the selection of the appropriate dimensions for each design element.

3. Design the roadside elements.

   The design of the roadside elements requires understanding the characteristics and activity of the adjacent existing or future context. For example, does or will the context include ground floor retail or restaurants that require a wider frontage zone to accommodate street cafes? Does or will the thoroughfare include a transit corridor that requires a wider furnishings zone to accommodate waiting areas and shelters? This guide provides general guidance on the optimal and constrained roadside width used initially, but the actual design might require more analysis of existing and future activity levels.

4. Assemble the thoroughfare components.

   This is an iterative process, particularly in constrained rights-of-way. This process entails identifying trade-offs to accommodate the roadside and traveled way elements within the right-of-way. It is important to refer back to the community vision stage to understand and evaluate the trade-offs. The last section of this chapter provides an approach to design thoroughfares in constrained conditions.

Flexibility in Application of Design Criteria

Flexibility in the application of design criteria requires an understanding of its functional basis and the ramifications of changing dimensions or adding/eliminating design elements. Dimensions, whether for elements in the roadside, traveled way, or intersection, should not be applied arbitrarily. The thoroughfare designer should understand the relationship between a recommended criterion and its role in safety and mobility. The American Association of State Highway and Transportation Officials (AASHTO) emphasizes this requirement in the following quote from *A Guide for Achieving Flexibility in Highway Design* (2004c):

> *Only by understanding the actual functional basis of the criteria and design values can designers and transportation agencies recognize where, to what extent and under what conditions a design value outside the typical range can be accepted as reasonably safe and appropriate for the site-specific context.*

Therefore, the thoroughfare designer is strongly encouraged to become familiar with the criteria, principles, design controls and functional basis for the criteria presented in this and other guidance, including AASHTO's *A Policy on Geometric Design of Highways and Streets* (2004a), *Guide for the Planning, Design and Operation of Pedestrian Facilities* (2004b) and *Guide for the Development of Bicycle Facilities* (1999).

Flexibility is related to the design controls used in the selection of criteria. Design controls recognized by AASHTO include functional classification, location (urban versus rural), traffic volumes and level of service, design vehicle and driver and speed. All of these design controls are important regardless of whether the designer believes the thoroughfare design is context sensitive or not. CSS for major urban thoroughfares emphasizes the following design controls, which are the basis of the design flexibility presented.

1. **Location:** By definition, CSS for major urban thoroughfares address urban locations where context and the activities generated by the context substantially influence the design of the thoroughfare. These influences include, but are not limited to, pedestrians and bicyclists, transit, economic activity of adjacent uses and right-of-way constraints. In addition to urban contexts, the criteria vary by type of land use within urban areas. Some design criteria will differ on a thoroughfare serving predominantly residential uses versus a thoroughfare serving predominantly commercial uses with ground floor retail. This report focuses on criteria most affected by the design control of location. In certain locations communities may choose to make the character of the thoroughfare a dominant design control. In these circumstances, the use of thoroughfare types and guidance in this report may be used in making design decisions.
2. **Functional Classification:** Functional classification helps establish the thoroughfare type and characteristics of the vehicular travel using the thoroughfare (such as trip length and purpose). It provides information on whether the thoroughfare is a primary emergency response route, truck route, or major transit corridor. These factors help the designer determine lane widths, number of travel lanes and target speed.
3. **Design Vehicle:** The design vehicle plays an important role in the selection of certain design criteria such as lane width and curb return radii. Context sensitive design of major urban thoroughfares emphasizes the use of careful thought and common sense when selecting a design vehicle. Careful thought includes understanding the trade-offs of selecting one design vehicle over another. In urban areas it is not always practical or desirable to choose the largest design vehicle that might occasionally use the facility being designed, because of the impacts to pedestrian crossing distances, speed of turning vehicles, etc. In contrast, selection of a small design vehicle in the design of a facility regularly used by large vehicles can invite frequent operational

problems. Consistent with AASHTO *A Policy on Geometric Design of Highways and Streets*, otherwise known as the Green Book (2004a), , select the largest design vehicle that will use the facility with considerable frequency (for example, bus on bus routes, semi-tractor trailer on primary freight routes or accessing loading docks, etc.). In general, consideration must be given to a design vehicle (a vehicle that must be regularly accommodated without encroachment into the opposing traffic lanes) and a control vehicle (an infrequent vehicle that must be accommodated, but encroachment into the opposing traffic lanes, multiple-point turns, or minor encroachment into the roadside is acceptable) in thoroughfare design. If the control vehicle is larger than the design vehicle, its consideration will inform the practitioner of the potential ramifications to the design.

4. **Speed:** The most influential design control, and the design control that provides significant flexibility in urban areas, is speed. Thoroughfare design should be based on both design speed and target speed. Design speed governs certain geometric features of a roadway, primarily horizontal curvature, superelevation and sight distance. The target speed, in contrast to operating speed, is the desirable speed at which vehicles should operate on a thoroughfare in a specific context. Design speed should be no greater than 5 mph higher than the target speed. Operating speed, as defined by AASHTO, is the observed speed under free-flow conditions, typically based on the 85th percentile speed. It is recommended to not use operating speed as the basis for determining design speed since operating speed may be higher than desirable in an urban area with high levels of pedestrian activity, particularly on existing roadways originally designed with high design speeds.

   However, use caution against the blind application of lower speeds. Consistent with AASHTO, this report urges sound judgment in the selection of an appropriate target and design speed based on a number of factors and reasonable driver expectations. Factors in urban areas include transition from higher to lower speed roadways, terrain, intersection spacing, frequency of access to adjacent land and type of roadway median. AASHTO's *A Guide for Achieving Flexibility in Highway Design* (2004c) aptly summarizes the selection of speed in urban areas:

   > *Context-sensitive solutions for the urban environment often involve creating a safe roadway environment in which the driver is encouraged by the roadway's features and the surrounding area to operate at lower speeds.*

Urban thoroughfare design for walkable communities should start with the selection of a target speed. The design speed (a maximum of 5 mph over the target speed) should be applied to those geometric design elements where speed is critical to safety, such as horizontal curvature and intersection sight distance. The target speed is not set arbitrarily, but achieved through a combination of measures that include:

- Setting an appropriate and realistic speed limit;
- Using physical measures such as curb extensions and medians to narrow the traveled way;
- Setting signal timing for moderate progressive speeds from intersection to intersection;
- Using narrower travel lanes that cause motorists to naturally slow; and
- Using design elements such as on-street parking to create side friction.

A target speed range is recommended based on the thoroughfare type and context including whether the area is predominantly residential or commercial. The associated design speed then becomes the primary control for the purposes of determining critical traveled way design values, including intersection sight distance and horizontal and vertical alignment.

Design Process in Constrained Right-of-Way

The nature of thoroughfare design is balancing the desired design elements of the ideal thoroughfare with right-of-way constraints. The thoroughfare designs presented illustrate the desired elements within the cross-section, but frequently actual conditions limit the width of the street. Designing thoroughfares in constrained rights-of-way requires prioritizing the design elements and emphasizing the higher priority elements in constrained conditions. Higher priority design elements are those that help the thoroughfare meet the vision and context sensitive objectives of the community (the objectives established in Stage 2). Lower priority elements have less influence on achieving the objectives and can be relinquished in cases of insufficient right-of-way.

Often the width of the public right-of-way varies along the thoroughfare, making the job of the designer even more challenging. When the width of the right-of-way varies, it is useful to prioritize design elements and develop a series of varying cross sections representing:

1. Optimal conditions—sections without right-of-way constraints that can accommodate all desirable elements;
2. Predominant—representing sections of the predominant right-of-way width in the corridor that accommodate all of the higher priority elements;
3. Functional minimum—representing a typically constrained section where most of the higher priority elements can be accommodated; and
4. Absolute minimum—representing severely constrained sections where only the highest priority design elements can be accommodated without changing the type of thoroughfare.

Below the absolute minimum, or if the predominant right-of-way is equal to or less than the absolute minimum, consider changing the thoroughfare to a different type while attempting to maintain basic function; or consider converting the thoroughfare to a pair of one-way thoroughfares (couplet) or other solutions that achieve the community vision. This requires reiterating through the steps, potentially requiring a review of the community vision for the thoroughfare and the area transportation plan, and identifying a new context zone/thoroughfare relationship.

If the vision for the corridor is long range, then the necessary right-of-way should be acquired over time as the adjacent property redevelops. Under these circumstances the optimal thoroughfare can be phased in over time, beginning with the functional or absolute minimum design in the initial phase.

In constrained conditions it might be tempting to minimize the roadside width and only provide the minimum pedestrian throughway (5 ft.). In urban areas, however, it is important to maintain at least a minimum width furnishing zone to accommodate street trees, utility poles and other appurtenances. Without the furnishings zone, trees, utilities, benches and shelters and other street paraphernalia might encroach into the throughway for pedestrians.

Table 5.2 provides minimum recommended dimensions for the roadside in constrained conditions, which vary by the predominant land use. In residential areas, the furnishings zone can be a minimum of 3 ft. This width continues to provide a buffer between pedestrians and the traveled way and also allows a minimal width for plantings and other utilities. The clear throughway for pedestrians should be a minimum of 5 ft. The frontage zone should be a minimum of 1 ft. adjacent to buildings or eliminated adjacent to landscaping. These dimensions result in a minimum residential roadside width of 9 ft.

In predominantly commercial areas with ground floor retail, the furnishings zone minimum width is 4 ft. to allow for street trees, utilities, etc., the clear throughway for pedestrians is a minimum of 6 ft. to allow for a higher level of pedestrian activity, and the frontage zone minimum is 2 ft. to provide a buffer between moving pedestrians and buildings, resulting in a 12-ft. roadside width. When a wider frontage zone is needed (for street cafes, etc.), consider requiring the adjacent property to provide an easement to effectively expand the roadside width.

Works Cited

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

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

Table 5.2 Minimum Recommended Roadside Dimensions in Constrained Conditions

Roadside Zone	Min. Dimension
Residential (All Context Zones)	
Edge and Furnishing Zone (Planting Strip, utilities, etc.)	3 ft.
Clear Pedestrian Travel Way	5 ft.
Frontage Zone	1 ft.
Total Minimum Roadside Width:	9 ft.
Commercial with Ground Floor Retail (All Context Zones)	
Edge and Furnishing Zone (Treewell,[1] utilities, bus stops, etc.)	4 ft.
Clear Pedestrian Travel Way	6 ft.
Frontage Zone	2 ft.
Total Minimum Roadside Width:	12 ft.

[1] Plant only small caliper trees (4 in. diameter when mature) in 4-ft. treewells.

American Association of State Highway and Transportation Officials. 2002. *Roadside Design Guide*. 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.

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Chapter 6

Thoroughfare Design for Urban Areas

Purpose

This chapter identifies how design elements may be combined to produce a thoroughfare in urban areas with traditional characteristics (see Chapter 11 for determining cross-sections for vehicle mobility priority thoroughfares). This chapter includes tables of common cross-sectional design elements for thoroughfare types in each context zone and provides design examples under various situations. The variation in design criteria are presented by functional classification (arterial versus collector), context zone (C-3 through C-5/6), thoroughfare type (boulevard, avenue and street) and whether the thoroughfare serves a predominantly residential or commercial area with fronting ground floor retail.

Objectives

This chapter:

1. Describes how variables such as context zone and land use type can affect the design of thoroughfares; and
2. Provides design examples that guide the practitioner through the design process.

Basis for Thoroughfare Design Examples

The thoroughfare examples illustrate variations in the traveled way and roadside based on the variables of existing constraints, context zone, functional classification, thoroughfare type and predominant surrounding land use and ground floor uses. The general influence of each variable on the design of a thoroughfare is summarized in Table 6.1.

General Thoroughfare Design Parameters

Tables 6.2 and 6.3 present the general design parameters for arterial and collector thoroughfare types under varying context conditions. The tables provide general guidance on dimensions and criteria for common elements of the cross section and other vital design elements of major urban thoroughfares. Table 6.2 presents guidance for arterial thoroughfares (boulevards and avenues) and Table 6.3 presents guidance for collector thoroughfares (avenues and streets).

These tables provide a range of recommended dimensions and/or practices for key design criteria present-

Table 6.1 Effect of Variables on Thoroughfare Design Elements

Variable	Effect on Design Elements
Context Zone	A designation of design character that affects general design parameters including the selection of thoroughfare type, target speed, and the width and treatment of certain roadside elements.
Thoroughfare Type	Affects general design parameters of thoroughfares including target speed, number of through lanes, basic travel lane width, medians on Boulevards, and the width of certain roadside elements.
Predominant Land Use and Ground Floor Use	Divided into predominantly residential or commercial. Residential areas affect roadside width, parking lane width, landscaping, and building setback. Commercial development, particularly where there is ground floor retail, affects roadside dimensions and the width of the roadside uses for pedestrian facilities, bus stops, landscaping, and outdoor cafes, etc. Adjacent land uses, pedestrian activity, and building orientation, etc. directly influence the desired operating and design speeds (and related design elements).

Table 6.2 General Parameters for Arterial Thoroughfares

	Suburban (C-3)				General Urban (C-4)				Urban Center/Core (C-5/6)			
	Residential		Commercial		Residential		Commercial		Residential		Commercial	
	Boulevard	Avenue	Boulevard	Avenue	Boulevard	Avenue	Boulevard	Avenue	Boulevard	Avenue	Boulevard	Avenue
Context												
Building Orientation (entrance orientation)	front, side	front, side	front, side	front, side	front	front	front	front	front	front	front	front
Maximum Setback [1]	20 ft.	20 ft.	5 ft.	5 ft.	15 ft.	15 ft.	0 ft.	0 ft.	10 ft.	10 ft.	0 ft.	0 ft.
Off-Street Parking Access/Location	rear, side	rear, side	rear, side	rear, side	rear, side	rear, side	rear, side	rear, side	rear	rear	rear	rear
Roadside												
Recommended Roadside Width [2]	14.5 ft.	12.5 ft.	16 ft.	15 ft.	16.5 ft.	12.5 ft.	19 ft.	16 ft.	21.5 ft.	19.5 ft.	21.5 ft.	19.5 ft.
Pedestrian Buffers (planting strip exclusive of travel way width) [2]	8 ft. planting strip	6-8 ft. planting strip	7 ft. tree well	6 ft. tree well	8 ft. planting strip	6-8 ft. planting strip	7 ft. tree well	6 ft. tree well	7 ft. tree well	6 ft. tree well	7 ft. tree well	6 ft. tree well
Street Lighting	For all arterial thoroughfares in all context zones, intersection safety lighting, basic street lighting and pedestrian-scaled lighting is recommended. See Chapter 8 (Roadside Design Guidelines) and Chapter 10 (Intersection Design Guidelines).											
Traveled Way												
Target Speed (mph)	35	25-30	35	35	35	25-30	35	25-30 [3]	35	25-30	30	25-30 [3]
Design Speed	Design speed should be a maximum of 5 mph over the operating speed. Design speed is used as a control for certain geometric design elements including sight distance and horizontal and vertical curvature.											
Number of Through Lanes [4]	4-6	2-4	4-6	2-4	4-6	2-4	4-6	2-4	4-6	2-4	4-6	2-4
Lane Width [5]	10-11 ft.	10-11 ft.	10-12 ft.	10-11 ft.	10-11 ft.	10-11 ft.	10-12 ft.	10-11 ft.	10-11 ft.	10-11 ft.	10-11 ft.	10-11 ft.
Parallel On-Street Parking Width [6]	7 ft.	7 ft.	8 ft.	8 ft.	7 ft.	7 ft.	8 ft.	8 ft.	7 ft.	7 ft.	8 ft.	8 ft.
Min. Combined Parking/Bike Lane Width	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.
Horizontal Radius (per AASHTO) [7]	762 ft.	510 ft.	762 ft.	762 ft.	762 ft.	510 ft.	762 ft.	510 ft.	762 ft.	510 ft.	510 ft.	510 ft.
Vertical Alignment	Use AASHTO minimums as a target, but consider combinations of horizontal and vertical per AASHTO Green Book.											
Medians (which will accommodate single left-turn lanes at intersections) [8]	14-16 ft.	Optional 14 ft.	14-16 ft.	Optional 14 ft.	14-16 ft.	Optional 14 ft.	14-16 ft.	Optional 14 ft.	14-16 ft.	Optional 14 ft.	14-16 ft.	Optional 14 ft.
Bike Lanes (min./preferred width)	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.
Access Management [9]	Moderate	Low	High	Moderate	Moderate	Low	High	Low	Moderate	Low	High	Low
Typical Traffic Volume Range (vpd)	20,000-35,000	15,000-25,000	20,000-50,000	10,000-35,000	10,000-30,000	10,000-20,000	15,000-40,000	5,000-30,000	15,000-30,000	10,000-20,000	15,000-40,000	5,000-30,000
Intersections												
Roundabout	Consider urban single-lane roundabouts at intersections on arterial avenues with less than 20,000 entering vehicles per day, and urban double-lane roundabouts at intersections on Boulevards and Avenues with less than 40,000 entering vehicles per day.											
Curb Return Radii	Refer to Chapter 10 (Intersection Design Guidelines) for details											

Table Notes:

[1] For all context zones with predominantly commercial frontage, this table shows the maximum setback for buildings with ground floor retail. In suburban contexts, office buildings are typically set back 5 ft. further than retail buildings to provide a privacy buffer. In general urban and urban center/core areas, office buildings are set back 0-5 ft. Setback exceptions may be granted for important buildings or unique designs.

[2] Roadside width includes edge, furnishing/planting strip, clear travel way and frontage zones. Refer to Chapter 8 (Roadside Design Guidelines) for detailed description of sidewalk zones and widths in different context zones and on different thoroughfare types. Dimensions in this table reflect widths in unconstrained conditions. In constrained conditions roadside width can be reduced to 12 ft. in commercial areas and 9 ft. in residential areas (see Chapter 5 on designing within constrained rights-of-way).

[3] Desired operating speeds on collector avenues serving C-4 and C-5/6 commercial main streets with high pedestrian activity should be 25 mph.

[4] Six lane facilities are generally undesirable for residential streets because of concerns related to neighborhood livability (i.e., noise, speeds, traffic volume) and perceptions as a barrier to crossing. Consider a maximum of four lanes within residential neighborhoods.

[5] Lane width (turning, through and curb) can vary. Most thoroughfare types can effectively operate with 10-11 ft. wide lanes, with 12 ft. lanes desirable on higher speed transit and freight facilities. Chapter 9 (Traveled Way Design Guidelines) (lane width section) identifies the considerations used in selecting lane widths.

[6] An 8 ft. wide parking lane is recommended in any commercial area with a high turnover of parking.

[7] For guidance on horizontal radius - see AASHTO's section on "Minimum Radii for Low Speed Urban Streets - Sharpest Curve Without Superelevation." Dimensions shown above are for noted design speeds and are found in Exhibits 3-16 (Page 151) in *A Policy on Geometric Design of Highways and Streets* (2004), assuming a superelevation of -2.0 reflecting typical cross slope.

[8] These median widths can accommodate a single-left turn lane at intersections. The boulevard median width (16 ft.) can accommodate a minimum 6-foot wide pedestrian refuge adjacent to the turn lane. In constrained conditions, raised medians on arterial thoroughfares can be reduced to a minimum of 10 ft. and accommodate a single left-turn lane.

[9] Access management involves providing (in other words, managing) access to land development in such a way as to preserve safety and reasonable traffic flow on public streets. Low, moderate and high designations are used for the level of access restrictions. A high level of access management uses medians to restrict mid-block turns, consolidates driveways and controls the spacing of intersections. A low level of access management limits full access at some intersections.

Table 6.3 General Parameters for Collector Thoroughfares

	Suburban (C-3)				General Urban (C-4)				Urban Center/Core (C-5/6)			
	Residential		Commercial		Residential		Commercial		Residential		Commercial	
	Avenue	Street	Avenue	Street	Avenue	Street	Avenue	Street	Avenue	Street	Avenue	Street
Context												
Building Orientation (entrance orientation)	front, side	front, side	front, side	front, side	front	front	front	front	front	front	front	front
Maximum Setback [1]	20 ft.	20 ft.	5 ft.	5 ft.	15 ft.	15 ft.	0 ft.	0 ft.	10 ft.	10 ft.	0 ft.	0 ft.
Off-Street Parking Access/Location	rear, side	rear, side	rear, side	rear, side	rear, side	rear, side	rear, side	rear, side	rear	rear, side	rear, side	rear, side
Roadside												
Recommended Roadside Width [2]	12.5 ft.	10.5 ft.	15 ft.	14 ft.	12.5 ft.	10.5 ft.	16 ft.	14 ft.	19.5 ft.	16 ft.	19.5 ft.	16 ft.
Pedestrian Buffers (planting strip exclusive of travel way width) [2]	6-8 ft. planting strip	5-8 ft. planting strip	6 ft. tree well	5-6 ft. tree well	6-8 ft. planting strip	5-8 ft. planting strip	6 ft. tree well	5-6 ft. tree well	6 ft. tree well	6 ft. tree well	6 ft. tree well	6 ft. tree well
Street Lighting	For all collector thoroughfares in all context zones, intersection safety lighting, basic street lighting, and retail pedestrian-scaled lighting is recommended. See Chapter 8 (Roadside Design Guidelines) and Chapter 10 (Intersection Design Guidelines).											
Traveled Way												
Desired Operating Speed (mph)	30	25	30	25	30	25	25-30 [3]	25	25-30	25	25-30 [3]	25
Design Speed	Design speed should be a maximum of 5 mph over the operating speed. Design speed is used as a control for certain geometric design elements including sight distance, and horizontal and vertical curvature.											
Number of Through Lanes	2-4	2	2-4	2	2-4	2	2-4	2-4	4	2-4	4	2-4
Lane Width [4]	10-11 ft.	10-11 ft.	10-11 ft.	10-11 ft.	10-11 ft.	10-11 ft.	10-11 ft.	10-11 ft.	10-11 ft.	10-11 ft.	10-11 ft.	10-11 ft.
Parallel On-Street Parking Width	7 ft.	7 ft.	7-8 ft.	7-8 ft.	7 ft.	7 ft.	7-8 ft.	7-8 ft.	7 ft.	7 ft.	7-8 ft.	7-8 ft.
Min. Combined Parking/Bike Lane Width	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.
Horizontal Radius (per AASHTO) [5]	510 ft.	333 ft.	510 ft.	333 ft.	510 ft.	333 ft.	510 ft.	333 ft.	510 ft.	333 ft.	510 ft.	333 ft.
Vertical Alignment	Use AASHTO minimums as a target, but consider combinations of horizontal and vertical per AASHTO Green Book.											
Medians which will accommodate single left-turn lanes at intersections [6]	Optional 14 ft.	None	Optional 14 ft.	None	Optional 14 ft.	None	Optional 14 ft.	None	Optional 14 ft.	None	Optional 14 ft.	None
Bike Lanes	On collector Avenues, bike lanes may be provided (6 ft.-5 ft. wide adjacent to 7-8 ft. parking lanes respectively).											
Access Management [7]	Provide low to moderate levels of access management on collector Avenues and Streets											
Typical Traffic Volume Range (vpd)	1,500-10,000	500-5,000	1,500-15,000	1,000-10,000	1,500-10,000	500-5,000	1,500-15,000	1,000-10,000	1,500-10,000	500-5,000	1,500-15,000	1,000-10,000
Intersections												
Roundabout	Consider urban single lane roundabouts at intersections on collector avenues and streets with less than 20,000 entering vehicles per day											
Curb Return Radii	Refer to Chapter 10 on Intersection Design Guidelines for details											

Table Notes:

[1] In all context zones with predominantly commercial frontage, this table shows the maximum setback for buildings with ground floor retail. In suburban contexts, office buildings are typically set back 5 ft. further than retail buildings to provide a privacy buffer. In general urban and urban center/core areas, office buildings are set back 0-5 ft. Setback exceptions may be granted for important buildings or unique designs.

[2] Roadside width includes edge, furnishing/planting strip, clear travel way and frontage zones. Refer to Chapter 8 (Roadside Design Guidelines) for detailed description of sidewalk zones and widths in different context zones and on different thoroughfare types. Dimensions in this table reflect widths in unconstrained conditions. In constrained conditions roadside width can be reduced to 12 ft. in commercial areas and 9 ft. in residential areas (see Chapter 5 on designing within constrained rights-of-way).

[3] Desired operating speeds on collector avenues serving C-4 and C-5/6 commercial main streets with high pedestrian activity should be 25 mph.

[4] Lane width (turning, through, and curb) can vary depending on a number of factors. Chapter 9 (Traveled Way Design Guidelines) (lane width section) provides a range of lane widths for thoroughfares with various functions and design vehicle conditions.

[5] For guidance on horizontal radius - see AASHTO's section on "Minimum Radii for Low Speed Urban Streets - Sharpest Curve Without Superelevation." Dimensions shown above are for noted design speeds and are found in Exhibits 3-16 (Page 151) in *A Policy on Geometric Design of Highways and Streets* (2004), assuming a superelevation of -2.0 reflecting typical cross slope.

[6] The optional median width can accommodate a single left-turn lane at intersections. The avenue median width (14 ft.) does not provide enough width for a pedestrian refuge. A minimum 6-foot wide pedestrian refuge adjacent to the turn lane would require a 15-16 ft. wide median. In constrained conditions, raised medians on collector thoroughfares can be reduced to a minimum of 10 ft. at intersections to allow a striped 9 or 10 foot wide left-turn lane.

[7] Access management involves providing (in other words, managing) access to land development in such a way as to preserve safety and reasonable traffic flow on public streets. Low, moderate and high designations are used for the level of access restrictions. A high level of access management uses medians to restrict mid-block turns, consolidates driveways, and controls the spacing of intersections. A low level of access management limits full access at some intersections.

ed in Chapters 8 through 10. Every design situation is unique and the practitioner is encouraged to study the principles, considerations and recommendations in these chapters in depth. The parameters presented in the tables are the basis for the series of example thoroughfare designs described.

Design Examples

These design examples, shown in Figures 6.1 through 6.4, provide a brief synopsis of the design process, illustrating some of the key steps in developing and evaluating solutions to thoroughfare design problems. The examples do not represent all of the possible combinations, but do show some common thoroughfare situations. The four examples respectively illustrate the following thoroughfare design scenarios:

1. Creation of a retail-oriented main street collector avenue;
2. Transformation of an obsolete suburban arterial to a boulevard in a mixed use area;
3. Design of a high-capacity arterial boulevard in a newly urbanizing area;
4. Four- to three-lane arterial avenue conversion in the central business district of a large city.

The design process used in the examples follows the design stages introduced and described in Chapter 5. The design examples provide a general overview of the process to illustrate the five stages of design. The details of the evaluation and development of the actual design are omitted in the four examples.

Design Example #1: Creating a Retail-Oriented Main Street

Objective

Design a commercial-oriented street that supports an adjacent mix of retail, restaurants and entertainment uses on the ground floor.

Stage 1: Review or develop an area transportation plan

Review the area transportation plan to determine how the subject thoroughfare relates to the overall network, types of modes served, functional classification and existing and future operational characteristics, etc. Collect existing and projected data as necessary.

Existing Street Characteristics
Existing street is a four-lane, undivided collector street with the following characteristics:

- Functional classification: minor collector;
- Right-of-way: 60 ft.
- On-street parking: none
- ADT: 10,000–13,000 vpd
- Speed limit: 35 mph
- Percent heavy vehicles: 2–3 percent
- Intersection spacing: 600–700 ft.
- Network pattern: grid
- Center turn lane: none
- Transit: low frequency local route
- Bicycle facilities: not a designated bike route
- Sidewalks: 6-ft. wide on both sides
- No landscaping
- Conventional street and safety lighting

Stage 2: Understand community vision for context and thoroughfare

Vision
An existing commercial street in a suburban (C-3) area undergoing change to an urban center (C-5) emphasizes an active street life achieved through the mix and intensity of land uses, site and architectural design with an emphasis on pedestrian facilities and on-street parking.

Stage 3: Identify compatible thoroughfare types and context zones

Existing context is identified by assessing the character and attributes of existing land uses such as building orientation to the street, building height, parking orientation and mix and density of uses, etc. Future context is determined by interpreting the vision, goals and objectives for the area. Thoroughfare type is selected based on the urban thoroughfare characteristics (Table 3.4 in Chapter 3).

- Existing context zone: C-3
- Future context zone: C-5
- Thoroughfare type: avenue

Stage 4: Develop and test the initial thoroughfare design

Desirable Design Elements (in prioritized order based on vision)

- Lower operating speed
- On-street parking
- Wide sidewalks
- Street furniture and landscaping including benches and space for cafes, public space, etc.
- Pedestrian-scaled lighting
- Street trees
- Bus stops with shelters
- Transitions between main street and adjacent higher-volume segments
- Mid-block crosswalks
- Bike lanes

Factors to Consider/Potential Trade-Offs

- Right-of-way constrained to 60 ft.
- Maximizing parking with angled vs. parallel parking
- Reduction in the number of through lanes and vehicle capacity vs. wider sidewalks and on-street parking

- Accommodation of large vehicles vs. narrowing lane width and smaller curb return radii; and
- Accommodation of bicyclists vs. width of other design elements.

Alternative Solutions

1. Emphasize vehicular capacity by retaining existing four-lane section with 9-ft. wide travel lanes to allow 12-ft. wide sidewalks.
2. Emphasize parking by providing angled parking on one side, parallel parking on the other side and narrowing the two travel lanes.
3. Emphasize parking and wider sidewalks by providing parallel parking on both sides, two travel lanes and 12-ft. wide sidewalks.
4. Emphasize parking and vehicular capacity with parallel parking on both sides, 9-ft. wide sidewalks, two travel lanes and a center turn lane

Selected Alternative
Alternative #3:
- Maximizes sidewalk width
- Provides moderate to good level of on-street parking
- Balances street width with accommodation of larger vehicles and speed reduction
- Allows for left-turn lanes at intersections

Stage 5: Develop detailed thoroughfare design

Solution Design Features
Traveled Way:
- Target operating speed: 25 mph
- Two 10 ft. travel lanes
- Two 8 ft. parallel parking lanes

Roadside:
- 12 ft. sidewalks
- Pedestrian-scaled lighting
- Street trees in tree wells
- 6 ft. furnishings zone (includes 1.5 ft. edge zone)
- 6 ft. clear pedestrian throughway
- No frontage zone

Intersections:
- Curb extensions to reduce pedestrian crossing distance unless left-turn lane is provided
- High-visibility crosswalks
- Safety lighting
- Farside bus stops with curb extension and shelters
- ADA compliance

Figure 6.1A View of existing street. Source: Kimley-Horn and Associates Inc.

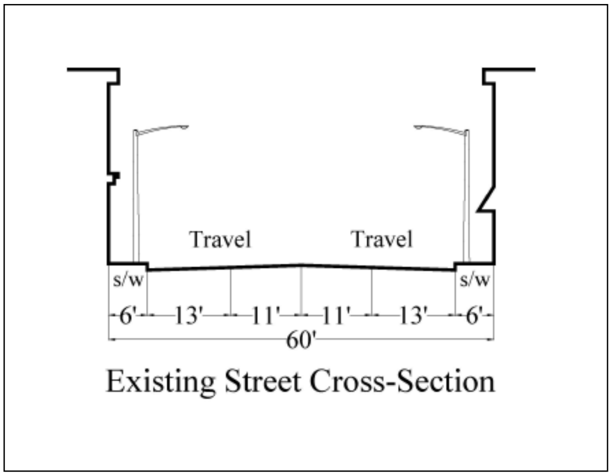


Figure 6.1B Existing street cross section. Source: Kimley-Horn and Associates Inc.

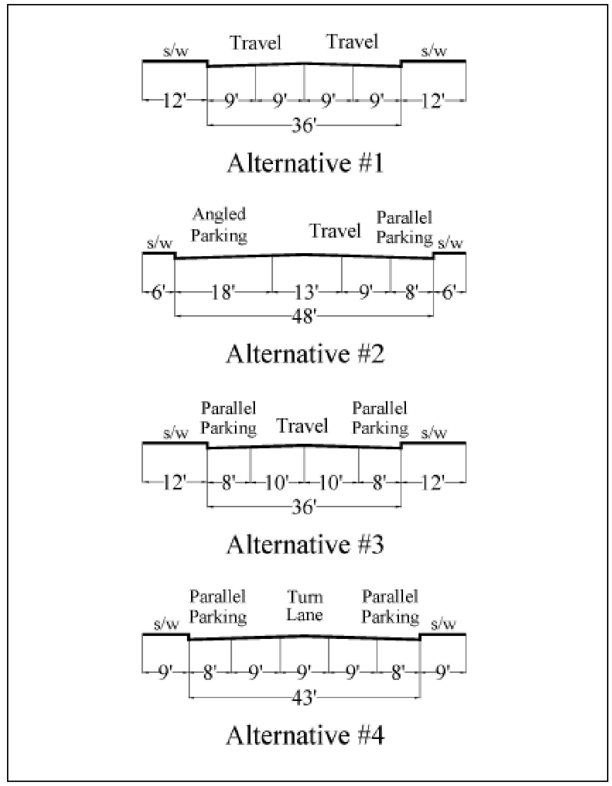


Figure 6.1C Alternative street cross sections. Source: Kimley-Horn and Associates Inc.

Relative Comparison of Trade-Offs

Alternative	Parking	Sidewalk Width	Vehicular Capacity	Large Vehicle Accommodation	Pedestrian Crossing Width	Left Turn Lanes	Bike Accommodation	Ped. Amenity Accommodation	Speed Reduction
Existing	- -	- -	+ +	+ +	- -	- -	- -	- -	- -
1	- -	+ +	+ +	- -	- -	-	- -	+ +	+
2	+ +	- -	-	+	+ +	+ +	- -	- -	-
3	+	+ +	-	+ +	+ +	-	- -	+ +	+
4	+	-	+	- -	+	+ +	- -	-	+ +

Score (relative to other alternatives)

- **+ +** Good (achieves objectives)
- **+** Fair
- **-** Poor
- **- -** Fails to meet achieve objectives

Figure 6.1D Relative comparison of alternative trade-offs. Source: Kimley-Horn and Associates Inc.

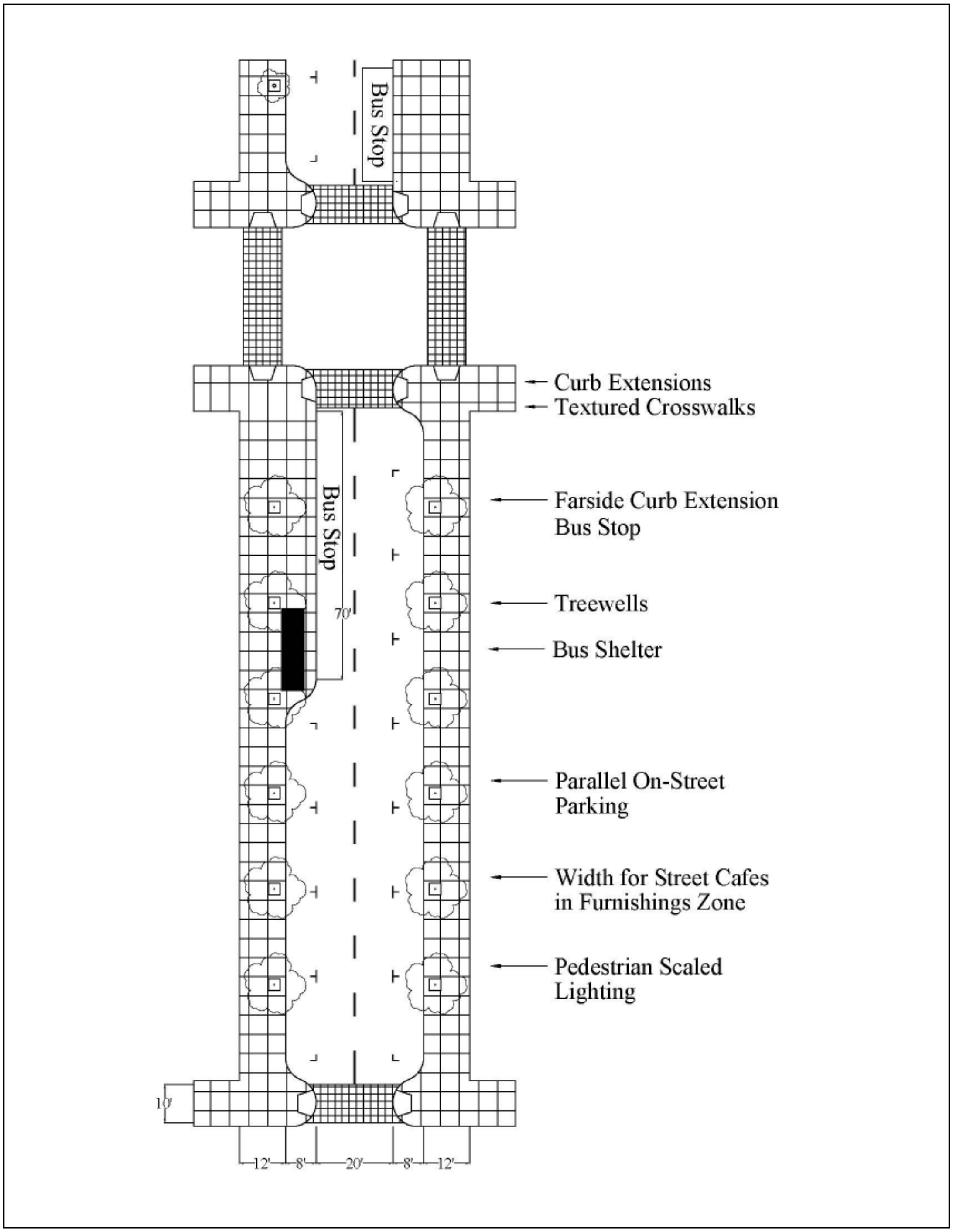


Figure 6.1E Schematic plan view of Alternative #3. Source: Kimley-Horn and Associates Inc.

Design Example #2: Transforming a Suburban Arterial

Objective

Transform an obsolete suburban arterial into a boulevard serving a mixed-use commercial-oriented street in an area evolving from a typical suburban pattern (C-3) to a mixed housing environment with commercial activity and walkable development pattern (C-4).

Stage 1: Review or develop an area transportation plan

Existing Street Characteristics
Existing street is a seven-lane undivided arterial street with the following characteristics:

- Functional classification: principal arterial
- Right-of-way: 100 ft.
- On-street parking: none
- ADT: 32,000–40,000 vpd
- Speed limit: 45 mph
- Percent heavy vehicles: 4–5 percent
- Intersection spacing: 1,250 ft.
- Network pattern: 1 mile arterial grid
- Center turn lane: 14 ft. TWLTL with turn bays at intersections
- Transit: high frequency regional route
- Bicycle facilities: not a designated bicycle route
- No sidewalks (4 ft. unpaved utility easement in right-of-way on both sides)
- No landscaping
- Conventional street and safety lighting

Stage 2: Understand community vision for context and thoroughfare

Vision
Community supports higher-intensity, higher-value development in an existing strip commercial corridor, transforming the suburban character of the corridor to general urban (C-4). Redesign of the street to create an attractive walkable boulevard is a public-sector investment strategy to stimulate change. The corridor is envisioned to support a diverse mix of pedestrian-oriented retail, office and entertainment.

Stage 3: Identify compatible thoroughfare types and context zones

- Existing context zone: C-3
- Future context zone: C-4
- Thoroughfare type: boulevard

Stage 4: Develop and test the initial thoroughfare design

Desirable Design Elements (in prioritized order based on vision)

- Lower operating speed (35 mph)
- Gradual speed transition from higher speed segments to study segment
- Landscaped median
- Wide sidewalks
- Street trees
- Pedestrian facilities including benches and space for cafes, public spaces, etc.
- Pedestrian-scaled lighting
- Bus stops with shelters
- On-street parking
- Increased crossing opportunities using consolidated signalized driveways

Factors to Consider/Potential Trade-Offs

- Reduction in the number of through lanes and vehicle capacity vs. wider sidewalks
- Accommodation of large vehicles vs. narrowing lane width
- Provision of on-street parking vs. median and wider sidewalks
- Right-of-way acquisition to accommodate desirable features
- Need to gradually reduce speed on higher speed segments approaching the lower speed segment under design

Alternative solutions

1) Provide parking, median and minimum width sidewalks by reducing to four travel lanes.

2) Provide wide median and sidewalks by reducing the travel lanes to four without providing on-street parking.

3) Provide all desirable features, including median, wide sidewalks and parking, by reducing travel lanes to four and acquiring right-of-way.

4) Emphasize vehicular capacity and provide median and sidewalks by retaining six narrower travel lanes without providing on-street parking. Alternatively, the 11 ft. outside lanes could be used for curb parking during off-peak periods and converted to travel lanes during the peak. This alternative would not provide curb extensions at intersections.

Selected Alternative

Alternative #1:

- Near term: Provides all desirable design features, except minimum width sidewalks.
- Long-term: As corridor redevelops, right-of-way can be acquired or development can be required to provide an easement to widen sidewalks.
- Selected alternative provides a balance between competing needs and provides most of the desirable design features without requiring right-of-way acquisition.

Stage 5: Develop detailed thoroughfare design

Solution Design Features

Traveled Way:

- Target operating speed: 35 mph
- Four 11 ft. travel lanes
- Two 8 ft. parallel parking lanes
- Tree planters in parking lane to increase planting opportunity
- Signalized intersection spacing at 400 ft. at consolidated driveways or mid-block pedestrian signals to create crossing opportunities

Roadside:

- 12 ft. sidewalks
- Pedestrian-scaled lighting
- Street trees in tree wells
- 6 ft. furnishings zone (includes 1.5 ft. edge zone)
- 6 ft. clear pedestrian throughway
- Throughway and frontage zone ultimately expanded with redevelopment

Intersections:

- Curb extensions to reduce pedestrian crossing distance
- High-visibility crosswalks
- Safety lighting
- Farside bus stops within parking lanes

Figure 6.2A View of existing street. Source: Kimley-Horn and Associates Inc.

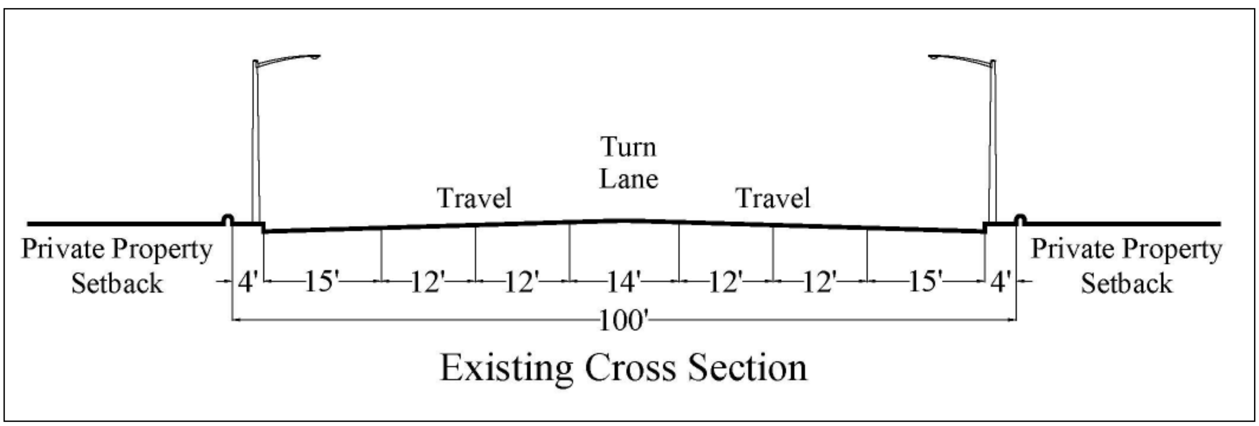


Figure 6.2B Existing street cross section. Source: Kimley-Horn and Associates Inc.

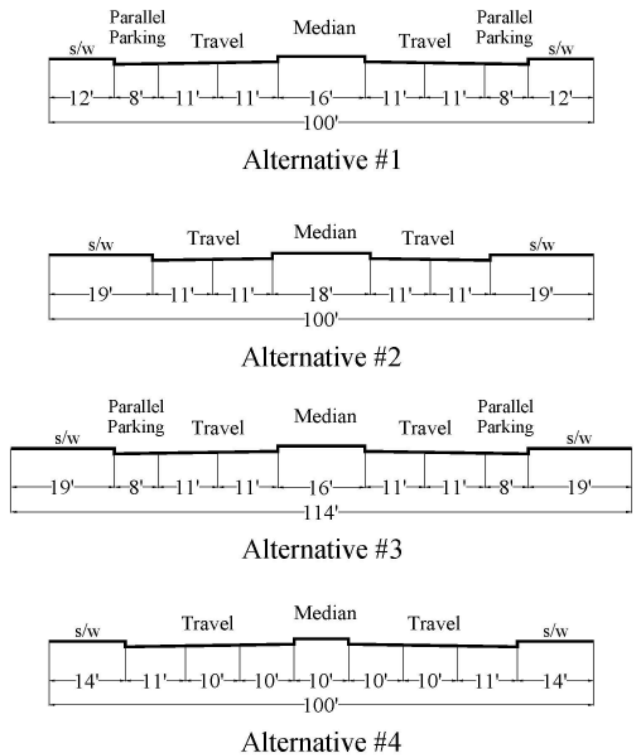


Figure 6.2C
Alternative street cross sections. Source: Kimley-Horn and Associates Inc.

Relative Comparison of Trade-Offs

Alternative	Parking	Sidewalk Width	Vehicular Capacity	Large Vehicle Accommodation	Pedestrian Crossing Width	Left Turn Lanes	Landscaped Median	Ped. Amenity Accommodation	Speed Reduction	Right-of-way Acquisition
Existing	- -	- -	+ +	+ +	- -	+ +	- -	- -	- -	+ +
1	+ +	-	+	+	+ +	+ +	+ +	- -	+	+ +
2	- -	+ +	+	+	+ +	+ +	+ +	+ +	+	+ +
3	+ +	+ +	+	+ +	+	+ +	+ +	+ +	+	- -
4	- -	+	+ +	-	- -	+	- -	-	-	+ +

Score (relative to other alternatives)

+ + Good (achieves objectives)
+ Fair
- Poor
- - Fails to meet achieve objectives

Figure 6.2D Relative comparison of alternative trade-offs. Source: Kimley-Horn and Associates Inc.

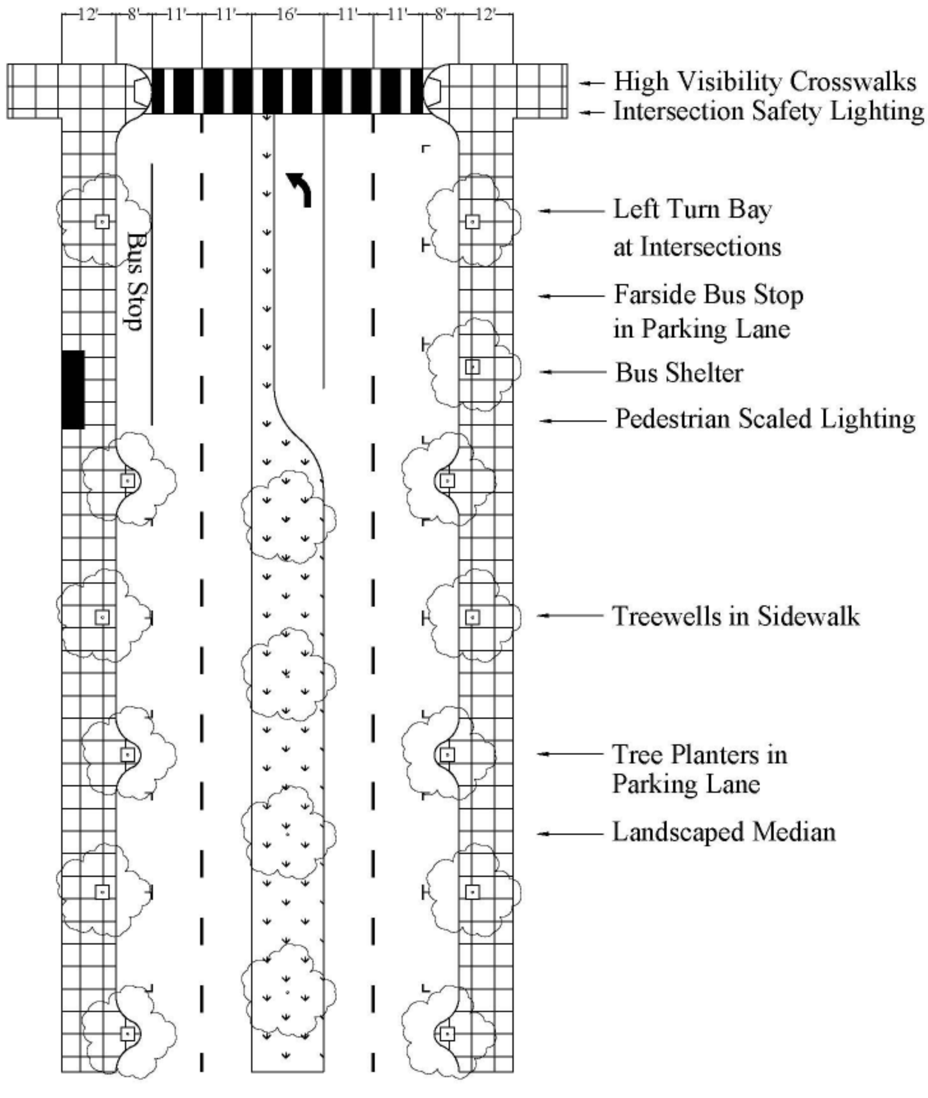


Figure 6.2E Schematic plan view of Alternative #3. Source: Kimley-Horn and Associates Inc.

Design Example #3: High Capacity Thoroughfare in Urbanizing Area

Objective

Design a thoroughfare in a newly urbanized area that accommodates high levels of traffic and buffers adjacent land uses from traffic impacts.

Stage 1: Review or develop an area transportation plan

Existing Street Characteristics
Existing street is a five-lane undivided arterial street with the following characteristics:

- Functional classification: minor arterial
- Right-of-way: 90 ft.
- On-street parking: none
- Existing ADT: 25,000–30,000 vpd
- Projected ADT: 45,000 vpd
- Speed limit: 40 mph
- Percent heavy vehicles: 4–5 percent
- Intersection spacing: 600–700 ft., but many driveways
- Network pattern: Suburban curvilinear, few alternative parallel routes
- Center turn lane: TWLTL with turn bays at intersections
- Transit: moderate frequency regional and local routes
- Bicycle facilities: designated bicycle route with 8-ft. wide paved shoulders on both sides
- Narrow attached sidewalks (5 ft.) on both sides
- No landscaping within right-of-way
- Conventional street and safety lighting

Stage 2: Understand community vision for context and thoroughfare

Vision
Area plans envision a mix of high-density housing, retail centers and low-intensity commercial uses fronting the street. Because the roadway accommodates high levels of through traffic, access control is desired. The roadway is currently a bicycle route with bicyclists using the paved shoulder, but bicycle lanes are desired to close gaps in the bicycle system. Adjacent properties provide off-street parking, but some fronting residential and commercial uses would benefit from on-street parking. Area will generate pedestrians who desire buffering from adjacent traffic. The area plan calls for a boulevard design including an alternative for a multi-way boulevard with fronting local streets.

Stage 3: Identify compatible thoroughfare types and context zones

- Existing context zone: C-3
- Future context zone: C-5
- Thoroughfare type: boulevard

Stage 4: Develop and test the initial thoroughfare design

Desirable Design Elements (in prioritized order based on vision)

- 35 mph operating speed
- Emphasis on vehicular capacity
- Access management with landscaped median
- Bicycle lanes
- Roadside buffered from traffic
- Street trees
- Bus stops with shelters
- Increased crossing opportunities at signalized intersections
- Pockets of on-street parking adjacent to fronting commercial (lower priority)
- Multi-way boulevard design

Factors to Consider/Potential Trade-Offs

- Effective width for roadside buffer vs. width requirements for elements in traveled way

- Accommodation of wider than minimum sidewalks, particularly in commercial areas
- Provision of on-street parking in select segments vs. other design elements
- Intersections spaced to optimize traffic flow vs. need for increased crossing opportunities
- Accommodation of large vehicles, particularly turning at intersections
- Right-of-way requirements for implementing a multi-way boulevard
- Efficient intersection operations with multi-way boulevard

Alternative Solutions

1) Emphasize roadside buffering and provision of bike lanes, provide minimal width median for access control and narrower travel lanes.
2) Implement multi-way boulevard with local access streets that provide on-street parking and bicycle lanes. Allows wider roadside area and removes bicycles from higher-speed roadway. Requires 16 ft. of right-of-way acquisition on each side of roadway or adjacent development dedicates roadside and on-street parking lane.
3) Emphasize landscaped median and bicycle lanes by narrowing roadside. Provides minimal sidewalk width and reduced buffer area.

Selected Alternative

Alternative #2:

- Provides desirable design features, including the desire for a multi-way boulevard
- Feasible to implement in newly urbanizing area
- Requires either dedication or right-of-way acquisition, but could be implemented in phases
- Intersections require special design to maintain efficient operations

Stage 5: Develop detailed thoroughfare design

Solution Design Features

Traveled Way:

- Operating speed: 35 mph
- Four 11 ft. travel lanes in central throughway
- Parallel 22-ft. wide local access roads separated by 8-ft. wide landscaped medians
- Local access roads provide 13 ft. combined parking/bicycle lane and 9 ft. travel lane

Roadside:

- 9 ft. sidewalks
- Pedestrian-scaled lighting
- Street trees in tree wells

Intersections:

- Special design treatment required to accommodate multiple movements between throughway and local access roads
- Intersections widen to accommodate left-turn lane within the central throughway

Figure 6.3A View of existing street. Source: Kimley-Horn and Associates Inc.

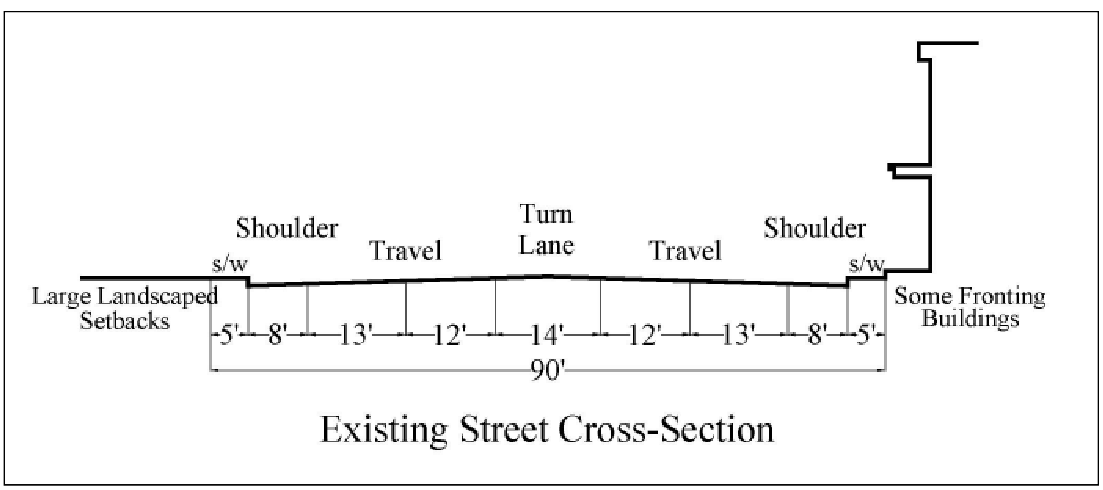


Figure 6.3B Existing street cross-section. Source: Kimley-Horn and Associates Inc.

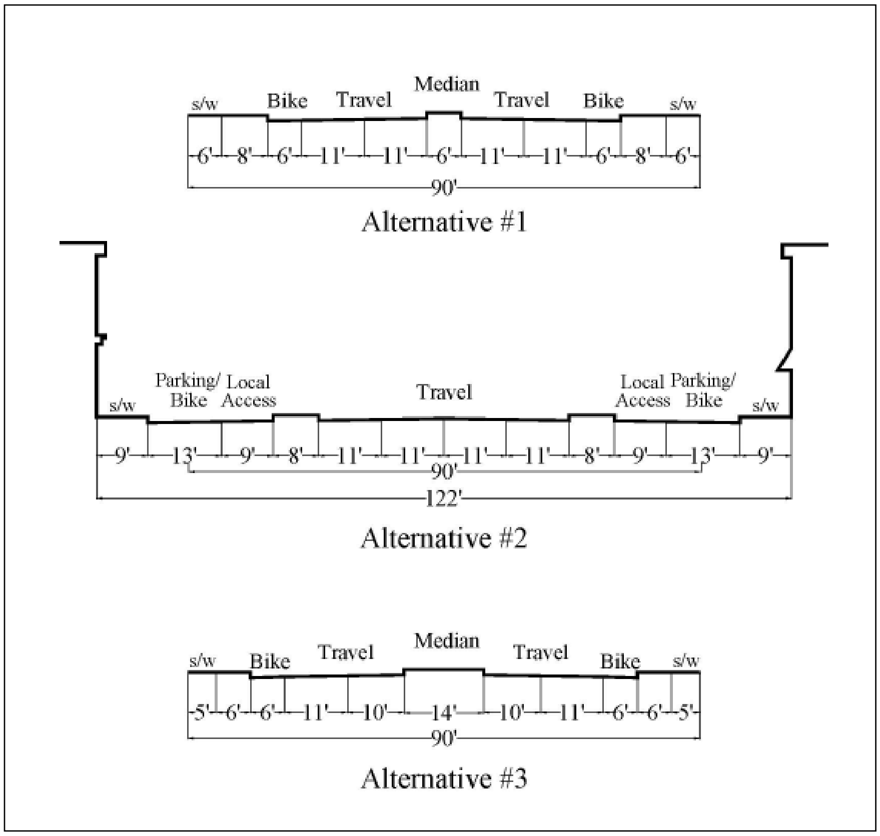


Figure 6.3C Alternative street cross sections. Source: Kimley-Horn and Associates Inc.

Relative Comparison of Trade-Offs

Alternative	Parking	Sidewalk Width	Roadside Buffer	Vehicular Capacity	Large Vehicle Accommodation	Pedestrian Crossing Width	Left Turn Lanes	Landscaped Median	Bike Lanes	Speed Reduction	Right-of-way
Existing	- -	- -	- -	+ +	+ +	- -	+ +	- -	+	- -	+ +
1	- -	-	+ +	+	+ +	-	-	-	+ +	+	+ +
2	+ +	+ +	+ +	+ +	+ +	+ +	-	+ +	+ +	+	- -
3	- -	- -	+	+	+	+	+ +	+ +	+ +	+ +	+ +

Score (relative to other alternatives)

- \+ + Good (achieves objectives)
- \+ Fair
- \- Poor
- \- - Fails to meet achieve objectives

Figure 6.3D Relative comparison of alternative trade-offs. Source: Kimley-Horn and Associates Inc.

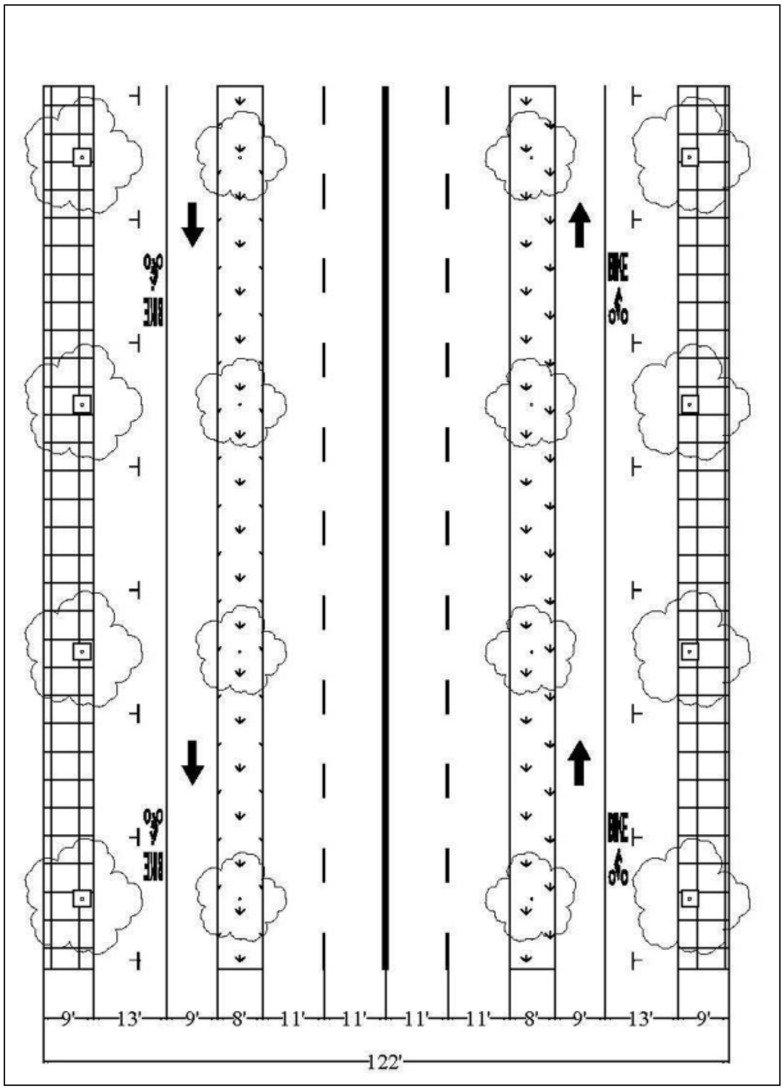


Figure 6.3E Schematic plan view of Alternative #2. Source: Kimley-Horn and Associates Inc.

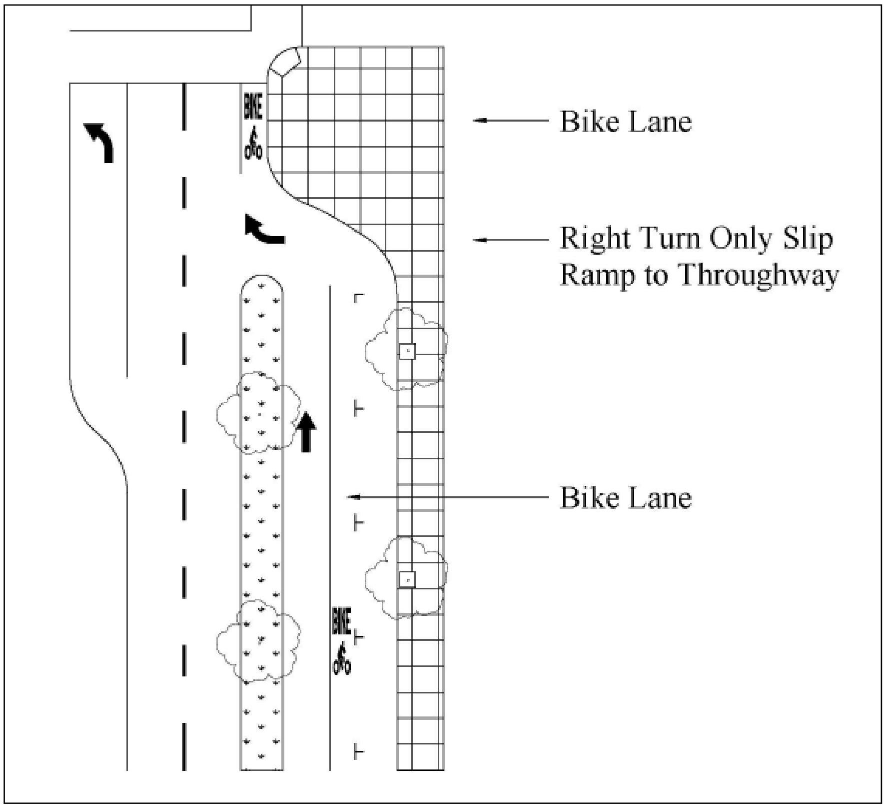


Figure 6.3F Special intersection design for Alternative #2. Source: Kimley-Horn and Associates Inc.

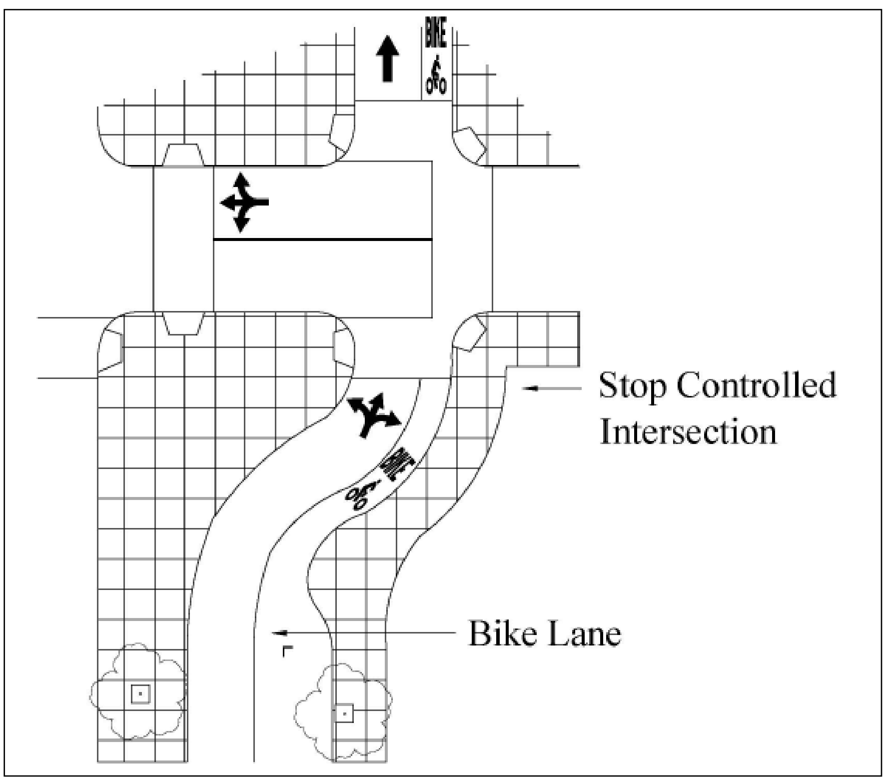


Figure 6.3G Special intersection design for Alternative #2. Source: Kimley-Horn and Associates Inc.

Design Example #4: Central Business District Four to Three-Lane Conversion

Objective

Convert an undivided four-lane arterial with parking on one side to three lanes plus parking and bicycle lanes on both sides in a central business district. The purpose of the conversion is to increase on-street parking, provide width for bicycle lanes and remove turning traffic from through lanes.

Stage 1: Review or develop an area transportation plan

Existing Street Characteristics
Existing street is a four-lane undivided arterial street with the following characteristics:

- Functional classification: minor arterial
- Right-of-way: 100 ft.
- On-street parking: parallel on one side
- Existing ADT: 12,000—15,000 vpd
- Projected ADT: 18,000 vpd
- Speed limit: 30 mph
- Percent heavy vehicles: 2 percent
- Intersection spacing: 400 ft.
- Network pattern: traditional downtown grid
- Center turn lane: none
- Transit: high frequency regional and local routes
- Bicycle facilities: designated bicycle route
- Wide 20 ft. sidewalks
- Street trees in tree wells
- Conventional street and safety lighting and pedestrian-scale lighting on sidewalk

Stage 2: Understand community vision for context and thoroughfare

Vision
The central business district is not envisioned to change significantly in terms of its context. It will remain the highest intensity development in the city with a mix of commercial uses, ground floor retail and office above. The district has very high levels of pedestrian and transit use, however, many of the buildings are converting to high-rise residential and new residential is being constructed. There is continued demand for on-street parking and an anticipated increase in pedestrian and bicycle travel as new residents increase 24-hour activities. The city has been implementing its bicycle plan over time by adding bicycle lanes to many of the arterial streets, particularly those serving transit lines. The traffic engineering department continues to look for opportunities to improve intersection operations and pedestrian safety by adding left-turn bays, curb extensions and protected-only left-turn signal phasing.

Stage 3: Identify compatible thoroughfare types and context zones

- Existing context zone: C-6
- Future context zone: C-6
- Thoroughfare type: avenue

Stage 4: Develop and test the initial thoroughfare design

Desirable Design Elements

- 25 mph operating speed
- Emphasis on pedestrian safety
- Bicycle lanes
- Retention of wide sidewalks
- Street trees
- Bus stops with shelters
- Maximization of on-street parking
- Reduced crossing width

Factors to Consider/Potential Trade-Offs

- Vehicular capacity vs. width required for all desirable elements

- Efficiency/safety benefits of turn lanes and protected-only left-turn signal phasing vs. four travel lanes
- Provision of on-street parking in select segments vs. other design elements
- Accommodation of large vehicles, particularly turning at intersections vs. curb extensions and reduced crossing width
- Ability to bypass double parked vehicles and emergency vehicle access vs. reduced number of lanes
- Effective turning radius with addition of bicycle lanes

Alternative Solution
Only one alternative design is considered in this design example:

1. Reduce number of through lanes to one in each direction, add an alternating center turn lane, on-street parking on both sides and bicycle lanes on both sides. Implement curb extensions at intersections. Retain existing roadside width.

Selected Alternative
Alternative #1:

- Projected traffic volumes can be accommodated with two lanes, and added turning lane improves intersection operations
- Substantial parking supply added
- Addition of bicycle lanes on both sides of the roadway closes gaps in the bicycle network and improves safety
- Curb extensions and protected-only left-turn signal phasing provide substantial pedestrian benefit by reducing crossing distance, improving visibility and eliminating left-turn conflicts

Stage 5: Develop detailed thoroughfare design

Solution Design Features
Traveled Way:

- Operating speed: 25 mph
- Two 11 ft. travel lanes and 12 ft. alternating center turn lane
- Combined 13-ft. wide parking/bike lanes on both sides

Roadside:

- Retain existing 20 ft. roadsides, pedestrian-scaled lighting and street trees in tree wells

Intersections:

- Curb extensions and protected-only left-turn signal phasing

Figure 6.4A View of existing street. Source: Kimley-Horn and Associates Inc.

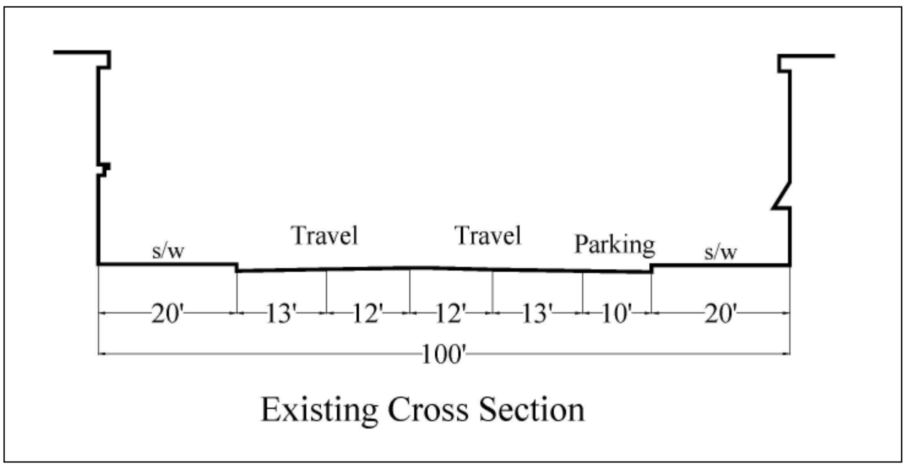


Figure 6.4B Existing street cross section. Source: Kimley-Horn and Associates Inc.

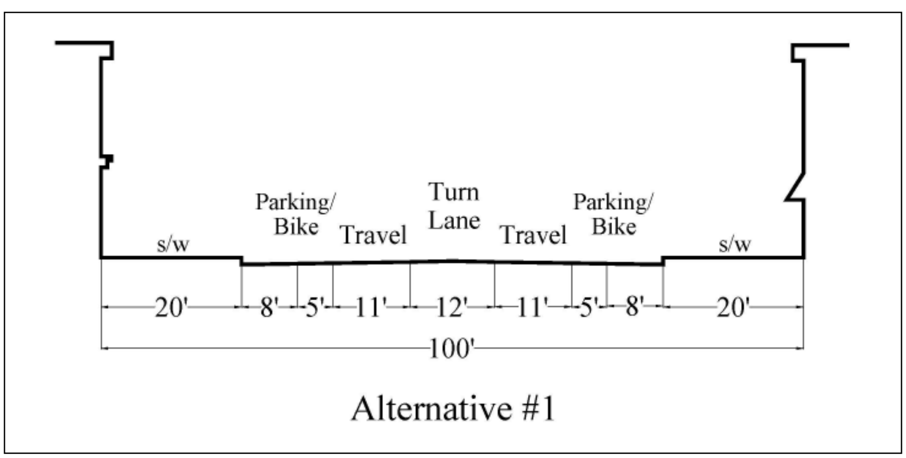


Figure 6.4C Alternative street cross section. Source: Kimley-Horn and Associates Inc.

Relative Comparison of Trade-Offs

Alternative	Parking	Sidewalk Width	Capacity and Intersection Operations	Large Vehicle Accommodation	Pedestrian Crossing Width and Safety	Left Turn Lanes	Bike Lanes	Speed Reduction
Existing	+	+ +	+	+	+	- -	- -	- -
1	+ +	+ +	-	+	+ +	+ +	+ +	+ +

Score (relative to other alternatives)

- **+ +** Good (achieves objectives)
- **+** Fair
- **-** Poor
- **- -** Fails to meet achieve objectives

Figure 6.4D
Relative comparison of alternative trade-offs. Source: Kimley-Horn and Associates Inc.

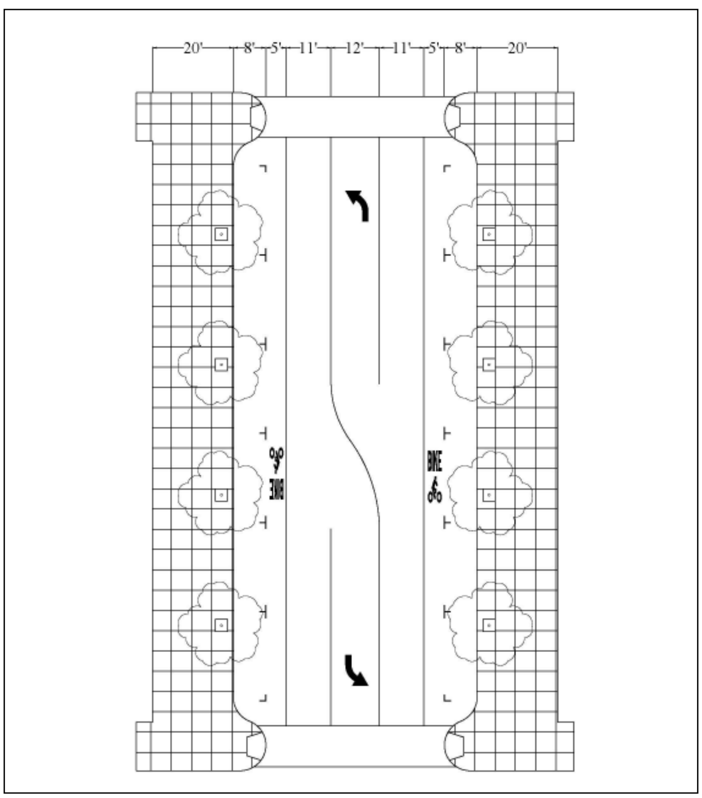
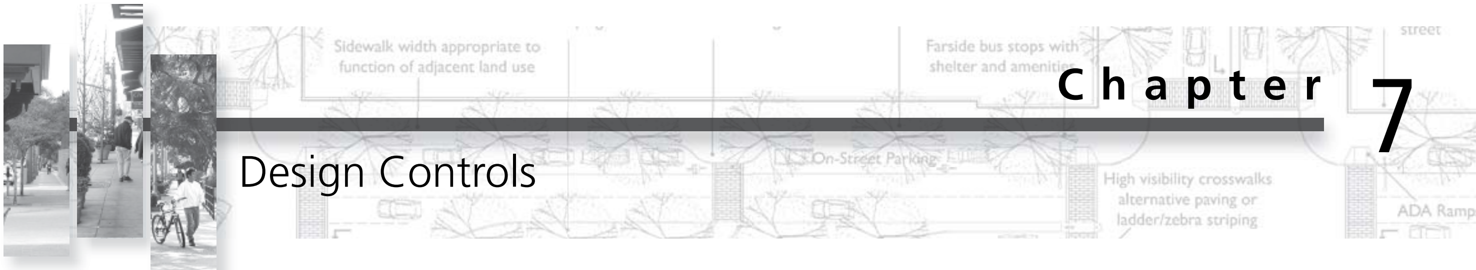


Figure 6.4E
Schematic plan view of Alternative #1. Source: Kimley-Horn and Associates Inc.



Chapter 7
Design Controls

Purpose

This chapter discusses the fundamental design controls that govern urban thoroughfare design; acts as a prelude to the following chapters that present detailed design guidance for the roadside, traveled way and intersections; and identifies the consistencies and divergences between design controls used where capacity is the dominant consideration and where the character of the thoroughfare is the dominant consideration.

Objectives

This chapter:

1. Defines the term "design controls" and identifies the controls used in the conventional design process;
2. Identifies design controls and how they differ from conventional practice;
3. Introduces the concept of a "target speed" in combination with design speed for selecting design criteria;
4. Identifies factors that can used in thoroughfare design to influence speed;
5. Introduces the concept of a "control vehicle" in combination with a design vehicle to select intersection design criteria; and
6. Provides an overview of the design controls recommended.

Introduction

Controls are physical and operational characteristics that guide the selection of criteria in the design of thoroughfares. Some design controls are fixed—such as terrain, climate and certain driver-performance characteristics—but most controls can be influenced in some way through design and are determined by the designer.

The AASHTO Green Book and its supplemental publication *A Guide for Achieving Flexibility in Highway Design* (2004b), identify location as a design control and establish different design criteria for rural and urban settings. AASHTO recognizes the influence context has on driver characteristics and performance. The Green Book defines the environment as "the totality of humankind's surroundings: social, physical, natural and synthetic" and states that full consideration to environmental factors should be used in the selection of design controls. This guide focuses on design controls and critical design elements in the urban context.

Design Controls Defined by AASHTO

AASHTO books identify functional classification and design speed as primary factors in determining highway design criteria. The Green Book separates its design criteria by both functional classification and context—rural and urban. The primary differences between contexts are the speed at which the facilities operate, the mix and characteristics of the users and the constraints of the surrounding context.

In addition to functional classification, speed and context, AASHTO presents other design controls and criteria that form the basis of its recommended design guidance. The basic controls are:

- Design vehicle;
- Vehicle performance (acceleration and deceleration);
- Driver performance (age, reaction time, driving task, guidance, etc.);
- Traffic characteristics (volume and composition);
- Capacity and vehicular level of service;
- Access control and management;
- Pedestrians and bicyclists; and
- Safety.

AASHTO's Green Book presents the pedestrian needs as a factor in highway design and recognizes the pedestrian as the "lifeblood of our urban areas." Pedestrian characteristics that serve as design controls include walking speed, walkway capacity and the needs of persons with disabilities. AASHTO's *Guide for the Planning, Design and Operation of Pedestrian Facilities* (2004c) and *Guide for the Development of Bicycle Facilities* (1999) expand significantly on the Green Book, presenting factors, criteria and design controls. This report emphasizes pedestrians and bicyclists as a design control in all contexts, but particularly in the walkable, mixed-use environments primarily addressed.

Differences from Conventional Practice

This report presents design guidance that is generally consistent with the AASHTO Green Book, AASHTO's supplemental publications and conventional engineering practice. There are, however, four design controls in the application of CSS principles that are used differently than in the conventional design process. These controls are:

- Speed;
- Location;
- Design vehicle; and
- Functional classification.

Speed

This guide recommends the use of a target and design speed. These terms are defined below.

- **Target Speed** is the speed at which vehicles should operate on a thoroughfare in a specific context, consistent with the level of multimodal activity generated by adjacent land uses to provide both mobility for motor vehicles and a safe environment for pedestrians and bicyclists. The target speed is usually the posted speed limit.
- **Design Speed** is the speed that governs certain geometric features of the thoroughfare, primarily horizontal curvature, superelevation and sight distance. Design speed is typically higher than the posted speed limit to result in safety conservative values for design criteria such as sight distance or alignment. This report recommends that the design speed be 5 mph over the target speed.

Conventionally, design speed has been encouraged to be as high as is practical. In this report a design speed range, linked to the target speed, is recommended based on the functional classification, thoroughfare type and context, including whether the area is predominantly residential or commercial. Design speed then becomes the primary control for determining the following design values:

- Minimum intersection sight distance;
- Minimum sight distance on horizontal and vertical curves; and
- Horizontal and vertical curvature.

Design speed ranges from 30 to 40 mph (corresponding to target speeds of 25 to 35 mph), which is a range consistent, but somewhat lower than, the higher end of AASHTO's recommended range for urban arterial streets. A lower target speed is a key characteristic of thoroughfares in walkable, mixed-use traditional urban areas.

Design Factors that Influence Target Speed

Establishing a target speed that is artificially low relative to the design of the roadway will only result in operating speeds that are higher than desirable and difficult to enforce. The design of the thoroughfare should reflect the anticipated target speed. The following design factors contribute to speed reduction and should be incorporated into thoroughfare designs as appropriate in urban areas:

- Lanes of appropriate width without excess;
- Minimal or no horizontal offset between inside travel lane and median curbs;
- Elimination of superelevation;
- Elimination of shoulders in most urban applications (shoulders may be used strategically to provide space for breakdowns, large vehicle off-tracking at curves, or to expedite turning maneuvers);
- On-street parking;
- Smaller curb return radii at intersections and elimination or reconfiguration of high-speed channelized right turns;

- Spacing of signalized intersections and synchronization to the desired speed;
- Paving materials with texture (crosswalks, intersection operating areas) detectable by drivers as a notification of the possible presence of pedestrians; and
- Proper use of speed limit, warning, advisory signs and other appropriate devices to gradually transition speeds when approaching and traveling through a speed zone.

Other factors widely believed to influence speed include a canopy of street trees, the enclosure of a thoroughfare formed by the proximity of a wall of buildings and the striping of bicycle lanes, etc. These are all elements of walkable, mixed-use urban areas, but should not be relied upon as speed reduction measures until further research provides a definitive answer.

The practitioner should be careful not to relate speed to capacity in urban areas, avoiding the perception that a high-capacity street requires a higher design speed. Under interrupted flow conditions, such as on major urban thoroughfares in urban areas, intersection operations and delay have a greater influence on capacity than speed.

The *Highway Capacity Manual* (TRB 2000) classifies urban streets (Class I through IV) based on a range of free-flow speeds. The thoroughfares upon which this report focuses have desired operating speeds in the range of 25 to 35 mph (Class III and IV based on the *Highway Capacity Manual*). Level of Service C or better is designated by average travel speeds ranging from 10 mph to 30 mph. Therefore, adequate service levels can be maintained in urban areas with lower operating and design speeds. Capacity issues should be addressed with sound traffic operations management, such as coordinated signal timing, improved access management, removal of unwarranted signals and the accommodation of turning traffic at intersections.

Location

Conventional thoroughfare design is controlled by location to the extent that it is rural or urban (sometimes suburban). In this guidance, all locations are urban, but vary in intensity from suburban to highly urban. Additionally, the variation in design elements controlled by location is expanded to include predominant land uses such as residential or commercial. Land uses govern the level of activity, which in turn influence the design of the thoroughfare. These influences include, but are not limited to, pedestrians and bicyclists, transit, economic activity of adjacent uses and right-of-way constraints. The CSS approach may also consider planned land uses that represent a departure from existing development patterns and special design districts that seek to protect scenic, environmental, historic, cultural, or other resources.

Design Vehicle

The design vehicle influences the selection of design criteria such as lane width and curb return radii. Some practitioners will conservatively select the largest design vehicle (WB 50 to WB 65) that could use a thoroughfare, regardless of the frequency. Consistent with AASHTO, CSS emphasizes an analytical approach in the selection of a design vehicle, including evaluation of the tradeoffs involved in selecting one design vehicle over another.

In urban areas it is not always practical or desirable to choose the largest design vehicle that might occasionally use the facility because the impacts to pedestrian crossing distances, speed of turning vehicles, etc. may be inconsistent with the community vision and goals and objectives for the thoroughfare. In contrast, selection of a small design vehicle in the design of a facility regularly used by large vehicles can invite frequent operational problems. The practitioner should select the largest design vehicle that will use the facility with considerable frequency (for example, bus on bus routes, semi-tractor trailer on primary freight routes or accessing loading docks, etc.). In general, the practitioner may consider the use of a single-unit truck design vehicle as an appropriate design vehicle where the mix of traffic and frequency of large vehicles is unknown. Two types of vehicles are recommended.

- Design vehicle—must be regularly accommodated without encroachment into the opposing traffic lanes. A condition that uses the design vehicle concept arises when large vehicles regularly turn at an intersection with high volumes of opposing traffic (such as a bus route).

- Control vehicle—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 when occasional large vehicles turn at an intersection with low opposing traffic volumes (such as a moving van in a residential neighborhood or once per week delivery at a business) or when large vehicles rarely turn at an intersection with moderate to high opposing traffic volumes (emergency vehicles).

Chapter 10 (Intersection Design Guidelines) provides further guidance on the design of intersections to accommodate large vehicles.

Functional Classification

Functional classification defines a thoroughfare's function and role in the network, as well as governing the selection of certain design controls. As discussed in Chapter 4, functional class is used to determine aspects of the thoroughfare such as its continuity through an area and the types of places it connects, its purpose and lengths of trips accommodated, level of land access it serves, type of freight service and types of public transit served. These functions are important factors to consider in the design of the thoroughfare, but the physical design of the thoroughfare in CSS is determined by the thoroughfare type designation (as introduced in Chapter 4 and further discussed in Chapter 6). Functional class continues to be used to determine two critical design controls including design speed and sight distance.

The Role of Capacity and Vehicular Level of Service in CSS

The conventional design process uses traffic projections for a 20-year design period and strives to provide the highest practical level of service. CSS takes traffic projections and level of service into account and then balances the needs of all users or emphasizes one user over another depending on the context and circumstances (for example, reduces number of travel lanes to accommodate bicycle lanes or an exclusive busway). While capacity and vehicular level of service play a role in selecting design criteria, they are only two of many factors the practitioner considers and prioritizes in the design of urban thoroughfares. Often in urban areas, thoroughfare capacity is a lower priority than other factors such as economic development or historical preservation and higher levels of congestion are considered acceptable. CSS also emphasizes network capacity as opposed to the capacity of the individual thoroughfare (see Chapter 4).

Additional Controls to Consider in Thoroughfare Design

In addition to the design controls discussed above, other critical design controls in the conventional design process remain applicable in the application of CSS principles. Design controls related to roadway geometry—sight distance, horizontal and vertical alignment, and access control—continue to be based on conventional design practices.

Sight Distance

Sight distance is the distance that a driver can see ahead in order to observe and successfully react to a hazard, obstruction, decision point, or maneuver. Adequate sight lines remain a fundamental requirement in CSS. The criteria presented in the AASHTO Green Book for stopping and intersection sight distances based on the design speed described above should be used in urban thoroughfare design.

Horizontal and Vertical Alignment

The design of horizontal and vertical curves is a controlling feature of a thoroughfare's design. Curvature is effected by speed and affects speed. For urban thoroughfares, careful consideration must be given to the design of alignments to balance safe vehicular travel with a reasonable operating speed. The AASHTO Green Book provides guidance on the design of horizontal and vertical alignments for urban streets.

Access Management

Access management is defined as the management of the interference with through traffic caused by traffic entering, leaving and crossing thoroughfares. Access management is a regulatory or policy tool. Access management on urban thoroughfares controls geometric design by establishing criteria for raised medians and median breaks, intersection and driveway spacing, and vehicle movement restrictions through various channelization methods. The AAS-

HTO Green Book and TRB *Access Management Manual* (2003) provide extensive guidance on this subject. Chapter 9 (Traveled Way Design Guidelines) provides an overview of access management methods and general guidelines for managing access on urban thoroughfares.

Pedestrian and Bicyclist Requirements as Design Controls

Pedestrian and bicyclist requirements affect the utilization of a thoroughfare's right-of-way. Thoroughfares with existing or desired high levels of pedestrian and bicycle usage require appropriate roadside and bicycle lane facilities to be included in transportation projects. This requirement usually affects the design elements in the traveled way. Therefore, pedestrian and bicycle requirements function as design controls that influence decisions for the utilization and prioritization of the right-of-way. For example, requirements for bicycle lanes might outweigh the need for additional travel lanes or a median, resulting in a design that reduces the vehicular design elements to provide bicycle design elements. CSS thoroughfares emphasize allocating right-of-way appropriately to all modes depending on priority and as defined by the surrounding context. This process results in a well thought out and rationalized design tradeoff—the fundamental basis of context sensitive solutions.

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Chapter 8

Roadside Design Guidelines

Purpose

This chapter provides principles and guidance for the design of a thoroughfare's roadside and the specific elements that comprise the roadside. It addresses how the design of the roadside varies with change in context. The guidance in this chapter is used in conjunction with the guidance for the other two thoroughfare components—the traveled way (Chapter 9) and intersections (Chapter 10).

Objectives

This chapter:

1. Introduces and defines four distinct zones that comprise the roadside: edge, furnishings, throughway and frontage;
2. Describes the uses and activities that are typically accommodated within the roadside in urban areas;
3. Describes fundamental design principles of the roadside as they relate to intersection sight distance, speed and clear zones and lateral clearance;
4. Describes the role and placement of roadside facilities, public spaces and public art; and
5. Provides principles, considerations and design guidance for roadside width and functional requirements.

Introduction

The roadside is the portion of the thoroughfare that accommodates activity—the business and social activities—of the street. It extends from the face of the buildings or edge of the private property to the face of the curb. A well-designed roadside is important to the thoroughfare's function as a "public place." Thoroughfares are the most extensively used civic spaces or in our communities.

Roadside Zones and Buffering

This chapter addresses the design of sidewalks and the buffers between sidewalks, moving traffic, parking and/or other traveled-way elements. The roadside consists of the following four distinct functional zones:

1. Edge Zone—area between the face of curb and the furnishing zone, an area of required clearance between parked vehicles or traveled way and appurtenances or landscaping.
2. Furnishings Zone—area of the roadside that provides a buffer between pedestrians and vehicles, which contains landscaping, public street furniture, transit stops, public signage, utilities, etc.
3. Throughway Zone—walking zone that must remain clear, both horizontally and vertically, for the movement of pedestrians.
4. Frontage Zone—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. and can also be used for street cafes. This zone is sometimes referred to as the "shy" zone.

Figure 8.1 illustrates the four zones using the example of a roadside in a commercial area. Guidance is provided for each of these zones with the width varying in relation to thoroughfare type and function, and context zone and specific land use characteristics.

Urban Design Elements

The roadside can contain a variety of urban design elements, ranging from large-scale elements such as plazas, seating areas, transit stops and other public spaces to the details of street furniture, street trees, public art and materials used for constructing sidewalks, walls, etc.

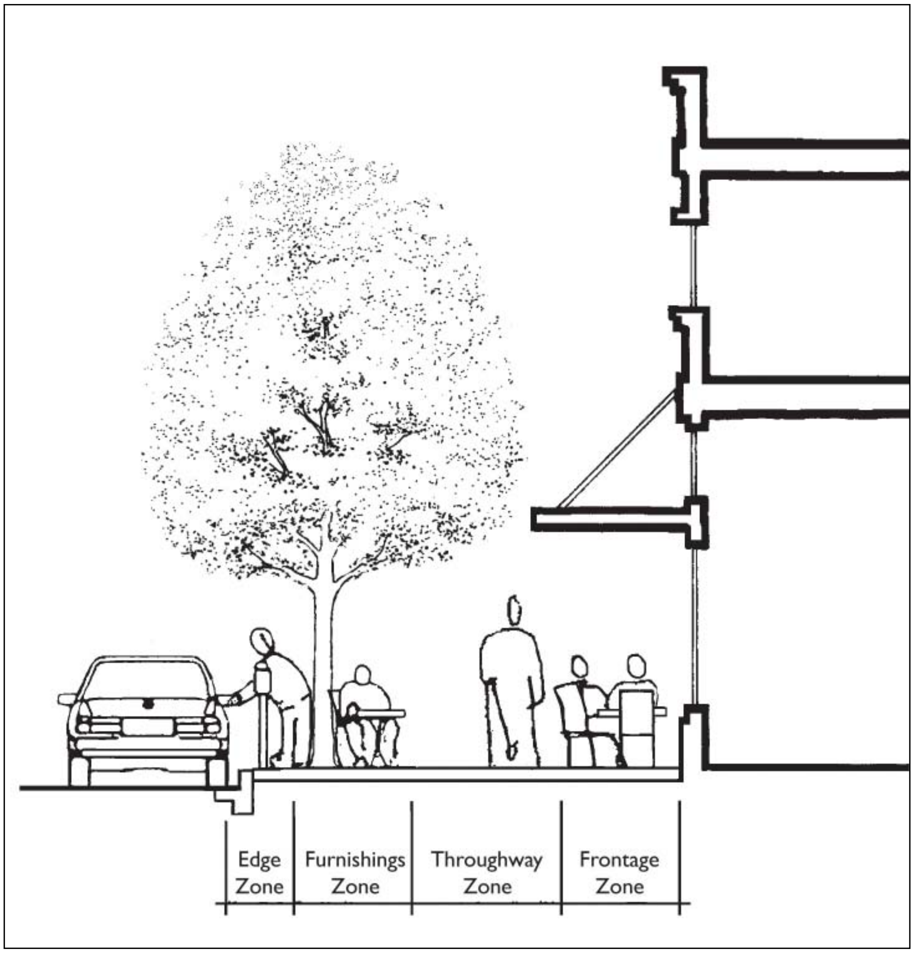

Figure 8.1 Roadside zones. Source: Community, Design + Architecture.

Technical Considerations

There is a broad range of technical and engineering considerations that need to be coordinated with the design of the roadside, including the requirements of ADAAG, needs for utilities (including lighting for both the traveled way and roadside), provision of signage for traffic and pedestrians and evaluation of multimodal accessibility. This chapter provides guidance for how these technical issues can be addressed in coordination with the other elements of major urban thoroughfares.

The Urban Roadside: Uses and Activities

The basic functions of the roadside in any context are the conveyance of pedestrians, access to adjoining buildings and properties, and the provision of clear zones and space for utilities and other roadside appurtenances. In urban contexts these basic functions are shared with the activities generated by the adjacent land use and general civic functions, which can include aesthetics (such as street trees and public art), sidewalk cafes, plazas and seating areas, transit amenities (such as benches, shelters, trash receptacles and waiting areas), merchandise display and occasional public activities (such as farmers' markets or art shows).

Roadside functions vary by context zone and predominant ground floor land use. The width of certain elements of the roadside (the furnishings zone functions as a traffic buffer) will vary by thoroughfare type depending on the existence or lack of on-street parking and the speed and volume of vehicular traffic on the thoroughfare. Variations in the width of the roadside are addressed in the design guidelines in the section on roadside width and functional requirements.

Design Principles

Safety

When designing the roadside, the practitioner is concerned about the safety of all users of the thoroughfare. Roadside safety concerns in urban contexts are different than those in rural contexts; speeds are higher and most travel is by vehicle. In designing the roadside for traditional urban areas, the practitioner is concerned about the safety of a wider range of users including pedestrians on the sidewalk, motorists, motorcyclists and bicyclists using the traveled way. The practitioner should consider the context of the thoroughfare, including competing demands within limited right-of-way and time when the space may be needed.

Roadside safety in urban areas is achieved by separating modes of different speeds and vulnerabilities to the extent possible by both space and time (bicyclists from pedestrians and pedestrians from vehicles), informing all users of the presence and mix of travel modes and through provision of adequate sight distance. The difficulty for the practitioner is developing solutions to resolve the inherent conflicts where modes of travel cross paths. Design guidelines for improving pedestrian safety at intersections is discussed in Chapter 10.

Roadside safety for the users of the traveled way in traditional urban areas focuses on meeting user expectations, providing uniform and predictable designs and traffic control, removing clearly hazardous roadside obstacles and establishing an appropriate design speed, which in turn controls the speed-related geometric design elements of the thoroughfare. The practitioner should be familiar with the concepts and guidance provided in AASHTO's *Roadside Design Guide* (2002).

Relationship of Speed to Roadside Design

A person's decision to walk is influenced by many factors, including distance, perceived safety and comfort, convenience and visual interest of the route (AASHTO 2004b). In the roadside, pedestrians may feel exposed and vulnerable when walking directly adjacent to a high-speed travel lane. Vehicle noise, exhaust and the sensation of passing vehicles can negatively affect the comfort of the pedestrian. Factors influencing pedestrian comfort include a separation from moving traffic and a reduction in speed. In traditional urban environments, a buffer zone that improves pedestrian comfort can be achieved with the width of the edge and furnishings zones, landscaping and on-street parking.

Many pedestrians are struck at night by vehicles running off the road at higher speeds than during the day. It is important to consider changes in conditions between day and night, and higher than normal speeds, in designing the roadside. The practitioner needs to consider the possible tradeoffs between the safety of the roadside and traveled-way users when evaluating design elements to buffer pedestrians. For example, would a roadside feature that provides comfort for the pedestrian (such as street trees) constitute a significant roadside hazard for drivers?

Clear Zones

The application of a clear zone is most critical on high-speed roadways and is usually not practical on low-speed urban roadways with right-of-way constraints. In many cases the hazard of roadside obstacles is substantially less in urban areas because of lower speeds or parked vehicles. Roadside features in urban areas may still constitute a hazard for the errant driver. Therefore, the practitioner needs to design a facility that reduces the hazard of these crashes while still being practical and responsive to constraints and community objectives, including mobility of all thoroughfare users. This requires flexibility in the application of design criteria including the width of clear zones to ensure safety and functionality for all users.

The concept of the clear zone includes an edge clear of roadside obstructions and fixed objects, which allows out-of-control vehicles to leave the road to safely recover. Clear zones and roadside safety in urban areas are addressed in AASHTO's *Roadside Design Guide* (2002) and in *A Guide for Achieving Flexibility in Highway Design* (2004b). Roadside features considered obstructions or fixed objects in urban areas include signs, poles, utilities, public art and trees. In urban contexts, roadside features may be of less consequence and are usually less avoidable. On these roadways the focus is to provide a roadside design that functions effectively for the competing demands in urban areas. These functions include pedestrian travel, placement of utilities and traffic control devices, urban design features, landscaping, snow storage, etc.

AASHTO recommends the following guidelines for context sensitive roadside design:

- Avoid establishing unrealistically low target and design speeds;
- Apply a consistent roadside treatment approach for any given project;
- Avoid establishing an arbitrary clear-zone width;
- Remove or relocate signs, utility poles and other fixed objects to improve safety and aesthetics; and
- Encourage safe landscaping that, even when mature, maintains proper sight triangles and stays beyond desired clear-zones.

General considerations in urban contexts include the following.

- Use vertical curbs in the design of major urban thoroughfares. Vertical curbs do not deflect vehicles at high speeds and may, in fact, cause vehicles to vault if striking a curb. However, in low-speed urban areas, vertical curbs keep parking vehicles from encroaching into the roadside and provide some deflection at lower speeds.
- Breakaway sign supports and poles may be used, but consider the safety of pedestrians. In rare circumstances, breakaway supports might cause injury to nearby pedestrians. In areas of concentrated pedestrian activity, it might be desirable to use fixed supports for appurtenances. The practitioner should consider the level of pedestrian activity at the time when run-off-the-road incidents are likely to occur, typically late night, and evaluate the benefits of breakaway objects to the potential for pedestrian injury. Refer to AASHTO's handbooks for the proper application of breakaway objects and placement of signs and poles.
- On higher-speed suburban or vehicle mobility priority arterials (40 mph or more), consider provision of a 10 ft. clear zone. In some cases shoulders may serve as a clear zone. See Chapter 11 on vehicle mobility priority thoroughfare design.
- The practitioner should gain knowledge of community objectives regarding street trees since many communities value mature street trees. If valued by the community, avoid removal of existing mature trees (even if crash history warrants it or if the tree is located in a likely crash location, such as within a sharp horizontal curve), unless removal would effectively resolve a significant safety issue. Consider investigating the causes of the crashes and mitigating those causes (for example, pavement delineation, advanced warning signs, continuous speed enforcement, etc.). If the root causes cannot be mitigated, consider shielding the tree with a barrier (refer to AASHTO's *Roadside Design Guide* for proper installation of barriers). Carefully locate new trees where they are less likely to be struck by vehicles leaving the roadway, or use small caliper trees (4-in. diameter or less at maturity).

Public Space

Civic and community functions on the roadside may require additional space to complement adjacent civic or retail land uses or accommodate the high pedestrian flows of adjacent uses or transit facilities. Public spaces in the roadside are often used for these functions and are an important complement to the thoroughfare as a public place. Public spaces include public plazas, squares, outdoor dining, transit stops and open spaces. Transit stops and some plazas are generally within the roadside (some public spaces are located in medians of large thoroughfares as shown in Figure 8.2). Design considerations should account for the context of the public space within the thoroughfare and the surrounding land use context. Public spaces should be designed to serve functions that enhance the surrounding context, such as public gathering, special events, farmers' markets, quiet contemplation, lunch time breaks, etc. (Figure 8.3). General principles for the design of public spaces include the following.

- Public spaces in private property adjacent to the roadside should be visible and accessible from the roadside. These public spaces can accommodate higher levels of pedestrian activity at entries to major buildings or retail centers.

Figure 8.2 Medians designed as a public plaza. Source: Community, Design + Architecture.

Figure 8.3 Public space adjacent to the pedestrian realm should relate to the activities on the thoroughfare.
Source: Kimley-Horn and Associates Inc.

- Public spaces in the roadside should not impede the circulation of pedestrians and should provide appropriate features such as seating and lighting to make them attractive and functional places for people to use.
- Special paving and materials may be used to unify the look of the sidewalk, parking lane and crosswalks.
- Street trees, light fixtures, public art and other elements with a unified design can be used to highlight a segment of a thoroughfare that is specifically designed to function as a public gathering place.

Roadside Facilities

Roadside facilities include functional elements such as pedestrian-scale kiosks and retail stands, trash receptacles, water fountains, restrooms, other small ancillary structures and non-functional elements such as public art.

Placement of Roadside Facilities

Following the division of the roadside into edge, furnishings, throughway and frontage zones, the placement of roadside facilities should occur in the furnishings and frontage zones as well as in curb extensions. In no case should the placement of features reduce the width of the clear pedestrian throughway to less than 5 ft. All placements should be compliant with the most recent U.S. Access Board and ADA requirements.

Other considerations regarding roadside facilities are as follows:

1. The placement of facilities should be targeted to locations where their use will produce pedestrian activity levels similar to a main street, or where an activity focus is desired. Features such as public art should be located in highly visible areas including the center islands of low-speed roundabouts (ensuring sight triangles are

maintained and placement does not constitute a roadside hazard) and retaining walls.

2. The type, design and materials of roadside facilities should be selected to reflect the local character of the context and roadside. This will maximize the facility's contribution to creating a sense of community identity.
3. The design of facilities should be coordinated between elements (street furniture, light fixtures and poles, tree grates, etc.) that fit into a desired theme or unified style for a given thoroughfare. This can be best achieved through the preparation of a streetscape improvement plan.
4. Roadside facilities are particularly well suited to be placed on very wide sidewalks or large curb extensions. Facilities at street corners should be located in a manner that maintains clear sight triangles. (For more information, review the discussions on sight triangles and curb extensions in Chapter 10.)
5. The design and location of facilities should consider vehicle overhangs and door swings of parked vehicles.
6. Facilities should never obstruct the clear pedestrian throughway, curb ramps, or any accessible element of the roadside.
7. Vertical elements should be placed so they provide the required lateral clearance to the face of the curb and satisfactory shoulder clearance from the clear pedestrian throughway zone.
8. Avoid placement of roadside facilities where they become hazardous fixed objects for motorists.

Context Zones

The placement of roadside facilities should be focused in urban center (C-5) or urban core (C-6) context zones with predominantly retail- and entertainment-related ground floor uses with a main street level of pedestrian activity. The need for and benefits from facilities such as kiosks, restrooms, or small-scale retail stands is typically highest in C-5 and C-6 zones.

Facilities in the general urban (C-4) or suburban (C-3) context zones should be limited to nodes of increased intensity of retail and entertainment uses on the ground floor that produce high levels of pedestrian activity. The provision of facilities at public transit transfer centers should be considered in all context zones.

Public Art

Pedestrian improvements create an opportunity to implement public art (Figure 8.4). On a large scale, public art has the ability to identify a district or contribute to a design theme. It can be an effective means of encouraging pedestrian travel and creates community identity. The redesign of thoroughfares creates opportunities for the implementation of public art as part of an urban design or streetscape plan. The types of public art that may be considered include:

- Integrated: an upgrade to a standard treatment, or a custom design of, a functional element of the roadside.
- Semi-integrated: integrated into a functional element of the roadside, but includes stand-alone art that is not a functional element of the roadside.
- Discrete: stand-alone art and is not integrated with any functional element of the roadside.

Public art encourages pedestrian travel by adding interest along walking routes. Public art includes the incorporation of any object deemed as art into the thoroughfare right-of-way. This includes, but is not limited to: artistically designed paving; application of artistic expression or components into the design of furnishings or light fixtures, railings or low walls; individual or groupings of sculptural objects, murals or other surface treatments, etc. Structures such as arches, columns, or other monuments, which are intended to serve as an entry marker to a downtown or neighborhood also fall under the definition of public art for the purpose of this report.

Placement of Public Art

Public art can be incorporated into a variety of components of the thoroughfare, including medians, roadside and adjacent property.

Other considerations regarding the placement of public art are as follows:

1. Placement of public art and entry monuments should be targeted to locations where they can provide significant visual interest and can be enjoyed by a large number of thoroughfare users of all transportation modes;

Figure 8.4 Public art adds interest to a walking route. Source: Kimley-Horn and Associates Inc.

2. Design and placement of public art and other amenities such as street furniture along a thoroughfare should be mutually enhancing and well coordinated to ensure that all improvements add up to a coherent "theme" for a given thoroughfare;
3. Consideration should be given to the integration of public art into the elements of the thoroughfare, such as pavement treatments, street furniture, transit stops, light fixtures, etc. to maximize the quality of these elements; and
4. Placement of public art and monuments should not obstruct the driver's view of traffic control devices, be a distraction, or be located in a manner that could create a roadside hazard to motorists.

Context Zones

The placement of public art should be focused on thoroughfares that figure prominently (or have the potential to figure prominently) in the public's image of the community. The scale and intensity of the incorporation of public art into the elements of a thoroughfare should vary according to the intensity and character of uses in the surrounding context. For instance, the entry to a university or hospital complex located in a general urban (C-4) or suburban (C-3) context zone may be marked with an individual conspicuous piece of public art, whereas the intensity and frequency of public art should increase along thoroughfares in the urban center (C-5) and the urban core (C-6) context zones, where pedestrian and other activity levels are at their highest.

Thoroughfares with major transit corridors are uniquely suited to incorporate public art as an integral or special feature of the transit-way design elements. Public art as a transit-way and transit stop amenity can provide a wide range of aesthetic interest and linkages along the thoroughfare.

Design Guidance

Design guidance for the roadside elements of the thoroughfare is provided in the following sections. Specifically, design guidance is provided for roadside width and functional requirements, pedestrian buffers and edge and furnishings zone elements (trees and parkways, sidewalk crossings of driveways and alleys, utilities, street furniture and landscaping).

Roadside Width and Functional Requirements

Background and Purpose

> **Related Thoroughfare Design Elements:**
> - *Intersections*
> - *Edge and furnishings zone principles and considerations*
> - *Roadside facilities and public art*

The roadside, or sidewalk, provides for the mobility of people and is an important social space where people interact and walk together, wait for transit, window shop, access adjoining uses, or have a cup of coffee at a street cafe. The roadside must be wide enough to accommodate movement as well as the important social functions related to the land uses located along the thoroughfare. The width and function of the roadside influences safety and helps achieve accessibility. The optimal roadside width varies with the expected roadside activities, character of adjacent land uses and speed and volume of vehicular traffic in the thoroughfare.

General Principles and Considerations

General principles in the selection of appropriate roadside width include the following.

- The roadside should have well-defined zones so that the pedestrian throughway is clearly demarcated (Figure 8.5).
- Sidewalks should be provided on both sides of the street in urban contexts. In certain conditions, a sidewalk on one only side of the roadway is appropriate when unusual land uses, such as a canal, steep vertical wall, or railroad, exist and people do not have a need to access that side of the street.
- Care should be given where driveways and alleys cross sidewalks. At these locations there is a potential for conflict between drivers and pedestrians and an increased possibility that pedestrian safety will be compromised. Crossings of driveways, garage accesses, alleys and other crossings should maintain the elevation of the sidewalk and may be considered for special materials, colors, textures and markings alerting motorists that they are traversing a pedestrian zone.
- Utilities should not interfere with pedestrian circulation or block entrances to buildings or curb cuts, or interfere with sight distance triangles.

Figure 8.5 A roadside with well-defined zones. Source: Community, Design + Architecture.

- Space requirements for, and access to, transit facilities (such as bus shelters) should be included in the design of the roadside, but must be outside of the clear pedestrian travel way.
- Sidewalks must provide convenient connections between building entries and transit facilities.
- Designers should coordinate with utility providers regarding the location of utility elements such as poles, cabinets, grates and manholes.
- Sidewalks should be as straight and direct as possible except to avoid mature trees or unavoidable obstacles. Pedestrians in urban and suburban contexts have a desire to walk a straight course.

Edge Zone Principles and Considerations

Principles and considerations concerning edge zones include:

- The edge zone, which is sometimes referred to as the "curb zone," is the interface between the traveled way and the furnishing zone and provides an operational offset to:
  - Prevent vehicle overhangs from hitting vertical objects when turning or backing towards the curb;
  - Provide clearance from tall vehicles that are parked next to the curbs on highly-crowned pavements;
  - Provide clearance for extended bus and truck mirrors; and
  - Permit the opening of parked vehicle doors.
- In compact mixed-use urban areas with on-street parking, particularly those areas with ground floor retail activity, the edge zone should be a minimum of 1.5 ft. to accommodate the door swing of a parallel parked car and prevent potential conflicts with elements in the furnishing zone. While this zone should generally be kept clear of any objects, parking meters can be placed here with consideration to door swings.
- The width of the edge zone adjacent to angled parking should account for the depth of vehicle overhang, which can vary between 1.5 and 2.5 ft. depending on the angle of the parking spaces.

Roadside Zones

A Avenue, Lake Oswego, Oregon

A Avenue is classified as a major arterial thoroughfare located in a general urban context zone (C-4) in Lake Oswego's downtown central business district and civic center area. Downtown land uses consist of low to medium density commercial mixed use (office over retail/service) with low to medium density residential located one block from A Avenue. The ground floor uses are primarily commercial with a mix of retail, services, and restaurant. Although the roadside on A Avenue is limited, it contains distinct zones for edge, furnishings, clear throughway, and frontage. The edge zone is about 18 in. allowing an operational clearance for opening car doors. The furnishings zone (5 ft.) contains street trees in wells with decorative grates, light standards, shrubs in movable planters, seating, and a collection of public art. Underground utilities and vaults are also located in this zone. The clear throughway ranges from 5 to 8 ft. and the frontage zone (about 2-3 ft.) contains planters, window shopping areas, and seating for outdoor cafes.

- If reverse (back-in) angled parking is considered, the edge zone lateral clearance must be at least 30 in. due to the added overhang of the rear of most vehicles.
- At transit stops with shelters, the edge zone should be widened to a minimum of 4 ft. to provide wheelchair access to and in front of the shelter. A curb extension that stretches the length of the transit stop can also be an effective way to increase the width of the edge zone. Curb extension bus stops have additional advantages for transit operations, including faster passenger loading and

Figure 8.6 Utility poles and other fixtures should not interfere with the pedestrian throughway. This example shows a bus shelter and other street furniture properly located in the furnishings zone. Source: Kimley-Horn and Associates Inc.

unloading, more space for waiting passengers and less time for buses to re-enter the flow of traffic.

Furnishings Zone Principles and Considerations

Principles and considerations concerning furnishings zones include the following.

- The furnishings zone is the key buffer component between the active pedestrian walking area (throughway zone) and the thoroughfare traveled way. Street trees, planting strips, street furniture, utility poles, signal poles, signal and electrical cabinets, telephones, traffic signal cabinets, signs, fire hydrants, bicycle racks and the like should be consolidated in this zone to keep them from becoming obstacles in the throughway zone (Figure 8.6).
- The furnishings zone accommodates curbside transit stops, including boarding areas, shelters and passenger queuing areas.
- When signal control cabinets, signal poles and other traffic equipment are installed, they must leave pedestrians in clear sight of, and in alignment with, motorist's views at all times. This might require special setbacks for oversized equipment.
- Retail kiosks, stands, or other business activities are appropriate in the furnishings zone (see earlier section in this chapter on roadside facilities and public art) if the furnishings zone is sufficiently wide to maintain a 1.5 ft. minimum lateral clearance from the curb and overhanging parked vehicles.
- Installation of curb extensions (see the section in Chapter 10 on curb extensions) is an effective way to increase sidewalk space in the furnishings zone adjacent to crosswalks where pedestrians will wait before crossing the thoroughfare.
- Where no furnishings zone exists, elements that would normally be placed there, such as benches, light poles, signals, trash receptacles, etc. may occupy the frontage zone to keep the clear

pedestrian travel way unobstructed and comply with ADA requirements.

Throughway Zone Principles and Considerations

Principles and considerations concerning throughway zones include the following.

- Clear pedestrian throughway zone is intended for pedestrian travel only and should be entirely clear of obstacles and provide a smooth walking surface.
- Width of the throughway zone should vary by context and the activity of the adjacent land use (Table 8.1).
- Recommended clear pedestrian throughway zone minimum width in constrained conditions is 5 ft. in residential and 6 ft. in commercial areas.
- For thoroughfares with higher pedestrian volumes that have met minimum requirements for all other zones, the preferred dimension varies from 6 to 10 ft. (Table 8.1). For very high pedestrian volume areas, additional width should be provided.
- Within the "station area" of high-capacity transit stations, sidewalks should be sufficiently wide to accommodate expected pedestrian volume surges and provide opportunities for faster pedestrians to overtake slower pedestrians.

Frontage Zone Principles and Considerations

Principles and considerations concerning frontage zones include the following.

- Frontage zone is the area adjacent to the property line that may be defined by a building facade, landscaping, fence, or screened parking area.
- Generally pedestrians do not feel comfortable moving at a full pace directly along a building facade or wall. The width of the frontage zone may be increased to accommodate a variety of activities associated with adjacent uses, such as outdoor seating or merchant displays. In all cases, the minimum 18-ft. width that is clear of buildings, seating, etc. should be maintained to account for the pedestrian distance.
- Sidewalk businesses or other business activities should be conducted preferably in the frontage zone, or in some cases the furnishings zone. Private furnishings permitted in the frontage zone may include seating and tables, portable signage and merchandise displays. These furnishings may require permits from the agency that owns the right-of-way.
- Overhanging elements such as awnings, store signage, bay windows, etc. may occupy this zone and extend into the clear pedestrian travel way. These elements add vitality and visual interest to the street, but also must comply with local building codes and zoning ordinances. Overhanging elements require a vertical clearance of at least 8 ft.
- Where the roadside passes a parking lot, a buffer, such as a hedge or a low wall, should be used to prevent parked vehicles from overhanging into the frontage zone and maintain an attractive frontage along the roadside. Where surface parking is exposed to a thoroughfare right-of-way, and a buffering hedge or low wall cannot be accommodated within the private property, the frontage zone should be widened to provide space for the hedge (2 to 3 ft.) or low wall (0.5 to 1 ft.) with a visual screen up to 6 ft. in height.
- Table 4.1 in Chapter 4 includes a discussion of context zones, frontages and setbacks.

Driveway Crossing Principles and Considerations

Principles and considerations concerning driveway crossings include the following.

- Appearance of the sidewalk (scoring pattern or special paving) should be maintained across driveway and alley access points to indicate that although a vehicle may cross, the area traversed by a vehicle remains part of the pedestrian travel way.
- It is desirable to minimize, consolidate, or eliminate curb cuts and driveways in areas of highest pedestrian activity such as urban center (C-5) and urban core (C-6) commercial areas. In these areas, driveway and curb cut frequencies and

Table 8.1 Recommended Roadside Zone Dimensions

CONTEXT ZONE AND PREDOMINANT GROUND FLOOR LAND USE OR FRONTAGE

Thoroughfare	Sidewalk Zone [1]	C-6 and C-5			C-4 w/ Predominantly Commercial Ground Floor Use			C-4 w/ Predominantly Residential Frontage			C-3 w/ Predominantly Commercial Ground Floor Use			C-3 w/ Predominantly Residential Frontage		
Boulevard	**Edge**	1.5 ft. 2.5 ft. at diagonal parking	21.5 foot (recommended)	12 foot (constrained)	1.5 ft. 2.5 ft. at diagonal parking	19 foot (recommended)	12 foot (constrained)	0.5 ft.	16.5 foot (recommended)	9 foot (constrained)	1.5 ft. 2.5 ft. at diagonal parking	16 foot (recommended)	12 foot (constrained)	0.5 ft.	14.5 foot (recommended)	9 foot (constrained)
	Furnishings	7 ft. (trees in tree wells)			7 ft. (trees in tree wells)			8 ft. (landscape strip w/ trees and grasses, or groundcovers)			7 ft. (trees in tree wells)			8 ft. (landscape strip w/ trees and grasses, or groundcovers)		
	Throughway	10 ft.			8 ft.			8 ft.			6 ft.			6 ft.		
	Frontage	3 ft.			2.5 ft.			0 ft. along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 ft. along facades, tall walls and fences			1.5 ft.			0 ft. along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 ft. along facades, tall walls and fences		
Boulevard Without Parking	**Edge**	**THIS THOROUGHFARE TYPE NOT APPLICABLE TO THE PREDOMINANTLY COMMERCIAL GROUND FLOOR LAND USES FOUND IN C-4 THROUGH C-6 CONTEXT ZONES**						0.5 ft.	18.5 foot (Recommended)	9 foot (constrained)	**THIS THOROUGHFARE TYPE NOT APPLICABLE TO THE PREDOMINANTLY COMMERCIAL GROUND FLOOR LAND USES**			0.5 ft.	16.5 foot (recommended)	9 foot (constrained)
	Furnishings							10 ft. (landscape strip w/ trees and groundcovers. or low shrubs)						10 ft. (landscape strip w/ trees and groundcovers, or low shrubs)		
	Throughway							8 ft.						6 ft.		
	Frontage							0 ft. along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 ft. along facades, tall walls and fences						0 ft. along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 ft. along facades, tall walls and fences		
Avenue	**Edge**	1.5 ft. 2.5 ft. at diagonal parking	19.5 foot (recommended)	12.0 foot (constrained)	1.5 ft. 2.5 ft. at diagonal parking	16 foot (recommended)	12 foot (constrained)	0.5 ft.	14.5 foot (recommended)	9 foot (constrained)	1.5 ft. 2.5 ft. at diagonal parking	16 foot (recommended)	12 foot (constrained)	0.5 ft.	14.5 foot (recommended)	9 foot (constrained)
	Furnishings – With Parking	6 ft. trees in tree wells			6 ft. (trees in tree wells)			8 ft. (landscape strip w/ trees and grasses, or groundcovers)			6 ft. (trees in tree wells)			8 ft. (landscape strip w/ trees and grasses, or groundcovers)		
	Furnishings – Without Parking	8 ft. with buffer landscaping			8 ft. with buffer landscaping			8 ft. with buffer landscaping			8 ft. with buffer landscaping			8 ft. with buffer landscaping		
	Throughway	9 ft.			6 ft.			6 ft.			6 ft.			6 ft.		
	Frontage	3 ft.			2.5 ft.			0 ft. along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 ft. along facades, tall walls and fences			2.5 ft.			0 ft. along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 ft. along facades, tall walls and fences		
Street	**Edge**	1.5 ft. 2.5 ft. at diagonal parking	16 foot (recommended)	12.0 foot (constrained)	1.5 ft. 2.5 ft. at diagonal parking	16 foot (recommended)	12 foot (constrained)	0.5 ft.	11.5 foot (recommended)	9 foot (constrained)	1.5 ft. 2.5 ft. at diagonal parking	15 foot (recommended)	12 foot (constrained)	0.5 ft.	11.5 foot (recommended)	9 foot (constrained)
	Furnishings	6 ft. (trees in tree wells)			6 ft. (trees in tree wells)			5 ft. (landscape strip w/ trees and grasses, or groundcovers)			6 ft. (trees in tree wells)			5 ft. (landscape strip w/ trees and grasses, or groundcovers)		
	Throughway	6 ft.			6 ft.			6 ft.			6 ft.			6 ft.		
	Frontage	2.5 ft.			2.5 ft.			0 ft. along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 ft. along facades, tall walls and fences			1.5 ft.			0 ft. along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 ft. along facades, tall walls and fences		

NOTES: Recommended dimensions for the throughway zone may be wider in active commercial areas.
See Table 5.2 in Chapter 5 for discussion of minimum roadside zone widths in constrained conditions.

[1] In AASHTO's *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, the furnishing zone is termed the "buffer" zone, and the frontage zone is termed the "shy distance."

spacing should be kept to a practical minimum, ideally one curb cut per block.

- Consolidation of driveways is particularly important in areas with predominantly commercial ground floor uses in suburban (C-3) and general urban (C-4) context zones.
- Driveway crossings should maintain the elevation of the sidewalk.
- Driveway aprons should not extend into the clear pedestrian travel zone, where cross slopes are limited to a maximum of 2 percent; steeper driveway slopes are permitted in the frontage, furnishing and edge zones of the roadside.
- Along boulevards and avenues, the elimination of driveways and conflict points may be aided by the presence of continuous medians that restrict left turns.

Recommended Practice

Table 8.1 provides an overview of recommended width for each of the roadside zones described in this chapter. The table provides the recommended width of each of the zones by context zone, thoroughfare type and under varying predominant ground floor use conditions. Table 8.1 also provides the total width of the roadside for a recommended and constrained condition. If on-street parking affects the width of a zone, the thoroughfare type is subdivided to show the change in dimensions.

Additional Guidelines

Driveway Crossings

- The width of driveways for two-way traffic should not exceed 24 ft. unless a specific frequent design vehicle requires a wider dimension. Some driveway volumes warrant two lanes in each direction. In these cases, consider designing a median between directions to separate opposing traffic and provide a pedestrian refuge. When a driveway is one-way only, a maximum width of 14 ft. should be considered.
- In driveway or alley crossing locations, this minimum width requirement applies to the 5-ft. wide clear pedestrian throughway. Figure 8.7 illustrates a typical design under this minimum condition: a 5-ft. wide pedestrian travel way is maintained across the entire driveway, the slope does not exceed 2 percent. Note that the sidewalk remains level and the driveway apron does not extend into the sidewalk.

Utilities

- Aboveground utilities should be placed at least 18 in. from the back of curb and should not interfere with the minimum 5-ft. clear pedestrian through way. If buildings do not abut the right-of-way, place utilities behind the sidewalk where they will not interfere with the use of the adjacent property.
- Placing utilities underground avoids conflicts and clutter caused by poles and overhead wires and should be coordinated with street tree planting planning efforts to avoid conflicts between the trees and below-ground utilities and aboveground utility boxes. Placing utilities underground can be costly, particularly in retrofit situations.
- The design of sidewalks, planting strips, medians and other street elements must allow for service access to underground and overhead utilities.
- Longitudinal underground utility lines should be located in a uniform alignment as close to the right-of-way line as practical, or within a planting strip. In urban areas with abutting buildings, locate utilities within the parking lane or planting strip.

Refer to AASHTO's *A Guide to Accommodating Utilities Within Highway Right-of-Way* (2005) for additional information on the design and placement of utilities.

Street Furniture

Street furniture placed along a sidewalk is an amenity that encourages walking. Street furniture, such as a public telephone, seating, or a drinking fountain, provides both a functional service to pedestrians and visual detail and interest. Street furniture also conveys to other users of the thoroughfare that pedestrians are likely to be present. Guidelines include the following.

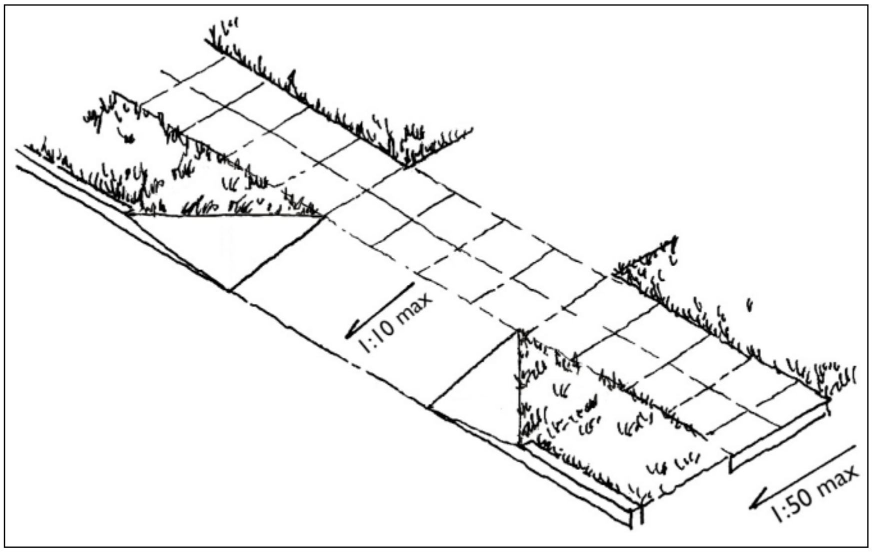

Figure 8.7 Preferred design of driveway and alley crossings. Source: Community, Design + Architecture.

- Street furniture may be placed within curb extensions as long as it does not obstruct the clear pedestrian throughway or access to curb ramps. Bicycle parking or landscaped areas with seating walls can be accommodated in curb extensions.
- Street furniture should be placed on thoroughfares expected to have high pedestrian activity. When resources are limited, prioritize locations for the placement of street furniture. Examples of priority locations for street furniture include:
  - Transit stops;
  - Major building entries;
  - Retail and mixed-use main streets; and
  - Restaurants.
- Select the type, design and materials of street furniture to reflect the local character of the surrounding context and contribute to a sense of community identity.
- Ensure that placement of furniture does not reduce the width of the clear pedestrian throughway to less than 5 ft.

Landscaping

Landscaping is typically located in the furnishings zone of the roadside. Vegetation, especially trees, adds soft textures and bright colors to the concrete and asphalt surfaces of the thoroughfare and thereby increases comfort and distinguishes an area's identity. Trees are frequently the most visibly significant improvement, if properly selected, planted and maintained. They provide shade from the sun, intercept stormwater and buffer pedestrians from passing vehicle traffic. Guidelines include the following.

- Ground cover, grasses and shrubs might be appropriate supplements to add character along

Utilities and Street Trees

Both overhead and underground utilities can pose conflicts with street trees.

Mature trees' branches may interfere with overhead wires and lead to "topping" by utility providers. This practice is unattractive and can be detrimental to the tree's branching structure. To avoid this situation, consider under-ground utility lines or select shorter trees whose branches will remain below the utility lines.

When planning for street tree planting, identify and avoid any underground utilities that could be damaged during the installation process or tree roots.

residential streets. Raised planters along mixed-use main streets can be used as seating and may increase pedestrian comfort by providing a visual buffer between pedestrians and traffic.

- Ensure that street trees and shrubs are placed to maintain sight distance. Small caliper trees with branching of adequate height should not reduce sight distance.
- Select plants that are adapted to the local climate and fit the character of the surrounding area.
- Consider the use of structural soils to allow for the planting of healthy street trees in narrow furnishing zones.
- Use street trees and other landscaping to complement street lighting and roadside facilities in creating a distinct character for specific streets, districts, or neighborhoods. Because lighting is an important aspect of thoroughfare safety, the practitioner needs to consider the effect of landscaping on the effectiveness of the lighting.
- If a continuous canopy of trees is desired by the community, space street trees between 15 and 30 ft. on-center, depending upon species, that shades the roadside, defines the edge of the street and creates a buffering effect between the traveled way and roadside.
- Landscape plantings in urban center (C-5) and urban core (C-6) context zones may have a formal characteristic (in a more linear and symmetrical pattern), with plantings becoming less formal in less intensive context zones (C-3 and C-4).
- In the more urban C-5 and C-6 context zones and along thoroughfare segments with predominantly commercial ground floor uses, trees should be planted in tree wells covered by tree grates to maximize the surface area for pedestrian circulation. Tree grates or landscaped cutouts should be considered for other context zones.
- Prune trees so that branches do not interfere with pedestrians, street lighting, parked vehicles and sight distance. The minimum vertical clearance should be 8 ft. above the pedestrian travel way in the roadside and at least 13 ft. from the top of curb in the traveled way to provide clearance for larger vehicles.
- On commercial streets with business signs, work with a landscape architect to select the appropriate types of tree and pruning techniques so that interference with sign visibility is minimized.
- Maintenance issues should be discussed in advance of the preparation of a streetscape improvement plan to ensure clear understanding of pruning and maintenance requirements.
- The width of the roadside landscaped area should be at least 5 ft. (preferred width is 8 ft.) to support healthy tree growth.
- Trees can be planted in curb extensions between parking bays (Figure 8.8). This helps reduce the visual width of the street and can be part of a design that maintains a wider pedestrian throughway, especially in constrained conditions.

Pedestrian Buffer

The buffering of the roadside from traffic in the traveled way is one of the most important factors in providing pedestrian comfort along major urban thoroughfares. The effectiveness of buffers is largely dependent on width (see the section in this chapter on roadside width and functional requirements) and the contributing buffer elements, such as street furniture and landscaping that can create a visual barrier between the pedestrian and moving traffic (Figure 8.9). On-street parking and edge and furnishings zones combine to provide buffering from traffic. Guidelines include:

- On-street parking should provide a buffer between pedestrians on the sidewalk and moving traffic; especially in areas with ground floor commercial uses and/or where high-volumes of pedestrian activity are expected. Texturing parking lanes or bays with the same material as the sidewalk can visually reduce the width of the roadway when the parking lane is empty.
- For thoroughfares without on-street parking and travel speeds of 30 mph or less, the width of the furnishings zone as a buffer for pedestrians should be at least 6-ft. wide.
- Consider reducing the frontage zone to its minimum or eliminating it so that an appropriately

wide pedestrian buffer can be achieved within the furnishings zone.

- Bicycle lanes can serve as a buffer if desired roadside widths cannot be achieved, or if roadside widths can only be achieved at the lower end of the ranges shown in Table 8.1.

Justification

Although the recommendations in this chapter are generally consistent with the guidelines contained in the AASHTO *Guide for the Planning, Design and Operation of Pedestrian Facilities* (2004b), the recommendations for buffer widths in this chapter are wider than those recommended in the AASHTO guide.

Recommendations related to street furniture and landscaping in this chapter are based on recently published best practices, specifically the Santa Clara Valley (California) Transportation Authority's *Pedestrian Technical Guidelines* (2003), which describes the principles behind the use of street furniture and landscaping to encourage pedestrian activity.

The effect of on street parking as a pedestrian buffer is generally recognized by practitioners as one factor in creating a comfortable pedestrian environment. Some pedestrian level of service methodologies place more weight on the presence of on-street parking.

Figure 8.8 Street tree planted in curb extension in parking lane. Source: Kimley-Horn and Associates Inc.

Figure 8.9 A combination of on-street parking, furnishings zone and wide pedestrian throughway provides ample buffer. Source: Kimley-Horn and Associates Inc.

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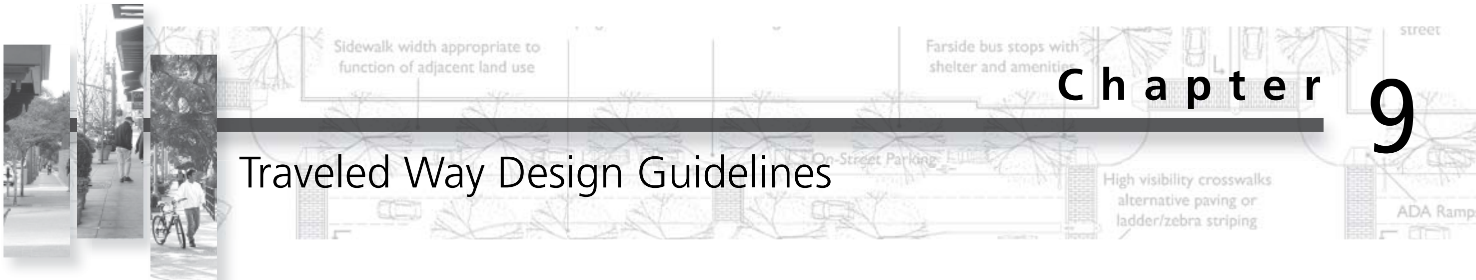

Chapter 9

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

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 where vehicles, via on-street parking, interface with the roadside. 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 sometimes vehicles and pedestrians crossing at midblock locations and intersections.

The traveled way typically utilizes the largest portion of the right-of-way. Fundamental principles of the design of this portion of the thoroughfare include uni-

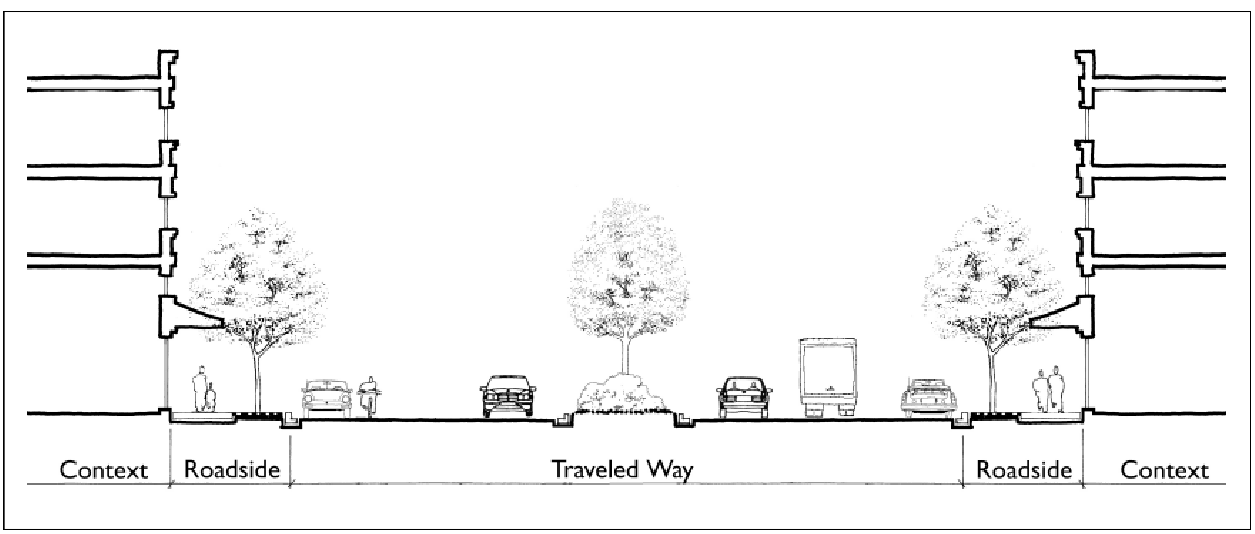

Figure 9.1 The traveled way is the component of the thoroughfare between the curbs. Source: Community, Design + Architecture.

form cross section along the length of the thoroughfare and transitions designed to change speed where cross-section elements change. The guidance in this report addresses the following considerations for the thoroughfare traveled way:

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

The guidance in this report address the following design guidelines for the thoroughfare traveled way:

- Lane width;
- Medians;
- Bicycle facilities;
- On-street parking and configuration;
- Transition design;
- Midblock crosswalks;
- Pedestrian refuge islands; and
- Midblock bus stops.

Design Considerations

Cross-Section Determination

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

- Determine context zone and identify thoroughfare type based on Tables 4.1 (Context Zone Characteristics—Traditionally Urbanized Areas), 4.2 (Thoroughfare Type Descriptions), 4.3 (Relationship Between Functional Classification and Thoroughfare Type) and 4.4 (Urban Thoroughfare Characteristics). This establishes the general parameters for the cross section (such as median width, parking lane width, roadside width and function).
- 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 parallel routes to accommodate travel demand) should influence the number of lanes on the thoroughfare. In this report, compact mixed-use urban areas are recommended to have a maximum of six through lanes.
- Determine the preliminary number of turn lanes at critical intersections. Intersection design in CSS may require evaluation of tradeoffs between vehicular capacity and level of service, and pedestrian crossing distance and exposure to traffic.
- Select the design and control vehicle (Chapter 7) for the thoroughfare by identifying the most common type of vehicle to accommodate without encroachment into opposing travel lanes.
- Identify transit, freight and bicycle requirements for the thoroughfare and establish the appropriate widths for each design element.
- 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 roadside) to utilize the available right-of-way.
- Avoid combining minimal widths for adjacent elements, except on very low speed facilities. 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

Properly locating and designing access is called access management, which provides access to adjoining properties to preserve safety and reasonable traffic flow on the public street system. Effective access management includes setting access policies for street and abutting development, keying 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. In a broad context, access management is resource management, since it is a way to anticipate and reduce crashes and congestion and improve traffic flow. It has been shown that good access management can reduce crashes by 50 percent or more, depending on the condition and treatment used (TRB 2002). The following principles define access management techniques:

- Classify the street system by function and context;
- Establish standards or regulations for intersection spacing;
- Limit direct access to streets that primarily serve a vehicular mobility function (see Chapter 11);
- On streets that serve an access function (the focus of this report), locate driveways and major entrances away from intersections and away from each other to minimize interference with traffic operations, minimize crashes and provide for adequate storage lengths for turning vehicles;
- Use curbed medians and locate median openings to manage access and minimize conflicts; and
- Minimize curb cuts in urban areas to reduce conflicts between vehicles, pedestrians and bicyclists.

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

Emergency Vehicle Operations

Major urban thoroughfares are the primary conduits for emergency response vehicles including police, fire and ambulance. Emergency vehicle access and operations should always be considered in thoroughfare and site design. Many factors affect emergency vehicle response time and on-site operations, including:

- Recurring and non-recurring congestion;
- Width of street and travel lanes;
- Number of travel lanes;
- Geometric design of intersections;
- Access management features; and
- Signal timing, coordination and existence of pre-emption devices.

Fire codes may have additional guidance on accessibility requirements such as minimum travelway 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 traveled ways to accommodate emergency vehicles.

- High levels of street connectivity improve emergency response by providing alternate routes. Look for opportunities to improve overall network connectivity.
- When establishing new or reviewing existing access management configurations, care should be taken to permit direct routing capability to emergency vehicles.
- Coordinate thoroughfare design with the local fire district to identify special width requirements (such as on streets adjacent to high-rise buildings or streets where fire stations are located).
- Use turning radius and width specific to the type of local emergency vehicle. Consider using emergency vehicles as a design vehicle for the design of curb return radii if the vehicle would use the roadway frequently. Emergency vehicles, are generally able to encroach into opposing travel lanes.
- On streets with medians or other access management features, emergency response time may be reduced by the implementation of mountable curbs within medians to allow emergency vehicles to cross (Figure 9.2). Consider a mountable median section about 200–300-ft. back from the approach of regularly congested intersections to allow emergency vehicles to cross the median to bypass blocked lanes.

Operational Considerations

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

1. Reducing non-recurring congestion using techniques, such as traffic incident management and information, special-events traffic management,

Figure 9.2 A mountable median allows emergency vehicles to access streets otherwise difficult to access because of access management. Source: Kimley-Horn and Associates Inc.

work-zone management and emergency-management planning.

2. Reducing recurring congestion using techniques such as freeway and arterial management, corridor 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 encompasses many of the strategies listed in Item 1 above.

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. From a purely geometric design perspective, transitions simply 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.

In CSS, however, transitions extend beyond geometric design requirements and reflect changes in context zone and associated levels of multi-modal 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; and
- Neighborhood or district, such as a transition between a commercial and residential district.

Principles for designing effective transitions include:

- Use the established guidance (MUTCD, AASHTO Green Book) to properly design, mark and sign geometric transitions; and
- Transitions should occur 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.

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

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. Provide 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, etc. as appropriate, or utilize appropriate traffic calming devices such as speed platforms or rumble strips where the zone is particularly short.
2. Provide visual cues to changes in context or environment. The intent of this principle is to combine regulatory speed change with traveled way or roadside features that influence driver speed. Visual cues can include roadside urban design features (landscaping, curbs, street light standards with banners, entry signs, thematic street furniture, etc.) 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 can affect driver perception. 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. Gateways (Figure 9.3) can be achieved with urban design features or unique intersections such as modern roundabouts.
3. Change the width of the street or travel lanes 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. Specifically, design guidance is provided for:

- Lane width;
- Medians;
- Bicycle facilities;
- On-street parking and configuration;
- Transition geometric design;
- Midblock crosswalks;
- Pedestrian refuge islands;
- Midblock bus stops; and
- Special considerations for snow removal.

Lane Width

Background and Purpose

Related Thoroughfare Design Elements

- *On street parking and configuration*
- *Access management*
- *Midblock bus stops*
- *Intersection layout*

Street width is necessary to support desirable design elements in appropriate contexts such as on-street parking, landscaped medians and bicycle lanes. Excessively wide streets, however, create barriers for pedestrians and encourage higher vehicular speeds. Wide streets can act as barriers, reducing 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 number of conflicting movements at intersections.

General Principles and Considerations

General principles and considerations in the selection of lane widths include:

- Base the overall width of the street and the traveled way on the accumulated width of the desired design elements (for example, 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.
- A minimum lane width of 10 ft. may be used for travel lanes on low speed urban collector streets. A 10-ft. wide turn lane may be considered on arterial streets in constrained rights-of-way. Consider design speeds of 35 mph or less (operating speeds of 25 to 30 mph) for application of 10-ft. lanes. Check local fire codes for restrictions on lane widths.
- 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).
- 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.
- On the lower-speed urban thoroughfares addressed in this report (35 mph or less operating speed), a range of lane widths from 10 to 12 ft. on arterials and 10 to 11 ft. on collectors is appropriate (excluding gutter pan). Lanes that are 11-ft. wide are appropriate under most circumstances addressed in this report. Arterial and collector roadways with design speeds of

Figure 9.4: An example of 10.5-ft. wide travel lanes on a mixed use arterial in Addison, TX.
Source: Kimley-Horn and Associates Inc.

30 mph (5 mph over the operating speed) are appropriate for applying the lower end of the ranges (10 ft.) (Figure 9.4). The conventional 12-ft. wide travel lane is appropriate for high speed (40 mph or higher) facilities (see Chapter 11 on Thoroughfares in Vehicle Mobility Priority Areas).

- Streets with high volumes of trucks or buses require wider travel lanes, particularly the curb lane. Modern buses can be 10.5-ft. wide from mirror to mirror and require a minimum 11-ft. wide lane on roadways with 30 to 35 mph design speeds. Wider curb lanes, between 13 to 15 ft. 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.
- When wider curb lanes are required, consider balancing the total width of the traveled way by narrowing turn lanes or medians to maintain a reasonable pedestrian crossing width.
- Consider wider lanes along horizontal curves to accommodate vehicle off-tracking, based on a selected design vehicle. The AASHTO Green Book provides guidance on widening for vehicle off-tracking.
- Turn lanes that are 10- to 11-ft. wide are appropriate in urban areas. Use the guidance in Chapter 7 regarding the design vehicle to select an appropriate turn lane width.
- Wider travel lanes only marginally increase traffic capacity. According to the *Highway Capacity Manual* (2002), an 11-ft. wide lane reduces the saturation flow rate by 3 percent when compared to a 12-ft. lane, while a 10-ft. wide lane reduces the saturation flow rate by about 7 percent. Consider other means of capacity enhancement such as access management or signal synchronization before using wider lanes.
- If a network evaluation determines that sufficient capacity exists to accommodate corridor- or area-wide 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.

- Consider converting two parallel streets into a pair of one-way streets (couplet) to increase capacity before widening thoroughfares. While 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, etc.

Recommended Practice

Select lane widths between 10 and 12 ft. based on the following four key considerations:

- Design speed—lanes 10-ft. wide may be considered on collector and arterial streets with design speeds of 30 mph or less. Use the wider end of the range (11 to 12 ft.) at design speeds of 35 to 40 mph.
- Design vehicle—vehicles such as transit buses or large tractor-trailers require wider lanes, particular in combination with higher design speeds if they frequently use the thoroughfare. Consider wider lanes only if appropriate for the frequency of the design vehicle.
- Right-of-way—balance the provision of the required 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 design speed justify, provide a wider travel lane to provide better separation between lanes (Figure 9.5).

The recommended range of lane widths for arterials (10 to 12 ft.) and for collectors (10 to 11 ft.) is consistent with AASHTO guidelines. An 11 ft. lane is used extensively on all classifications of major urban thoroughfares. AASHTO highlights benefits of narrower 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 economy of construction. The recommended travel lane widths 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).

Medians

Background and Purpose

Related Thoroughfare Design Elements

- *Access management*
- *Pedestrian refuge islands*
- *Intersection layout*
- *Lane width*

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. In CSS 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.

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, render 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 decrease in available roadside widths.

Figure 9.5: Bicycle lane on a residential collector street in California. Source: Kimley-Horn and Associates Inc.

Operational and safety benefits of medians include providing storage for turning vehicles, enforcement of turn restrictions, reduction of conflicts, snow storage, reduction of certain types of crashes such as head-on collisions and provision of space for vehicles crossing the thoroughfare at unsignalized intersections. With some innovation in design, curbed medians can provide bio-filtration swales to retain and improve the quality of stormwater runoff.

General Principles and Considerations

General principles and design considerations regarding medians include the following.

- 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.
- Avoid changes in median width along the corridor if possible. A uniform median width minimizes the need for shifting tapers in the through lanes.
- Use an appropriate design vehicle for left- and U-turns when designing median width.
- Avoid providing overly wide medians at the expense of unreasonably narrowing the roadside. In urban contexts, roadsides 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, in urban areas the width of medians at intersections should only be as wide as necessary to provide the desired function (accommodation of longitudinal left turns, pedestrian refuge, etc.), otherwise the intersection loses operation efficiency and vehicles crossing the median may use the width inappropriately (side-by-side queuing, angled stopping, etc.).
- On multi-lane thoroughfares, medians are important to aid pedestrians in their crossings. Even a narrow median of 6 to 8 ft. 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 pavers, colored stamped concrete, stone, or other contrasting material 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 ft. of an intersection approach that frequently experiences long queues). Mountable medians can be super-reinforced with grass-crete pavers or concrete with added rebar.
- Narrow medians (4 ft. or less) should only be used to restrict turning movements, separate opposing directions of traffic, and to provide space for traffic control devices (Figure 9.6A).
- 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.
- Landscaping on medians should be designed in a manner that does not obstruct sight-distance triangles. In general, plants should be trimmed to not more than a 2.5-ft. maximum height, while trees should have no branches in sight lines lower than 8 ft. from the ground. Small caliper trees (less than 4 in.), properly pruned, may be considered on medians adjacent to turn lanes up to 50 ft. back from the median nose. A 6-ft. wide median is adequate to support the healthy growth of small caliper trees (less than 4 in.), but a minimum 10-ft. wide median should be used for larger caliper trees.

Recommended Practice

Table 9.1 presents the recommended practice for median widths for various functions within low speed major thoroughfares (35 mph or less). Flexibility in median width design revolves around the median's function, appurtenances to be accommodated in the median and available right-of-way. The practitioner needs to consider the trade offs between the provision of a median and other design elements, particularly in constrained rights-of-way. 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 there is no need to provide an offset between the median curb face and the travel lane;
- Design the median nose using AASHTO guidelines ensuring proper end treatments to guide vehicles away from the median and pedestrian refuges;
- Design median turn lanes, tapers and transitions using AASHTO guidelines for intersection design; and
- At intersection crossings, 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.

- Small caliper trees can be healthy in medians that are at least 6-ft. wide, as long as a critical root area is provided. A 10-ft. wide median is recommended for larger trees. Consult an urban forester for guidance on health requirements for trees in medians. Consider the roadside safety issues of large caliper trees. AASHTO recommends avoiding trees in medians where speeds are greater than 45 mph and recommends special barriers designed to redirect vehicles if planting trees with diameters greater than 4 in. at maturity.

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

- Maintain a horizontal offset (minimum of 18 in.) between the trunk and median curb face and prune to maintain sight distance (Figure 9.7). It is important to recognize that this offset does not constitute a clear zone.
- Except for small caliper trees (less than 4 in.), trees in medians should be no closer than 50 ft. from the ends of medians to maintain sight distance. Trees should not reduce sight distance below the recommendations of AASHTO based on design speed. Trees should always be located and maintained so that the motorists' clear vision of any highway signs or signals will be assured at all times, retaining a vertical clear zone between 2.5 ft. (or 3 ft. from pavement surface) and 8 ft. from top of curb.
- Should the community desire a continuous canopy of trees in the median, space trees between 15 and 30 ft. on-center, depending upon species.
- Branches that extend beyond the curb into the travel lane should be pruned to a minimum height of 13 ft. above the pavement.
- Median trees should be an appropriate distance from light standards, signal standards, traffic control signs and other traffic control devices and utilities. Evaluate line of sight and potential interference with lighting on a case-by-case basis to determine the appropriate spacing. 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 soils, 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. Consider use of underdraining when needed for soil conditions.

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 space for turning vehicles and utilities in the center of the street. In CSS, 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 provide pedestrian refuge on wider street crossings (Figure 9.8).

Landscaping and trees in medians, typically discouraged in conventional street design, are strongly encouraged in context sensitive design not only for aesthetics, but for shade and stormwater interception. The use of medians for pedestrian refuge is recommended to reduce the pedestrian barriers created by wide urban arterials and 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.

Bicycle Lanes

Background and Purpose

Related Thoroughfare Design Elements

- *Lane width*
- *Bicycle lane treatment at intersections*
- *On-street parking*

Bicycle travel is an important element of 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 encompass a system of interconnected routes, paths and on-street bicycle lanes that provide for safe and efficent bicycle travel. This report focuses only on the provision of bicycle lanes on major thoroughfares. Refer to AASHTO's *Guide for the Development of Bicycle Facilities* for planning and design guidance for all types of bicycle facilities.

Figure 9.7 Example of trees in median with inadequate horizontal clearance. Median width should be designed to accommodate an 18-in. clearance when trees are mature. Source: Kimley-Horn and Associates Inc.

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

Thoroughfare Type	Minimum Width	Recommended Width
Median for access control		
Arterial boulevards and avenues Collector avenues and streets	4 ft.	6 ft. [1]
Median for pedestrian refuge		
Arterial boulevards and avenues Collector avenues and streets	6 ft.	8 ft.
Median for street trees and lighting		
Arterial boulevards and avenues Collector avenues and streets	6 ft. [2]	10 ft. [3]
Median for single left-turn lane		
Collector avenues and streets	10 ft. [4]	14 ft.
Arterial boulevards and avenues	12 ft.	16-18 ft.
Median for dual left turn lane		
Arterial boulevards and avenues	20 ft.	22 ft.

Table notes:
[1] A 6-foot wide median is the minimum width for provision of a pedestrian refuge.
[2] Six ft. (measured between curb faces) is generally considered a minimum width for proper growth of small caliper trees (less than 4 in.). A wider 10-foot median is recommended for larger trees.
[3] 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, angle stopping, etc.
[4] A 10-foot wide median allows for a striped left-turn lane (9 to 10 ft. wide) without a median nose.

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 urban thoroughfares is typically 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 lanes cannot be provided, then the safety of both the bicyclist and drivers are compromised (Figure 9.9).

General Principles and Considerations

General principles and considerations regarding bicycle lanes include the following.

- Implementation of bicycle lanes can meet many community objectives, including accessibility, connectivity between destinations, youth mobility, system capacity, etc.
- Bicycle lanes on major urban thoroughfares should be based upon a number of factors, including:
  - Interconnectivity between other bicycle facilities and direct connections between major origins and destinations including transit access points;
  - Ability to provide a continuous lane and overcome barriers such as topography, rivers, railroads, freeways, etc.; and
  - Availability of parallel bicycle facilities does not eliminate the need to have a bicycle lane on major thoroughfares. Bicyclists need to access properties along major corridors and they often benefit from traffic signals and other controls found on major urban thoroughfares.
- 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 have different needs, are as follows:
  - *Group A:* Advanced or experienced bicyclists—Require facilities for directness and speed. These riders are more comfortable riding in traffic and shared lanes, but want to avoid obstacles and delay.
  - *Group B:* Basic or casual bicyclists—Require comfortable and direct routes preferably on lower speed and lower volume thoroughfares. This group of riders prefers separated and delineated bicycle facilities.
  - *Group C:* Children—Require supervision by adults and typically only travel on very low volume and low speed residential streets. However, as children mature, many of their trip needs bring them to major urban thoroughfares, especially in poorly-connected suburban street systems. For this reason it is important to anticipate their presence on urban thoroughfares.
- Bicycle lanes on context-based urban thoroughfares should at least meet the needs of Group B bicyclists.
- For signs and pavement markings for bicycle lanes, refer to Part 9 of the MUTCD (FHWA 2003).
- When considering additional operating space in urban areas, it is a constant challenge to balance the 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 eliminating non-crucial 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 (Figure 9.10).

Figure 9.8 A wide median in Mountain View, CA provides attractive landscaping, benches, and other amenities. Source: Kimley-Horn and Associates Inc.

Figure 9.9 Bicycle lane adjacent to parking. Source: Kimley-Horn and Associates Inc.

Figure 9.10 A four to three lane conversion to accommodate bicycle lanes, City of San Leandro, CA. Source: City of San Leandro.

- Bicyclists require smooth surfaces for safety and comfort. Not only do rough surfaces or the accumulation of debris make for a bumpy ride, these surfaces can also cause a bicyclist to lose control and veer into traffic. Utility covers should be level with the pavement for the same reasons.
- The pavement of a wide outside lane or a bicycle lane should be free of large cracks and potholes and have smooth longitudinal joints, particularly between the pavement and gutter pan. Regular maintenance and street sweeping requires more attention than usual on bicycle routes.
- While it is preferable to remove obstructions in any bikeway, if not practical, use the typical pavement markings recommended in Part 9 of the MUTCD for obstructions such as posts, grates, piers, etc.
- Provide curb inlets for drainage whenever possible or use bicycle-safe inlet grates.
- A wider bicycle lane is more beneficial on uphill steep grades.
- Bicycle lanes at railroad crossings require special design treatments. Refer to the design sources at the end of this chapter for further detail.
- See Chapter 10 (Bicycle Lane Treatment at Intersections) for bicycle facilities at intersections.
- Designated bicycle facilities adjacent to 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.

Figure 9.11 Reverse (back-in) angled parking improves driver visibility of bicyclists. Source: Dan Burden, Walkable Communities Inc.

- 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 is thought to improve driver visibility of bicyclists (Figure 9.11).
- Avoid providing bicycle lanes between on-street parking and curbs or other roadside barriers unless the bicycle lane is at least 12-ft. wide because bicyclists can become trapped and might collide with opening doors of vehicles.
- Removing parking from one side of the street and narrowing excessively wide lanes might provide enough width for bicycle lanes. Converting excessively wide travel lanes (16-plus ft.) to 10 or 11 ft. will create enough space for bicycle lanes.
- 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, creating the potential for serious injury to pedestrians. Bicyclists might collide with numerous obstacles on sidewalks including street furniture, sign posts, etc. Additionally, drivers do not expect bicyclists on sidewalks, creating conflicts at intersections and driveways. Therefore it is important to provide convenient alternatives that will limit the attraction of sidewalk riding. While on-street facilities designed to the guidelines above are preferred, alternative routes on parallel streets may be a better choice in some situations. It might also be possible to provide a separated off-street multi-use path.

Once the decision has been made to provide bicycle facilities on a major urban thoroughfare, the street designer has less flexibility in the width of such facilities than with other design elements such as a sidewalk or median. This is not to say there are not innovative design treatments that can be applied to bicycle facilities. The ITE informational report *Innovative Bicycle Treatments* (2002) summarizes numerous innovations for bicycle facilities on thoroughfares, intersection lane treatments, use of technological advancements at intersections and signing and marking. Some of the innovations to consider include:

- Bicycle boulevards;
- Contra-flow bicycle lanes;
- Unique bicycle lane markings and coloration for visibility and separation;
- Specialized markings and signing for route identification;
- Channelized bicycle lanes at intersections; and
- Innovative bicycle detection and actuation devices.

Recommended Practice

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

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 use and typically will supplement the off-street parking supply. On-street parking provides the following benefits:

Related Thoroughfare Design Elements:

- *Lane width*
- *Curb extensions*
- *Bicycle facilities*

- 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;
- Slows traffic, making pedestrian crossing safer;
- Enables drivers and their passengers to become pedestrians conveniently and safely;
- 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;
- Increases local economic activity by increasing the visibility of storefronts and signs to motorists parking on street;
- Supports local businesses by reducing development costs for small business by decreasing on-site parking needs;
- Provides space for on-street loading and unloading of trucks, increasing the economic activity of the street and supporting commercial retail uses; and

Table 9.2 Recommended Practice for Bicycle Lanes on Major Urban Thoroughfares

	Minimum Width	Recommended Width
Bicycle lane width – combined with on-street parking lane		
All thoroughfare types	12 Ft.	13 Ft.
Bicycle lane width – no on-street parking		
All thoroughfare types	5 Ft. [1]	6 Ft.

Table notes:

[1] Requires a minimum 4-foot width outside of gutter pan. If no gutter pan is present, the minimum width is 4 ft.

Figure 9.12 Angled parking on a retail-oriented main street in Hayward, CA. Source: Kimley-Horn and Associates Inc.

- Provides an indication to the motorist that desired operating speeds are reduced and that he/she is entering a low or moderate travel speed area.

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 urban thoroughfare, needs of the adjacent land uses, applicable local policies and plans for parking management.
- On-street parking should be primarily parallel parking on urban arterial boulevards and avenues. Angled parking may be used on low-speed and low-volume commercially-oriented collector avenues and streets, primarily those serving as main streets (Figure 9.12). On-street parking should be prohibited on major streets with speeds greater than 35 mph due to potential conflicts associated with maneuvering in and out of spaces.
- Orientation of parking (parallel or angled) should be determined according to the thoroughfare's desired volume and speed, context and ability of the right-of-way width to accommodate the desired elements.
- Width of the parking space is dependent on the context zone and thoroughfare type, and the anticipated frequency of parking turnover.
- Use metered parking to enforce parking time limits that provide reasonable short-term parking for retail customers and visitors while discouraging long-term parking. Avoid time limits of 30 minutes or less in commercial retail areas, except where very short-term, high-turnover parking is desired at convenience retail stores, dry cleaners, etc. Avoid time limits longer than 2 hours where turnover of parking spaces is important to support nearby retail business.
- In developing areas 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.

- 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, the MUTCD (Figure 3B–17, referenced in Section 3B.18) shows an example of a parallel parking configuration that consists of a repeated sequence of two parking spaces at 20 ft. by 8 ft., with an 8 ft. maneuvering area between the spaces. This configuration reduces the total number of parking spaces that can be provided within a given length, but minimizes interruption of traffic flow by allowing vehicles to drive forward into a parallel parking space. It requires backing maneuvers in the 8 ft. no-parking area without blocking the adjacent moving traffic lane.

Recommended Practice

As shown in Table 9.3, the preferred width of a parallel on-street parking lane is 8 ft. on commercial boulevards, avenues and streets or where there is an anticipated high turnover of parking, and 7-ft. wide on residential boulevards, avenues and streets. These dimensions are inclusive of the gutter pan and applicable to all context zones (C-3 through C-6).

On low-volume, low-speed avenues and streets in commercial main streets areas, where sufficient curb-to-curb width is available, angled parking may be appropriate. Angled parking should have the dimensions shown in Table 9.4 for a variety of different angles. Angled parking can create sight distance problems associated with cars (especially those parked next to vans and recreational vehicles) backing out of parking spaces. The use of reverse (back-in) angled parking in some cities has overcome these sight distance concerns and is considered safer for bicyclists traveling adjacent to angled parking (Figure 9.13).

Additional Guidelines

Additional guidelines regarding on-street parking include:

- Where traffic capacity needs to be balanced with on-street parking, consider using the curb lane for parking during off-peak periods and peak periods. It is important to consider enforcement requirements of this strategy.
- Angled parking should be allowed in C-4 and C-5 context zones where operating speeds are 30 mph or less, and where the community finds the delay produced by parking maneuvers acceptable.
- Provide a minimum 1.5-ft. 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 20 ft. of either side of fire hydrants (or per local code), at least 20 to 50 ft. from midblock crosswalks and at least 20 ft. from the curb return of intersections (30 ft. from an approach to a signalized

Table 9.3 Recommended Parallel Parking Lane Widths

Thoroughfare Type in C-3 through C-6 Context Zones	
Parallel parking lane width (commercial and residential areas)	
Arterial boulevard (commercial)	8 Ft.
Arterial boulevard (residential)	7 Ft.
Parallel parking lane width (residential areas)	
Arterial avenue	7 Ft.
Collector avenue and street	7 Ft.
Parallel parking lane width (commercial areas)	
Arterial avenue	8 Ft.
Collector avenue and street	8 Ft.

Figure 9.13 Reverse (back-in) angled parking improves driver visibility. Source: Dan Burden, Walkable Communities Inc.

Table 9.4 Minimum Dimensions for Angled On-Street Parking

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

Typical design vehicle dimensions: 6 ft., 7 in. by 17 ft., 0 in. Use 9.0-foot wide stall in commercial areas with moderate to high parking turnover.
Source: Adapted from *Dimensions of Parking*, 4th Edition, Urban Land Institute

intersection) or as required to maintain a proper sight distance triangle depending on speed and roadway geometrics (see Chapter 7 section on sight triangles). Curb extensions can be used to reduce this distance while still maintaining sight triangles. See the Chapter 10 section on curb extensions.

- At bus stops, intersections and various midblock locations, extend curbs by 6 ft. 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 roadside due to the longer overhang at the rear of most vehicles. This extra width can be compensated by the narrow travel lane needed adjacent to parking for maneuvering.

Justification

The recommendations in this guidance are based on the same 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."

Transition Design

Background and Purpose

Transitions refer to a change in the width or speed of a thoroughfare. 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.

Recommended Practice

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

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

Where L equals the length of the transition taper (ft.), W equals the width of the lateral shift or offset (ft.) and S equals the 85th percentile operating speed in mph or posted speed in mph (whichever is higher), or the design speed in new construction projects (Figure 9.14).

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 10:1 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 ft. for single turn lanes and 150 ft. for dual turn lanes.

Midblock Crossings

Background and Purpose

Related Thoroughfare Design Elements:

- *On-street parking*
- *Pedestrian refuge islands*

Midblock crossings provide convenient locations for pedestrians to cross major urban thoroughfares in areas with infrequent intersection crossings or where the nearest intersection crossing creates substantial

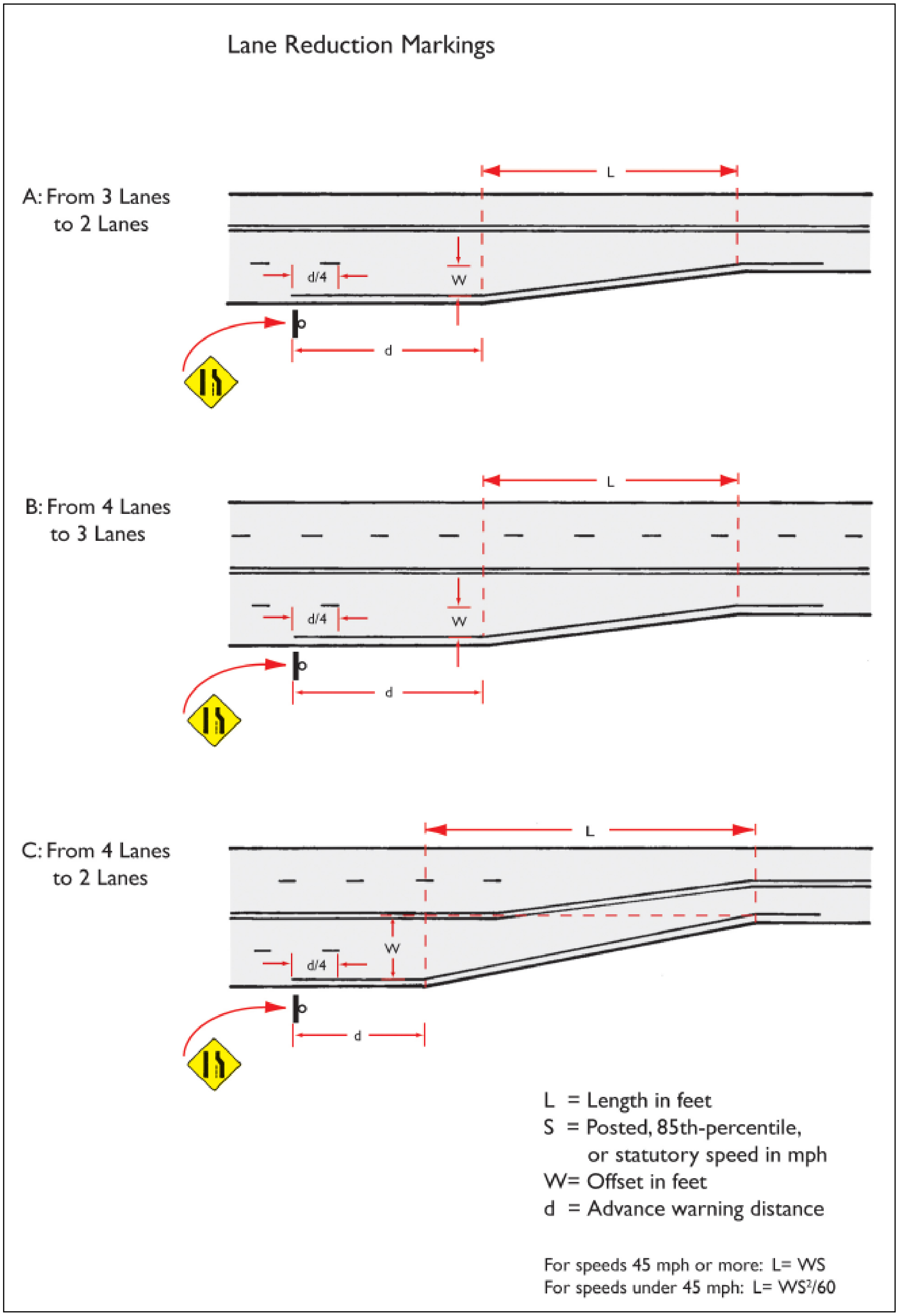

Figure 9.14 Typical transition design and markings. Source: Community, Design + Architecture, adapted from the *Manual of Uniform Traffic Control Devices* (FHWA 2003).

Figure 9.15 Midblock crosswalks provide opportunities to cross streets with long distances between intersection crossings. Source: Dan Burden, Walkable Communities Inc.

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 and warning signs warn drivers of potential pedestrians, protect crossing pedestrians, and encourage walking in high-activity areas.

General Principles and Considerations

General principles and considerations regarding midblock crossings include:

- Installing midblock crosswalks can: (1) help channel crossing pedestrians to the safest midblock location, (2) provide visual cues to allow approaching motorists to anticipate pedestrian activity and unexpected stopped vehicles and (3) 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).
- Appropriate intersection sight distance is a critical part of the design of midblock crossings.
- 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 detec-

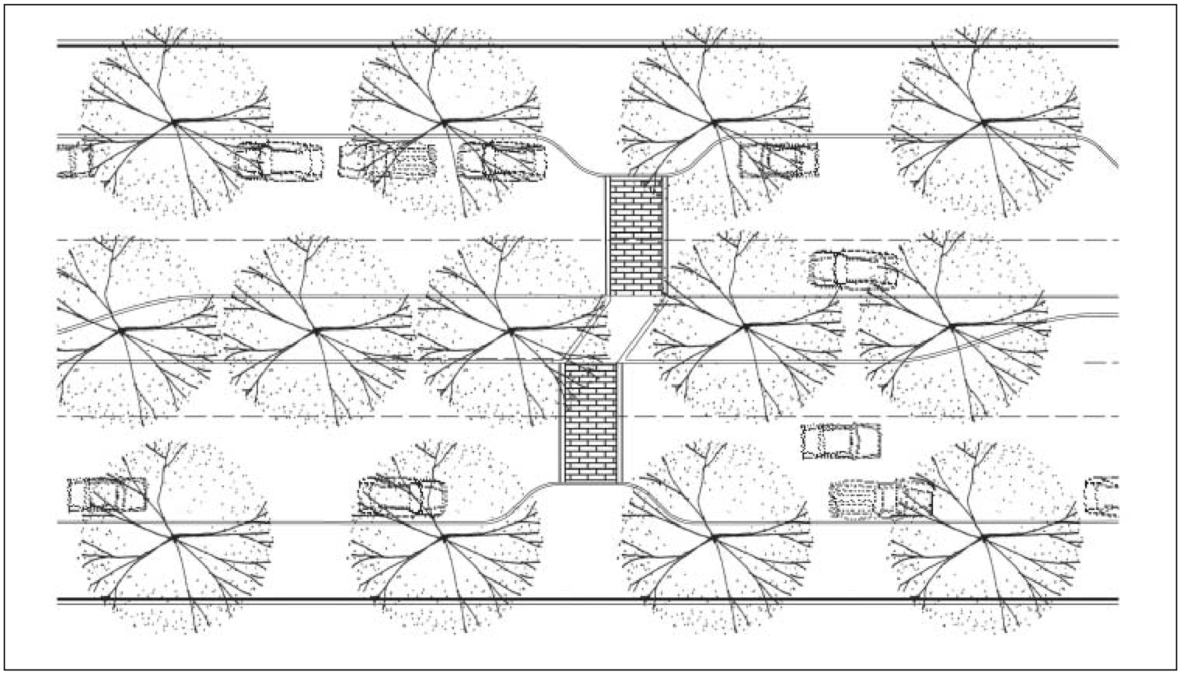

Figure 9.16 Mid-block crossings with a "Z" configuration force pedestrians crossing the median to look towards oncoming traffic. Avoid street trees that interfere with visibility. Source: Community, Design + Architecture.

tor might be sufficient. The use of a tactile strip across the width of the sidewalk leading to the crosswalk should be considered so that pedestrians are alerted to the presence of the crossing.

- For a crosswalk to exist at a midblock location, it must be a marked crosswalk. Therefore, this section assumes that the midblock crosswalk is marked, either by two transverse lines that are separated by a space of 6 to 10 ft. or preferably by diagonal or longitudinal lines, with or without the two transverse lines.
- When an unsignalized midblock crosswalk is installed, warning signs should be placed for both directions of traffic. A pedestrian warning sign with an AHEAD 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.

Recommended Practice

The recommended practice for midblock crossings on major urban thoroughfares is shown in Table 9.5. Examples are provided in Figures 9.16 through 9.19.

Justification

Street life and activity entering and leaving buildings is usually 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.

Table 9.5 Recommended Practice for Midblock Crossings

General
• 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 ft., or so that crosswalks are located no greater than 200 to 300 ft. apart in high pedestrian volume locations, and meets 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 ft. 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.
Criteria
• Streets with an average daily traffic volume of 12,000 vehicles per day or less.
• Multi-lane streets carrying less than 15,000 ADT if a raised pedestrian refuge median is provided.
• Prevailing 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.
Recommendations
• 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 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.
• On streets with continuous two-way left-turn lanes, provide a raised median pedestrian refuge with a minimum refuge length of 20 ft. and a minimum width of 6 ft.
• Provide overhead safety lighting on 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 ft.
• 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 Figure 9.16). Provide an at-grade channel in median at a 45-degree angle toward advancing traffic to encourage pedestrians to look for oncoming traffic.
Other Considerations
• 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 Figure 9.17). Consider use of overhead flashing beacons.

Adapted from:

Safety Effects of Marked versus Unmarked Crosswalks at Uncontrolled Locations, FHWA, 2002

Manual of Uniform Traffic Control Devices, FHWA, 2003 Edition

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

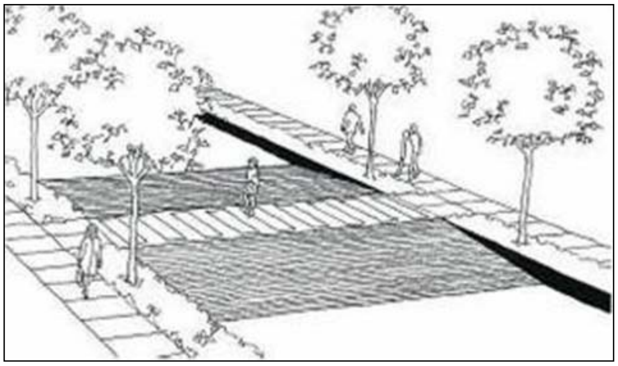

Figure 9.17 The raised roadway crosswalk concept combines mid-block crosswalks with traffic calming devices. Source: Kimley-Horn and Associates Inc.

Figure 9.18 Mid-block crossing with pedestrian detection and in-pavement lights. Source: Kimley-Horn and Associates Inc.

Figure 9.19 Example of a signalized mid-block crossing. Source: Dan Burden, Walkable Communities Inc.

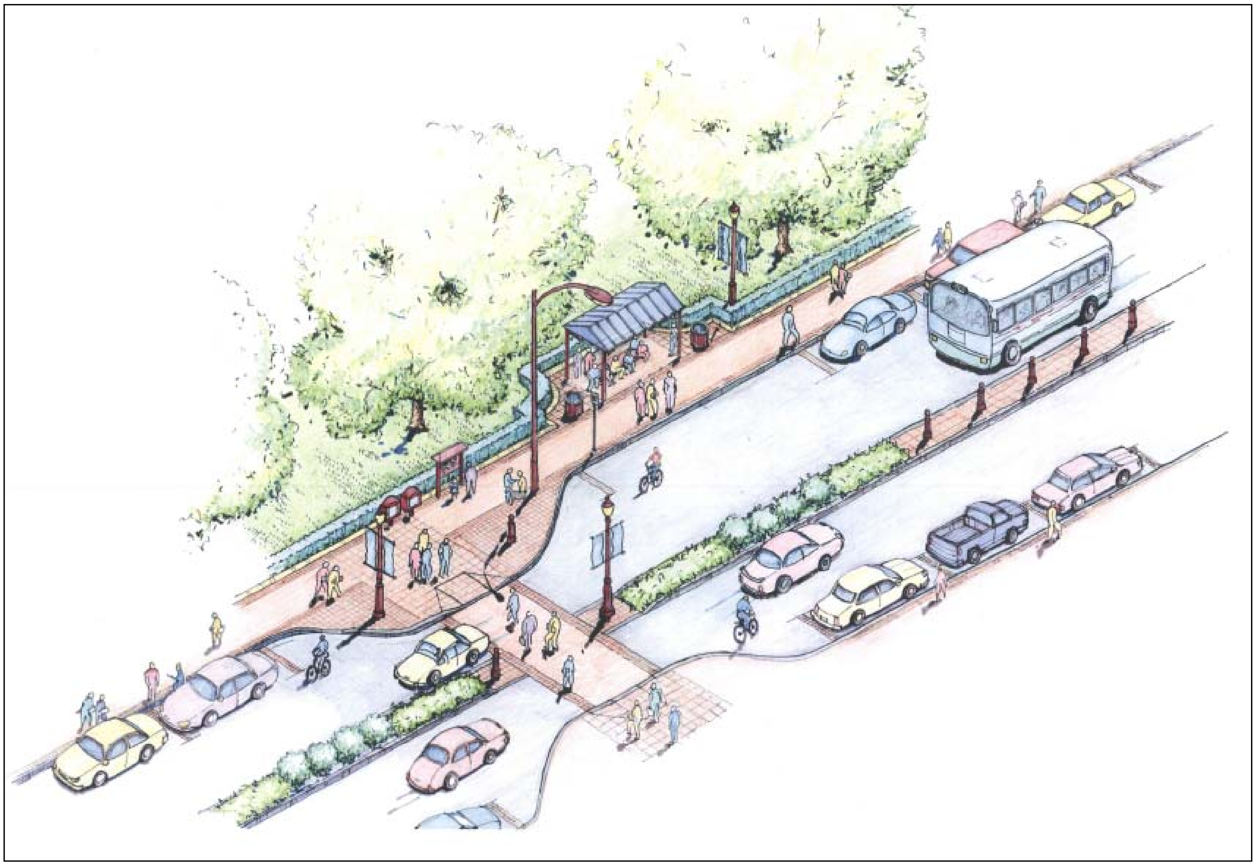

Figure 9.20 Refuge islands can be used at mid-block locations, channelized right turns, or at long intersection crossings. Source: Kimley-Horn and Associates Inc.

Pedestrian Refuge Islands

Background and Purpose

> **Related Thoroughfare Design Elements**
> - *Lane width*
> - *Right-turn channelization*
> - *Modern roundabouts*
> - *Medians*

Refuge islands provide pedestrians and bicyclists a refuge area within intersection and midblock crossings. Refuge islands provide a location for pedestrians or bicyclists to stop partially through their crossing. Refuge islands also break up crosswalks at complex multi-lane and multi-legged intersections into shorter and easier portions for pedestrians to cross.

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:

1. Unsignalized crossing of a high-volume thoroughfare of four or more lanes, or high volumes of roadway traffic and/or speeds create unacceptable conditions for pedestrians and crossing bicyclists; or
2. The crossing will be used by a number of people who walk slower than 3.5 ft. per second, such as older persons, schoolchildren, persons with disabilities, etc., and their crossing cannot be completed in the available crossing time.

Recommended Practice

Recommended practices regarding pedestrian refuge islands include:

- Islands should be sufficiently large to command attention. For pedestrian refuge, islands should have an area at least 120 sq. ft. with minimum dimensions of 6-ft. wide and 20-ft. long.
- Refuge islands are generally good practice in urban areas to reduce pedestrian exposure to traffic. Specifically, refuge islands may be considered on major urban thoroughfares where the pedestrian crossing distance is more than 60-ft. long, but can be used at intersections with shorter crossing distances where a need exists.
- Medians expected to be used as pedestrian refuges should be surrounded by vertical curbs to delineate the pedestrian refuge from the surrounding roadway.
- Refuge islands should be at least 6- to 8-ft. wide when they will be used by bicyclists, or at least 10-ft. wide for bicycles with trailers.
- Pedestrians and bicyclists should have a clear path through the island at street grade and should not be obstructed by poles, sign posts, utility boxes, curbs, etc.

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. Medians also 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.

Midblock Bus Stops

Background and Purpose

Related Thoroughfare Design Elements

- *Lane Width*
- *Midblock crossings*

There are more than 9 billion trips made by transit in the United States each year, with nearly 5.3 billion trips made by bus (National Transit Database 2002). Buses are the most common form of mass transit in the country, and the majority of bus travel occurs on major urban thoroughfares in metropolitan areas. Since major 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 affects 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 major urban thoroughfares compiled from the design guidelines of transit agencies. Location-specific guidance should be obtained from local transit agencies.

General Principles and Considerations

Fundamentals of Bus Stop Placement

Fundamentals of bus stop placement include:

- Bus stops may be placed at intersections (nearside or farside, see Chapter 10 section on intersection bus stops), or midblock locations. Bus routing, turning movements, obstructions in the furnishings zone of the roadside, location of transit patron guideways and space available for seating and shelters are among the factors that affect bus stop locations.
- Bus stops should be based on population density and/or major passenger generators.

- Bus stop locations should be clearly marked by a sign with appropriate vertical and horizontal clearance.
- Bus stop locations should have adequate parking restrictions to allow buses to pull into and out of the bus zone unimpeded.
- Pedestrians must be able to safely access bus stops and cross the street to get to them.
- Bus stop boarding areas should have a level and firm surface to accommodate boarding and alighting of passengers with special needs.
- Pathways leading to and from bus stop areas should be level with firm surfaces to accommodate passengers with special needs.
- Bus stops should be located in places with minimal above-grade obstacles (such as guy wires, power poles, utility boxes, etc.).
- 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 farside or midblock stop is generally preferred (see Chapter 10 section on intersection bus stops).
- When locating a bus stop in the vicinity of a driveway, issues related to sight distance, blocking of driveway access and potential conflicts between buses and other traffic need to be considered.

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. General elements to consider when determining bus stop placement include the following:

- Proximity to major trip generators;
- Presence of sidewalks, marked crosswalks and curb ramps;
- Nearby enhanced crossings, either midblock or at an intersection;
- Connection to a nearby pedestrian circulation system;
- Access for people with disabilities;
- Convenient 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;
- Passenger protection from passing traffic;
- Width of sidewalks;
- Width of furnishings zone as well as locations of any obstructions;
- Pedestrian activity through intersections;
- 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;
- 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 re-entering traffic stream; and
- Proximity to rail crossings.

- The preferred location for bus stops is the nearside or farside of an intersection (see the section on intersection bus stops in Chapter 10). This location provides the best pedestrian accessibility from both sides of the street and the cross streets, and provides connection to intersecting bus routes.

- While not preferred, bus stops may also be placed at a midblock location on long blocks 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 9.6 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 farside or midblock stop is generally preferred (see section on intersection bus stops in Chapter 10).
- When locating a bus stop in the vicinity of a driveway, issues related to sight distance, blocking of driveway access and potential conflicts between buses and other traffic need to be considered.

Spacing of Bus Stops

Below are general bus stop spacing guidelines encompassing C-3 to C-6 context zones.

1. Provide bus stops at major generators, such as:
   - Employment centers;
   - High density residential areas;
   - Retail centers;
   - Education centers; and
   - Major medical facilities.
2. Provide bus stops at transfer points.
3. Provide intermediate stops based on the distance a person has to travel to a bus stop with spacing as follows:
   - Urban center (C-5) and urban core (C-6): Maximum 500 ft.
   - General urban (C-4) with more than 5,000 persons per square mile: 750 to 900 ft.
   - Suburban (C-3) with 3,500 to 5,000 persons per square mile: 900 to 1,300 ft.

Overall urban transit bus dimensions

Overall height: 10 ft., 6 in.
Overall width: 10 ft., 4 in. (including mirrors)
Overall length (large bus): 40 ft.
Overall length (articulated bus): 60 ft.

Wheelchair lift dimensions

Width: 4 ft.
Extension (from edge of bus): 4 ft., 6 in.
Turning radii
40-foot coach:
Inner rear wheel – 25.5 ft.
Outer front corner – 47.8 ft.
Centerline radius – 40.8 ft.

60-foot articulated:
Inner rear wheel – 21.3 ft.
Outer front corner – 44.3 ft.
Centerline radius – 35.5 ft.

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

Table 9.6 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.	• Might encourage uncontrolled midblock pedestrian crossings .
• Might result in less interference with traffic flow.	

Figure 9.21 Parking restrictions at a bus stop using a red curb. Source: Kimley-Horn and Associates Inc.

Recommended Practice

Design Vehicle

On urban thoroughfares with transit routes, the bus is one of the design vehicles used in design. Important dimensions of standard and articulated buses are shown in the sidebar including the turning radii requirements for a 40-ft. coach and 60-ft. articulated bus. The minimum interior radius is 21 to 26 ft. and the minimum outer radius is 44 to 48 ft. 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 under special circumstances such as:

- Bus speeds greater than 10 miles per hour;
- Sight distance limitations;
- Bicycle racks on front of bus (which adds 3 ft. to the length of the bus);
- Changes in pavement grade; 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 9.21). The lack of parking restrictions impacts bus operations, traffic movement, safe sight distance and passenger access. Considerations include:

- Bus may have to double park when at a stop, interfering with traffic movements;

Figure 9.22 A typical bus turnout on an arterial avenue. Source: Kimley-Horn and Associates Inc.

- 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 60-ft. long bus stop, no-parking zones before and after the bus stop allows buses to pull into the bus stop and re-enter traffic. Use the following dimensions for no- parking zones at midblock bus stops:

- Before stop: 40 ft. min. (60 ft. if bus turns from cross street).
- After stop: 40 ft. min.

Bus Turnouts

Bus turnouts (a recessed curb area located adjacent to the traffic lane as shown in Figure 9.22) are desirable only under selected conditions because of the delay created when the bus must re-enter traffic.

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;
- Cearly 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 re-enter traffic, increasing bus delay and average travel time for buses; and
- Use additional space and might require right-of-way acquisition.

Bus turnouts are desirable where traffic speeds are 40 mph or greater and one or more of the following conditions exist:

- Peak period boarding average exceeds 20 boardings per hour;
- Average peak period dwell time exceeds 30 seconds per bus;
- A high frequency of accidents involving buses and/or pedestrians occurred within the past year; and
- When traffic in the curb lane exceeds 250 vehicles during the peak hour and the curb lane is less than 20-ft. wide or when bus volumes exceed 10 or more per peak hour.

Bus Turnout Design

On high-speed suburban or rural arterial thoroughfares, the design of a midblock bus turnout would typically include an entrance taper, deceleration lane, stopping area, acceleration lane and exit taper resulting in a bus turnout exceeding 500 ft. in length. In urban areas, though, because of right-of-way limitations, it is usually infeasible and impractical to provide bus turnouts of this length. Typical urban bus turnouts are usually comprised of an entrance taper (40 to 60 ft.), stopping area (50 to 70 ft. per each standard and articulated bus respectively) and exit taper (40 to 60 ft.).

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, benches, etc. 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 9.23 shows a basic boarding area.

Figure 9.23 A simple passenger boarding area. Source: Kimley-Horn and Associates Inc.

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

- Front door clearance minimum 5-ft. wide along the curb by 8-ft. deep (from face of curb to back of boarding area);
- Rear door clearance minimum 8-ft. wide along the curb by 10-ft. deep (from face of curb to back of boarding area);
- Distance between front and rear boarding area is 18 ft.;
- Surface material is stable, firm and slip resistant;
- Slope does not exceed 1 ft. vertical over 20 ft. horizontal (5 percent);
- Cross slope does not exceed 1 ft. vertical over 50 ft. horizontal (2 percent);
- Clear throughway width of 48 in. maintained in boarding area; and
- Vertical clearance of 84 in. maintained in boarding area.

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

- In roadsides with a detached sidewalk (planting strip between curb and sidewalk):
  - Provide a landing area adjacent to the curb for a minimum distance of 34 ft. in length and a minimum of 8 ft. 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 stopso coach operators have a clear view of passengers and waiting passengers can see oncoming buses.
- Driveways should be kept to a minimum in and adjacent to the bus stop area.
- Street furniture more than 2.5-ft. tall should be located 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

Figure 9.24 An example layout of a shelter and other street furniture. Source: Kimley-Horn and Associates Inc.

shelter. Approved pavers (textured/decorative tiles) can be used in combination with the concrete pad to provide a pleasing aesthetic and architectural balance. Slope of pad should match slope of adjacent sidewalk and allow drainage of pad (2 percent maximum per ADA 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. All landscaping should be carefully 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 ft. 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 48 in. of horizontal clearance wherever possible for access and maintenance between components and switch boxes, mail boxes, etc. Figure 9.24 illustrates a typical layout of a shelter and other street furniture.
- There should be at least 10 ft. of clearance between a pedestrian crosswalk and the front or rear of a bus at a 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.

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 provides between 2 to 5 ft. candles of illumination within the bus stop area. If street lighting does not exist, solar lighting could be considered to enhance security at night.
- If possible, 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. Provide adequate lines of sight as passengers and law enforcement officers approach the bus stop.
- If possible, 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.
- If possible, 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 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 re-entering the traffic stream (farside bus stop placement and curb extension bus stops). The boarding area must be designed, at a minimum, to accommodate ADA 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 Snow Removal

Background and Purpose

Related Thoroughfare Design Elements

- *Roadside*
- *Bicycle facilities*
- *On-street parking*
- *Medians*

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 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 include ensuring that the most-heavily used pedestrian routes are cleared, including bus stops and curb ramps at

Figure 9.25 Snow is stored in the median of this multi-way boulevard in Albany, NY. Source: Community, Design + Architecture.

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, including Minnesota, most snowplow operations clear the entire roadway from curb to curb. After the roadway is cleared, a smaller "snow blow" (such as brushes, pick-ups and plows) are used to clear pedestrian facilities. This typically occurs one to two days after a snow event.

General Principle

Clear snow from the entire roadway from curb to curb. Snow may be stored in the roadside planting strips or within medians (Figure 9.25). After the roadway is clear, remove snow from the adjacent pedestrian facilities, including curb ramps and bus stops.

Recommended Practice

The following practices are recommended regarding snow removal.

- Roadside 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 in the winter.
- Eliminate or move objects in the furnishings zone that interfere with the ability to plow snow onto the roadside, such as large raised planters, street furniture, continuous hedges and utility and traffic control cabinets. Objects that snow can wrap around include trees, signs and light poles.
- The salting of streets for de-icing can adversely affect landscaping in the roadside. If salt is used, design the furnishings zone with hardscape or setback plantings and trees beyond the plow line.
- Care should be taken to not plow snow in a manner that blocks bicycle lanes, sidewalks, or curb ramps. A "best practice" would be to have pedestrian area cleaning equipment arrive as soon as possible after the road clearing operation.

Pavement Markings Covered by Snow

Snow removal is an important aspect of bicyclist and pedestrian safety. When the surface of the street is covered by a layer of snow, the pavement markings associated with crosswalks and bicycle lanes cannot be seen and unfamiliar drivers might not be aware that these facilities exist. In areas where snow remains on the pavement, increased use of traffic signs can be helpful.

When Snow Removal Is Not Possible

Pedestrians have similar disadvantages in keeping foot traction, therefore appropriate measures should be taken to clear the walking surfaces or at least improve traction. In some regions, snow is hard-packed, but not completely removed by emergency crews. While certainly having environmental questions, de-icing compounds (salt or sand/salt mix) can be used to improve traction for pedestrian and vehicles alike.

Justification

The U.S. Department of Justice has stated that snow removal may be required in some locations to ensure accessibility, as per the Americans with Disabilities Act. Furthermore, during and after a snowstorm, there are public safety benefits to reducing motor vehicle use through increased walking and other modes of travel.

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Chapter 10
Intersection Design Guidelines

Introduction

Multimodal intersections operate with pedestrians, bicycles, cars, buses, trucks, and in some cases, trains. The diverse uses of intersections involve a high level of activity and shared use. Intersections have the unique characteristic of accommodating the almost constant occurrence of conflicts between all modes, and most collisions on major 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, roadside, driveways, and also affects land uses (Figure 10.1). The designer should begin with an understanding of the community objectives and priorities related to design tradeoffs such as vehicular capacity, large vehicle turning requirements, conflicts and safety, pedestrian and bicycle convenience and the efficiency of public transit service. Intersections are perhaps the most sensitive operational component of thoroughfare systems.

The efficiency, safety, speed, cost of operation and capacity of the thoroughfare system depends on the design of intersections. The effective capacity of signalized intersections typically defines the at-

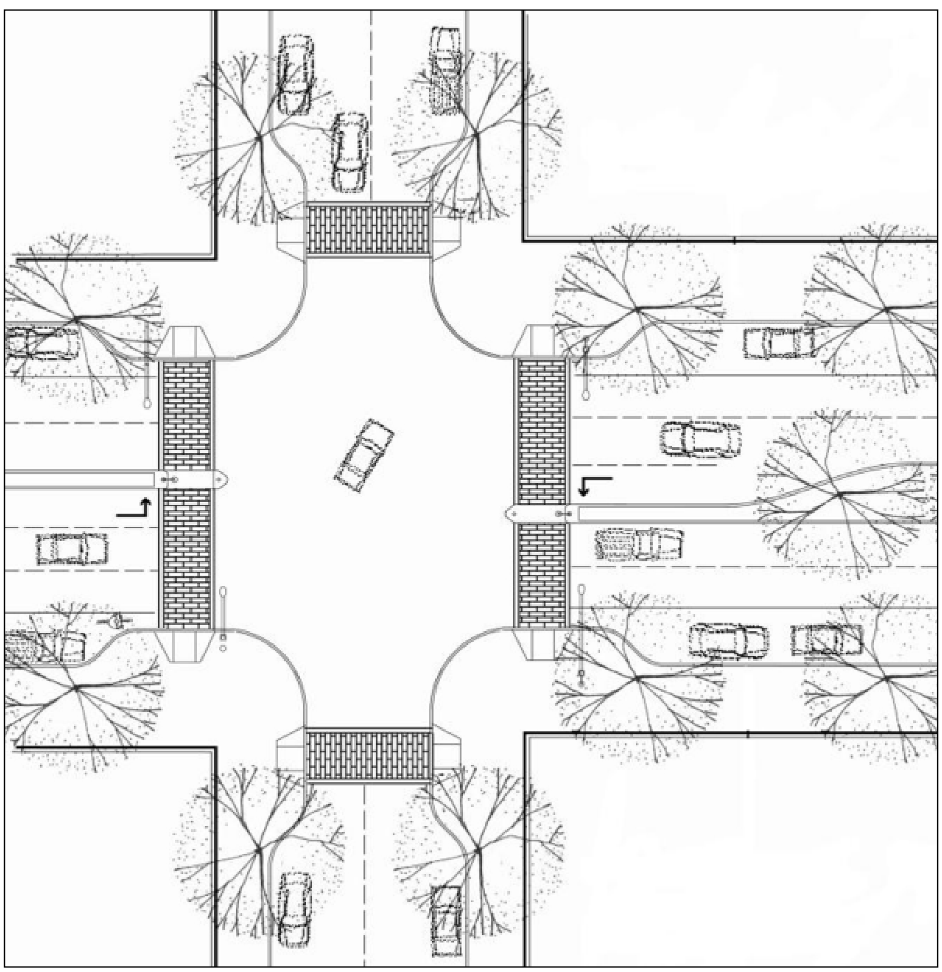

Figure 10.1 The design of intersections encompasses the intersection itself, the approaches to the intersection and can even affect adjacent land uses. Source: Community, Design + Architecture.

Figure 10.2 Intersections have the unique characteristic of accommodating the almost constant occurrence of conflicts between all modes. Source: Kimley-Horn and Associates Inc.

grade capacity of the thoroughfare. Design criteria used to create the most efficient thoroughfares are easily thwarted when the thoroughfare meets a busy intersection with lots of traffic vying for the same limited space (Figure 10.2). Add the need to safely accommodate bicyclists and pedestrians with varying degrees of mobility, and the challenge faced by designers becomes complicated.

In urban areas, intersections have a significant urban design function as well as a transportation function. 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. Drivers expect to safely pass through intersections with minimal delay and few conflicts with other vehicles. Drivers of large vehicles expect to be able to negotiate turns. Pedestrians and bicyclists expect to be able to safely and comfortably cross the street. 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, etc.). Provide crosswalks on all approaches except under cases of severe and unavoidable traffic conflicts.

Figure 10.3 Intersections are community gateways. Public art in the center island of a modern roundabout. Source: Iteris/Meyer, Mohaddes and Associates Inc.

- 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.
- Avoid elimination of any travel modes due to intersection design. Intersection widening for additional turn lanes to relieve traffic congestion should be balanced against potential impacts to pedestrians and bicyclists.
- Provide good driver and non-driver visibility through proper sight distance triangles (see the section on roadside design principles in Chapter 8) 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.
- 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.

Considerations regarding intersection design include the following.

- The preferred location for pedestrian crossings is at intersections. However, if the block length exceeds 400 ft., consider adding a mid-block crossing. The target spacing for pedestrian crossings in more intensive urban areas (C-4 to C-6) is every 200 to 300 ft.
- Intersection vehicular capacity improvements might increase pedestrian wait times at crossing locations 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 Tables 6.3 and 6.4 in Chapter 6.

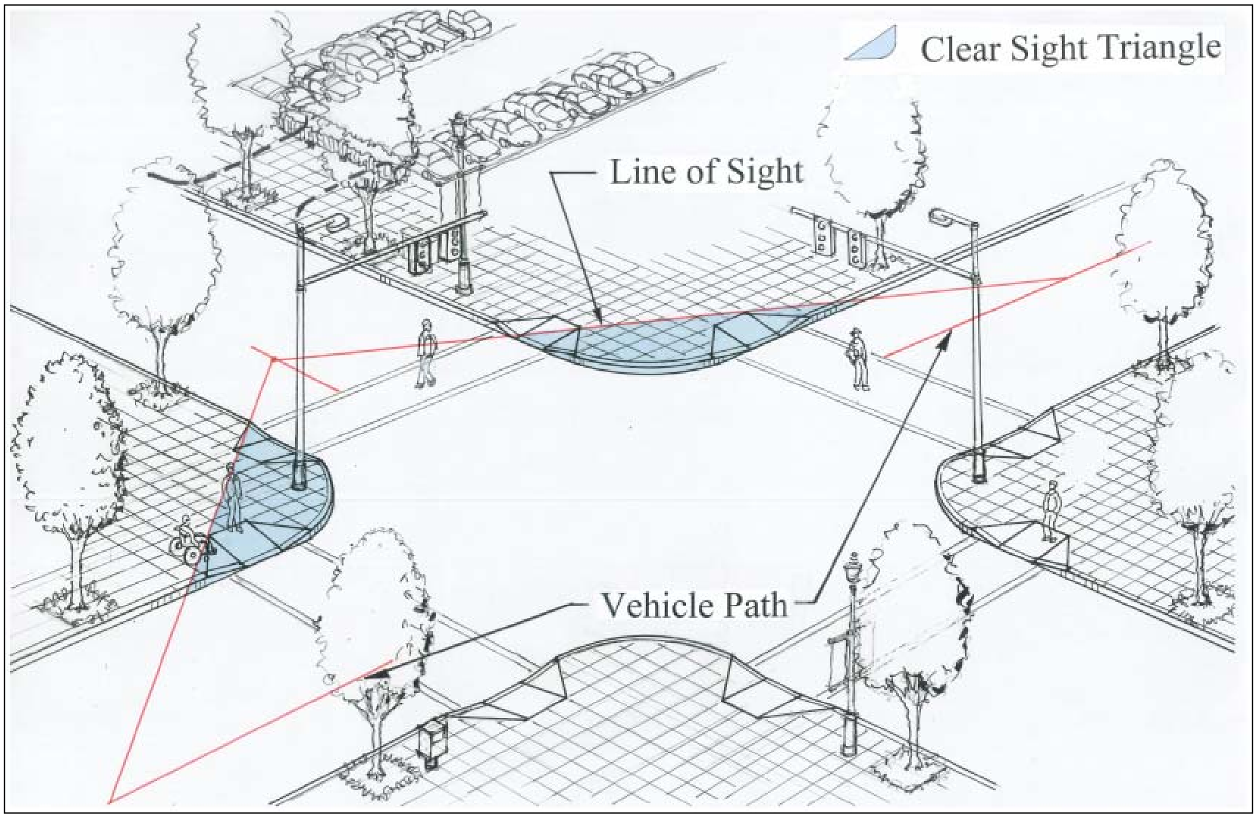

Figure 10.4 The concept of the sight distance triangle at intersections. Source: Kimley-Horn and Associates Inc.

- Facilitate shared cross-access legal agreements between adjacent properties to close and consolidate non-residential driveways within 200 ft. of 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 the approach to intersections.
- Traffic control alternatives should be evaluated for each intersection, including yield and 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 AASHTO guidelines to determine the U-turn radii needs. 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 extend through the crosswalk if a channel at street grade or a ramp is provided through the median.

Intersection Sight Distance

Specified areas along intersection approaches, called clear sight triangles (shown in Figure 10.4), 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 design 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 desirable locations for urban design features, landscaping and other roadside features such as newspaper racks, public art and seating. In CSS the practitioner works in an interdisciplinary environment and has a responsibility to balance the desire for these roadside features with the provision of adequate sight distance, ensuring safety for all users.

The determination of clear sight triangles is addressed in the AASHTO Green Book. The selection of appropriate design speeds and traffic control should consider the effect of clear sight triangles on the design of the roadside at corners and also on the location of the traveled-way edge relative to the edge of buildings at the corner. Factors that limit sight distance include physical objects that limit sight lines for motorists approaching an uncontrolled intersection. Such objects might include vehicles in adjacent lanes, parked vehicles, bridge piers and abutments, large signs, large caliper trees, tall shrubs and hedges, walls, fences and buildings. The practitioner should provide at least the minimum required clear sight triangle for the given design speed, but should strive to maximize the clear sight triangle to the extent that it is practical. If the sight triangle for the appropriate design speed 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, use small caliper street trees with branch height greater than 8 ft., or use lower appurtenances).

Sight distance triangles should be measured for each approach to an intersection regardless of the type of control, including approaches that are uncontrolled, yield-controlled, two-way stop-controlled, or signalized. Intersection sight distance provisions should be designed based on the design vehicle with the longest stopping distance that approaches at a sufficient frequency.

Managing Modal Conflict at Intersections

Strategies to minimize or avoid conflict can result in designs that favor one mode over others. For example, choosing not to mark crosswalks at urban intersections as a strategy to minimize conflicts will not stop pedestrians from crossing and will place them in greater danger. Instead, use marked crosswalks on all approaches and provide additional safety features that encourage pedestrian activity.

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

Safety aspects need to be identified in an engineering review. 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. The following three strategic decisions need to be considered when improving intersection safety design and operation:

- Eliminate vehicle and pedestrian conflicts without reducing accessibility or mobility for any of the various types of users;
- When it is not possible to eliminate all conflicts, reduce the number of conflict points to reduce the chances of collisions; 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 by more than 30 percent. Injury accidents involving left-turning vehicles can be decreased by as much as 50 percent with left-turn lanes. In walkable urban areas, turn lanes should be limited to a single left-turn lane. The practitioner needs to consider the safety benefits of adding turn lanes while minimizing pedestrian crossing distance.
- **Signals**. Increase the size of signal lenses from 8 to 12 in. 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.
- **Non-traditional intersection design**. Consider non-traditional intersection designs such as modern roundabouts in appropriate applications. Roundabouts reduce speed, eliminate certain types of crashes and lessen the severity of other types of crashes. Application of modern

roundabouts requires careful review of pedestrian and bicycle activity levels.

- **Pavement condition**. Upgrade pavement quality to improve drainage and resist skidding.
- **Improve drivers ft. sight distance**. Restrict parking near intersections, properly trim vegetation and move stop lines back from crosswalks by 4 ft.
- **Upgrade and supplement signs and enforce traffic laws**. Enforcing laws that encourage safer intersection driving is a necessity at even well designed and regulated intersections. Enforcement must be consistent. Sustained enforcement efforts have been found to lower both intersection violations and crash rates, sometimes significantly.

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.

General Intersection Layout

Intersection layout is primarily comprised of the alignment of the legs; width of traffic lanes, bicycle lanes, and sidewalks on each approach (number of lanes, median and roadside 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.

Intersection Fundamentals

Intersections are comprised of a physical area—the area encompassing the central area of two intersecting streets as shown in Figure 10.5. 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), otherwise known as the Green Book, 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), multi-leg intersection (containing five or more legs) and modern roundabout, which is discussed in this chapter.

Intersection Conflicts

Intersections, by their very nature, create numerous conflicts between vehicles, pedestrians and bicyclists. Figure 10.6 illustrates the number of conflicts between different 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 attributes 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 and signalized intersections;
- Adequate Crossing Time—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
- Clear Crossing—Eliminating barriers and ensuring accessibility for all users.

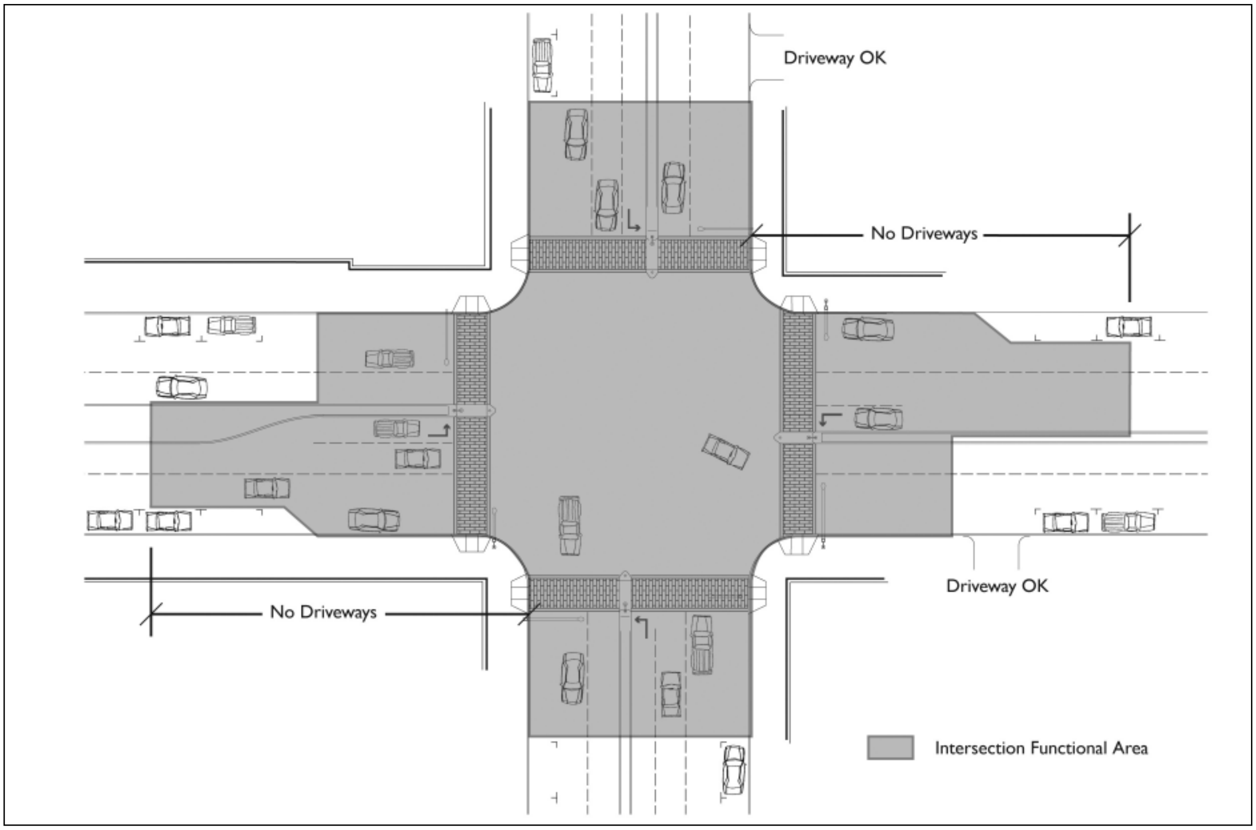

Figure 10.5 Many decisions are made within the functional area of an intersection. Source: Community, Design + Architecture.

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, exposure to traffic, encourage pedestrian travel and increase safety.
- Use 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).

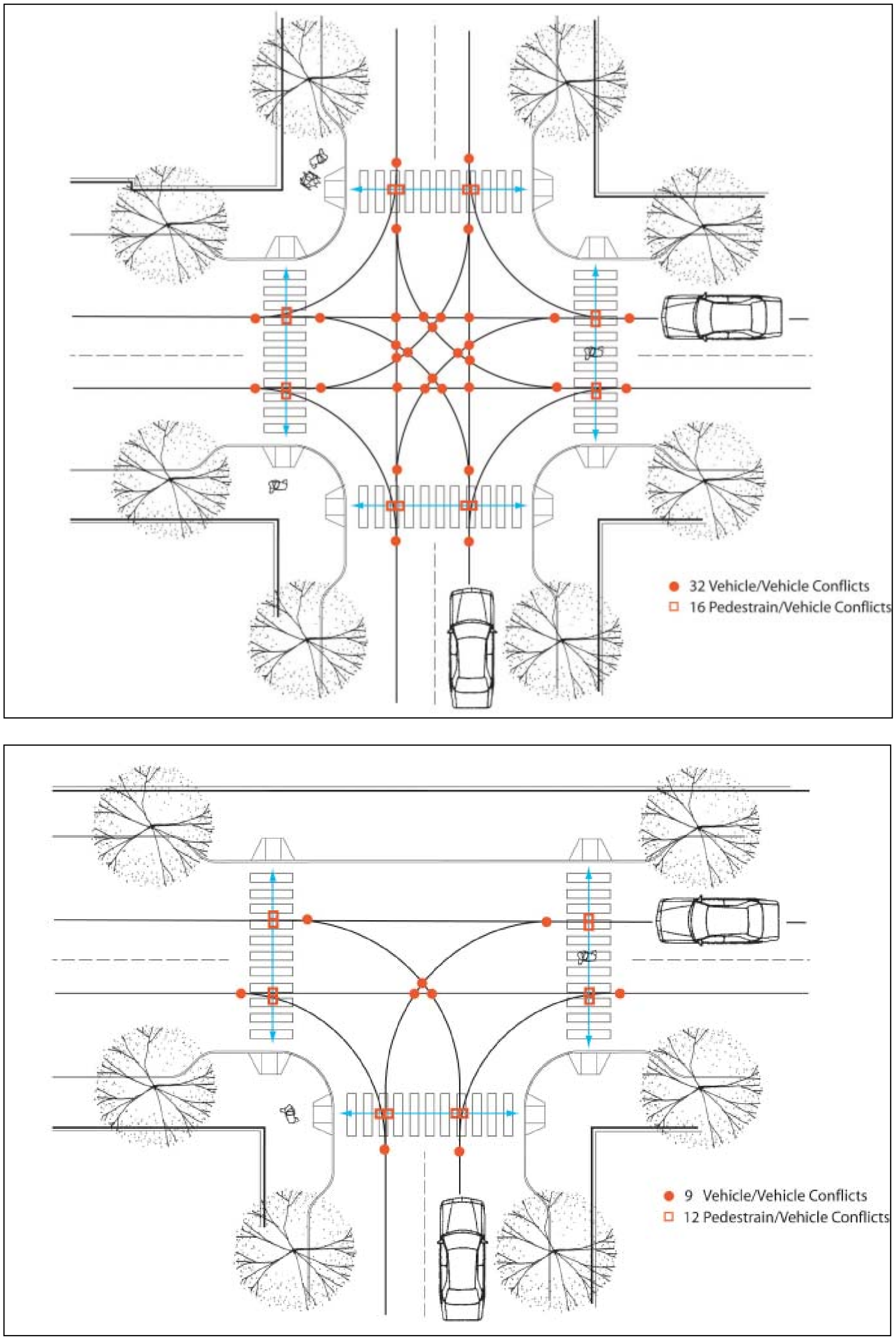

Figure 10.6 Vehicle and pedestrian conflicts at three- and four-leg intersection. Source: Community, Design + Architecture, adapted from an illustration by Michael Wallwork.

Curb Return Radii

Background and Purpose

> **Related Thoroughfare Design Elements**
> - *Selecting the design vehicle*
> - *Speed*
> - *On-street parking*
> - *Right-turn channelization*
> - *Pedestrian refuge islands*

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 longer radii used to facilitate the turning of large trucks and buses. Larger radius corners increase the length of pedestrian crosswalks.

In CSS, 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.

General Principles and Considerations

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

- Curb return radii should be designed to accommodate the largest vehicle type that will frequently turn the corner (sometimes referred to as the control vehicle). This principle assumes that the occasional large vehicle can encroach into the opposing travel lane as shown in Figure 10.7. If encroachment is not acceptable, then a larger design vehicle should be used.
- 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 10.8).

Effect of Curb Radii on Pedestrian Crossing Distance (Compared to 15 ft. Radius)		
Curb Return Radius (Feet)	Added Crossing Distance (Feet)	Added Crossing Time (Seconds) [1]
15	0	0
25	8	2
50	38	10

[1] Crossing time at 4 ft. per second.

- 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 multi-lane 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.
- Apply curb return radii that are compatible with the design vehicle. Occasional turns by vehicles that are larger than the design vehicle could be accomplished by turning more slowly and possibly encroaching into oncoming travel lanes to complete the turn.
- 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 AASHTO's 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.

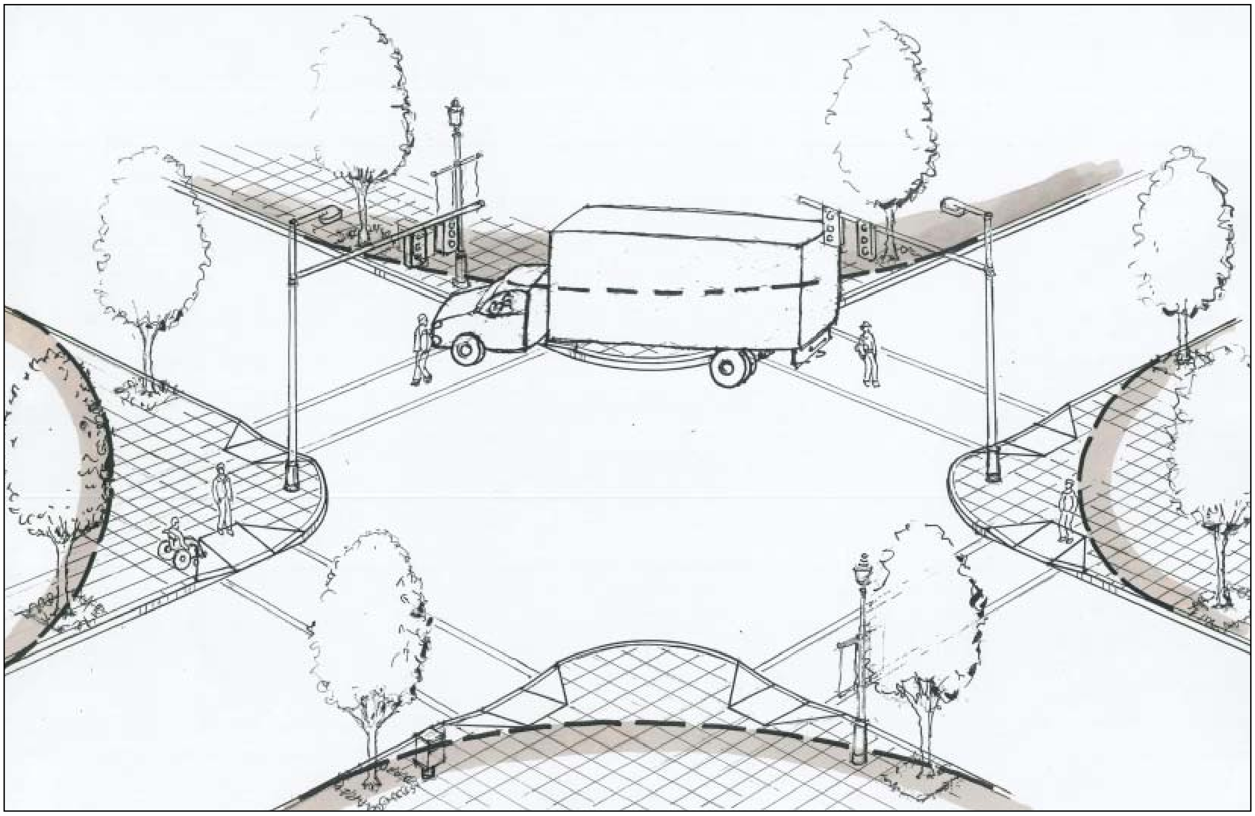

Figure 10.7 Smaller curb return radii shorten the distance that pedestrians must cross at intersections. The occasional turn made by large trucks can be accommodated with slower speeds and some encroachment into the opposing traffic lanes. Source: Kimley-Horn and Associates Inc.

Recommended Practice

Flexibility in the design of curb return revolves around: (1) choice of design vehicle, (2) combination of dimensions that make up the effective width of the approach and receiving lanes and (3) 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 appears reasonable to 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 ft.
- A typical minimum curb return radius of 10 to 15 ft. 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. Passenger vehicles constitute the majority of 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.

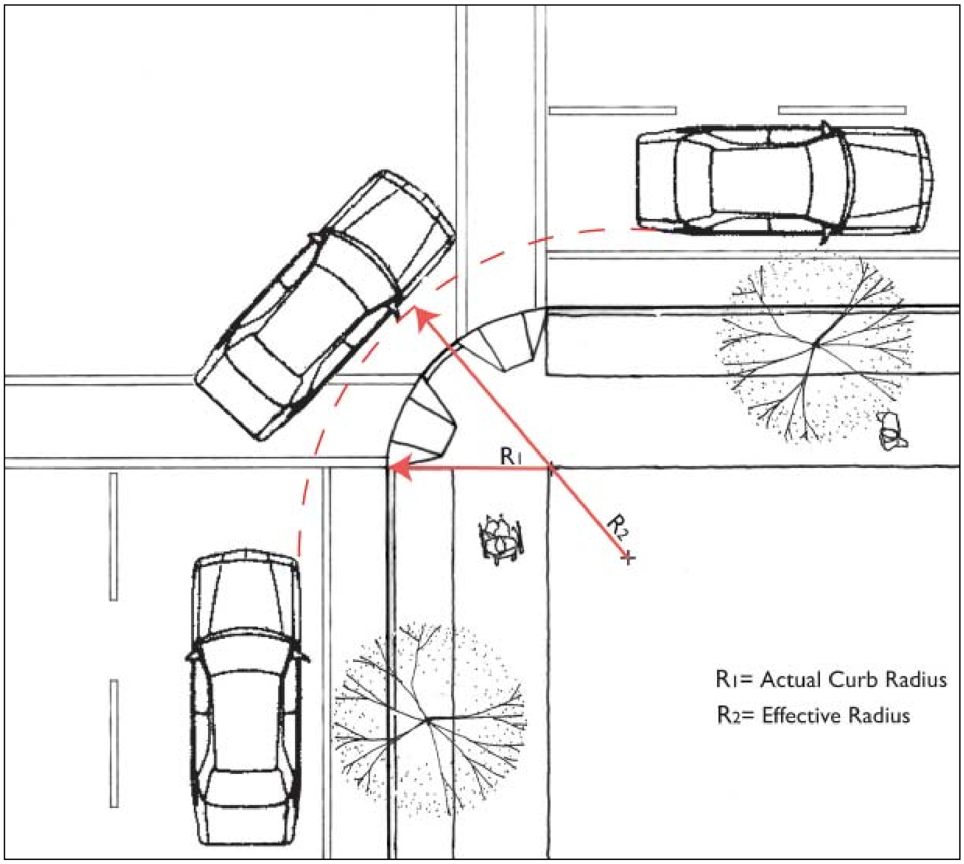

Figure 10.8 The existence of parking and bicycle lanes creates an "effective" turning radius that is greater than the curb return radius. Source: Community, Design + Architecture, adapted from the *Oregon Bicycle and Pedestrian Plan*.

- Curb radii will 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 ft. in width.

Recommendations for Curb Radii on Transit and Freight Routes

Trucks routes should be designated on a minimum number of appropriately selected streets to reduce the impact of large turning radii on pedestrian routes. Where designated local or regional truck routes conflict with high pedestrian volumes or activities, analyze freight movement needs and consider re-designation 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 ft., 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 it could potentially cause large vehicles to regularly travel across the curb and into the pedestrian waiting area of the roadside.

Justification

Intersections designed for the largest turning vehicle traveling at significant speeds with no encroachment results 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 CSS, the selection of curb returns ranging from 5 to 25 ft. 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*

In urban contexts, high-speed channelized right turns are often inappropriate because they create conflicts with pedestrians. Under some circumstances, 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 poorly designed 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.

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 significant. If a channelized right-turn lane is unavoidable, use design techniques described 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 10.9).
- If an urban 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.
- Consider channelized right-turn lanes at multilane all-way stop controlled intersections to provide pedestrians an additional refuge among the complex right-of-way patterns that affect traffic movements.

Figure 10.9 A channelized right turn lane typically provides a pedestrian refuge island and an uncontrolled crosswalk. Source: Dan Burden, Walkable Communities Inc.

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.
- 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 or 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 10.10).
  - 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 150 sq. ft.) for pedestrians to safely wait in a position where they are at least 4 ft. 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.
  - Unless the turning radii of large vehicles, such as tractor-trailers or buses, must be ac-

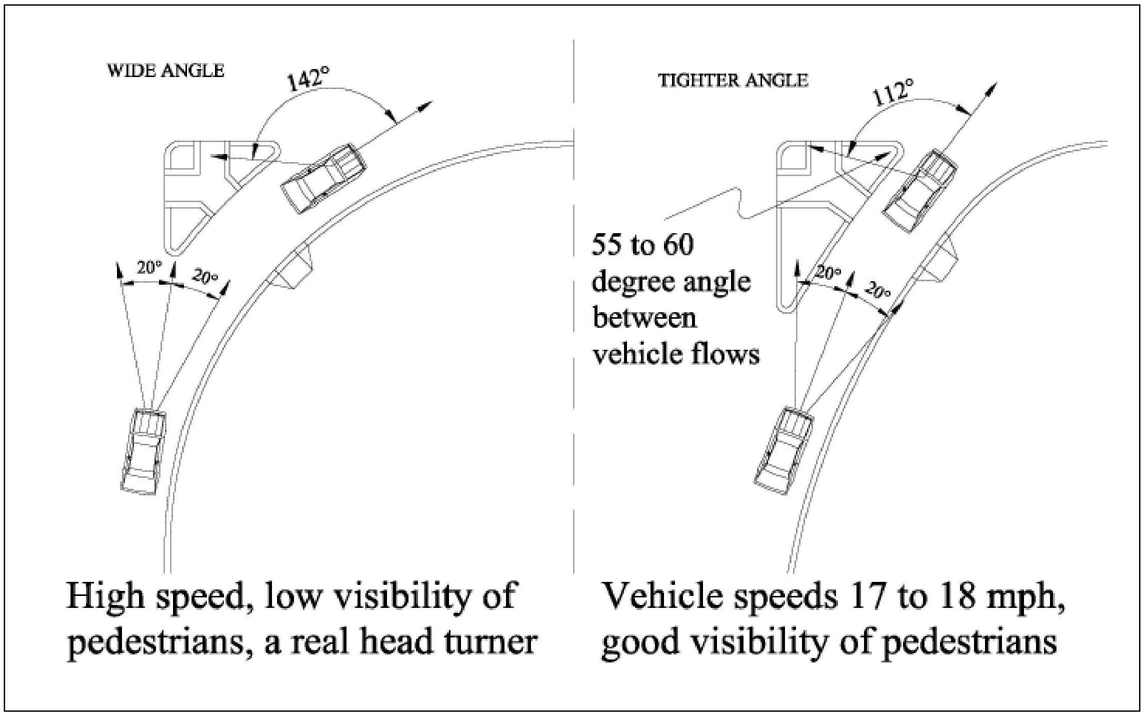

Figure 10.10 The preferred design of a channelized right-turn lane uses an approach angle that results in a lower speed and improved visibility. Source: Kimley-Horn and Associates Inc., adapted from an illustration by Dan Burden.

commodated, the pavement in the channelized right-turn lane should be no wider than 16 ft. 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 ft. 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) sign or warning signs such as the Pedestrian Crossing (W11-2) sign 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) a high pedestrian-vehicle crash experiences.

Modern Roundabouts

Background and Purpose

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, aesthetics and operational functionality and capacity.

Related Thoroughfare Design Elements

- *General intersection layout*
- *Pedestrian refuge islands*
- *Pedestrian treatments at intersections*
- *Bicycle treatments at intersection*

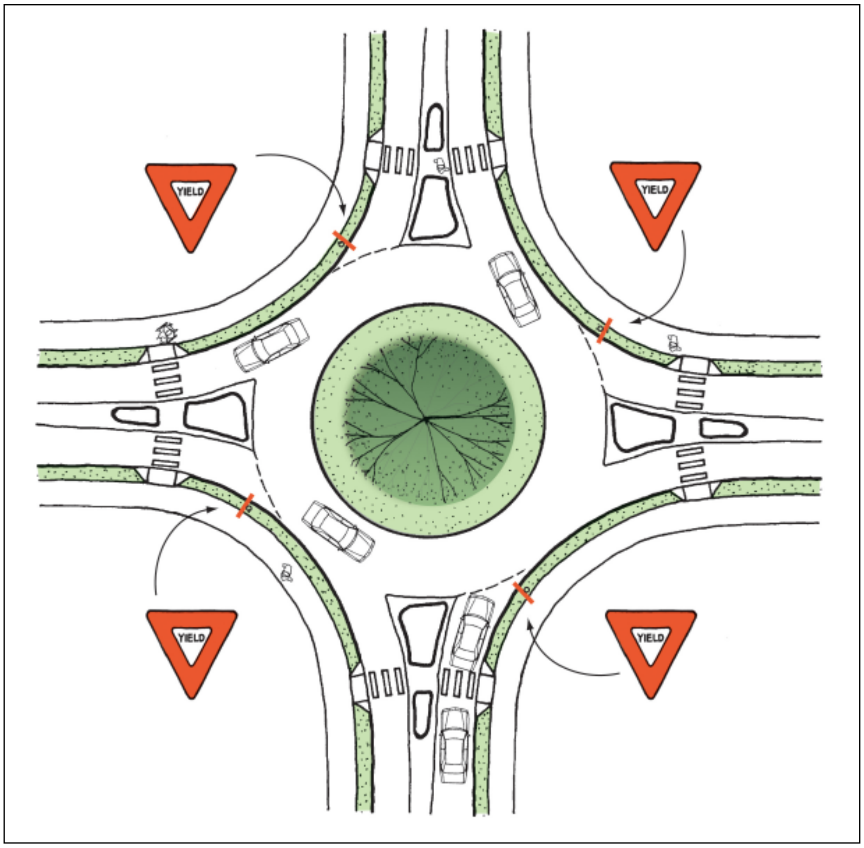

Figure 10.11 A typical single lane modern roundabout design provides yield control on all approaches and deflects approaching traffic to slow speeds. Source: Community, Design + Architecture, adapted from an illustration in *Roundabouts, An Informational Guide* (FHWA 2000).

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.

General Principles and Considerations

General principles and considerations for the design of modern roundabouts include the following.

- The purpose of a modern roundabout is to provide vehicles with free-flow capability through an intersection, while enhancing pedestrian and bicycle safety with reduced traffic speeds.
- Roundabouts are not always the appropriate solution. 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

Figure 10.12 Typical layout of a single lane modern roundabout. Source: Kimley-Horn and Associates Inc.

and yield to traffic already in the circulating roadway of the roundabout (Figure 10.11).

- 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.
- Locate pedestrian crossings at least 25 ft. from the roundabout entry point.
- Bicyclists can be accommodated by: (1) mixing with the flow of vehicular traffic (but without pavement markings delineating a bicycle lane), or (2) 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. 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 10.12) 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 mid-block locations away from the roundabout.
- Where traffic volumes at intersections of ramps with cross streets reach volumes that would require freeway grade separation reconstruction, roundabouts at such intersections might forestall bridge replacement.
- 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.
- 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 necessary.
- 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

Table 10.1 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	WB-50	WB-67 with lane encroachment on truck apron
Inscribed circle diameter (ft.)	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	Not applicable	Applicable	Not applicable
Street	Applicable	Applicable	Applicable	Not applicable

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 Manu*al of Uniform Traffic Control Devices* (FHWA 2003).

Recommended Practice

Table 10.1 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.

Pedestrian Treatments at Intersections—Crosswalks

Background and Purpose

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."

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.

> **Related Thoroughfare Design Elements**
>
> - *Minimizing pedestrian and vehicle conflicts*
> - *Mid-block crossings*
> - *Intersection layout*

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 restrict pedestrian movements to only certain 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 would be appropriate.

General Principles and Considerations

The following principles and considerations should help guide the planning or design of pedestrian crossings.

- Assume that pedestrians 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 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 mid-block locations.

> ***Manual of Uniform Traffic Control Devices* (MUTCD) Definition of "Crosswalk"**
>
> **Unmarked Crosswalk** — that part of a roadway at an intersection included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs or in the absence of curbs, from the edges of the traversable roadway, and in the absence of a sidewalk on one side of the roadway, the part of a roadway included within the extension of the lateral lines of the sidewalk at right angles to the centerline.
>
> **Marked Crosswalk** - any portion of a roadway at an intersection or elsewhere distinctly indicated as a pedestrian crossing by lines on the surface, which may be supplemented by contrasting pavement texture, style, or color.

- Pedestrians must be able to cross streets and highways at regular intervals. Unlike motor vehicles, pedestrians cannot be expected to go more than 300 to 400 ft. 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 and incorporate realistic crossing opportunities for pedestrians.
- There are three primary marking options: transverse, longitudinal (ladder) and diagonal (zebra) lines (Figure 10.13). 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.
- 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 tactile feedback to drivers and improve aesthetics (Figure 10.14). Care should be taken to ensure that the material

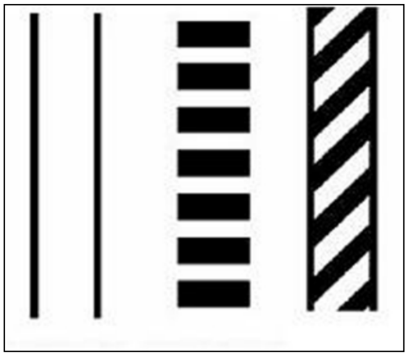

Figure 10.13 The three primary types of crosswalk markings (from left to right) are transverse, longitudinal and diagonal. Source: Kimley-Horn and Associates Inc.

used in these crosswalks is smooth, non-slip and visible. Avoid using a paver system that may shift and/or settle or that induces a high degree of vibration in wheelchair caster or drive 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.

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 lighting, etc.). 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).

Related Thoroughfare Design Elements

- *Curb return radii*
- *Channelized right turns*
- *Lane width*
- *Crosswalks*
- *Mid-block crossings*
- *Bus stops*

Figure 10.14 Crosswalks with colored bricks contrast with concrete pavement. Painted stripes marking the brick crosswalks increase visibility. Source: Kimley-Horn and Associates Inc.

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 mid-block 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 sight distance and 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;
- Enhance ADA requirements by providing space for level landings; 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 roadside. 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.

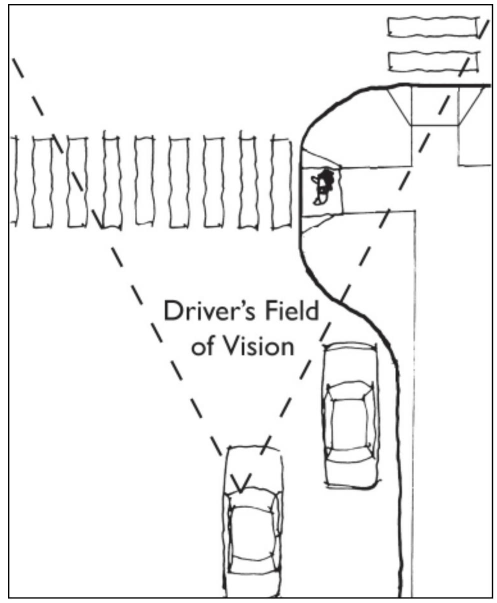

Figure 10.15 Curb extensions can improve pedestrian visibility and reduce crossing distance. Source: Community, Design + Architecture.

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 10.15.
- Curb extensions are used only where there is on-street parking and only a small percentage of turning vehicles that are larger than the design vehicle.
- Curb extensions are not applicable to roadways without on-street parking lanes, intersections

Figure 10.16 A mid-block crossing with a flush curb in Australia. Pedestrians are separated from passing vehicles with bollards. Source: Community, Design + Architecture.

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 vehicle 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 protect the pedestrian area as shown in Figures 10.16 and 10.17. Flush curb extensions are frequently combined with raised intersec-

Figure 10.17 Use of contrasting material and bollards to delineate the pedestrian and vehicle areas. Source: Kimley-Horn and Associates Inc.

tions. 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 ft. This will also help stormwater flow in the gutters around corners.

Recommended Practice

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

- Reduce crossing width at intersections by extending the curb line into the street by 6 or 7 ft. for parallel parking and to within 1 ft. 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 area 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 stormdrain 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 10.18). Consider that this design might require additional maintenance to keep the flowline clear.

Figure 10.18 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.

- 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.

Bicycle Lane Treatment at Intersections

Background and Purpose

> **Related Thoroughfare Design Elements**
> - *Bicycle facilities*
> - *Curb extensions*
> - *Right-turn channelization*
> - *Lane width*

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 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.

- To maintain continuity and improve bicyclist safety, bicycle lanes should be striped through the intersection approach and up to the stop line or crosswalk.
- 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, the only choice is to have bicyclists and right-turning motor vehicles yield to each other at the intersection.
- 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 just prior to entering the roundabout and should not be provided on the circular roadway of the roundabout intersection.

Recommended Practice

The recommended practice for bicycle lane treatment at intersections on major urban thoroughfares is shown in Table 10.2.

Justification

At intersections, bicyclists proceeding straight through and motorists turning right must cross paths. 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.

Table 10.2 Recommended Practice for Bicycle Lane Treatment at Intersections on Major Urban Thoroughfares

With pedestrian crosswalks
• Bike lane striping should not be installed across any pedestrian crosswalks, and, in most cases, should not continue through any street intersections.
With no pedestrian crosswalks
• Bike lane striping should stop a 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. • Bike lane striping may be extended through complex intersections with the use of dotted or skip lines.
Parking considerations
• The same bike lane striping criteria apply whether parking is permitted or prohibited in the vicinity of the intersection.
Bus stop on near side of intersection or high right-turn volume at unsignalized minor intersections with no stop controls
• 6-in. solid line should be replaced with a broken line with 2-ft. dashes and 6-ft. 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.
Bus stop located on far side of the intersection
• Solid white line should be replaced with a broken line for a distance of at least 80 ft. from the crosswalk on the far side of the intersection.
T-intersections with no painted crosswalks
• 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 at the crosswalks.
Pavement markings
• Bike lane markings should be installed according to the provisions of Chapter 9C of the MUTCD. • The standard pavement symbols are one of two bicycle symbols (or the words "BIKE LANE") and a 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.
Signs
• Bike lanes should be accompanied by appropriate signing at intersections to warn of conflicts (see Chapter 9B of the MUTCD).

Bus Stops at Intersections

Background and Purpose

Related Thoroughfare Design

- *Lane width*
- *Curb extensions*
- *Mid-block bus stops*
- *Curb return radius*
- *Crosswalks*

CSS 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 mid-block bus stops in Chapter 9.

Recommended Practice

Placement of Bus Stops at Intersections

The preferred location for bus stops is the nearside 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 may also be placed at a mid-block location on long blocks or serve a major transit generator (See Chapter 9). Guidance and considerations related to bus stops at intersections include the following.

- Consider a nearside stop on two lane thoroughfares where vehicles will not 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 nearside or far side.
- Where it is not desirable to stop the bus in a travel lane and a bus pullout is warranted, a far-side or mid-block 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 placement of bus stops at intersections vary 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 mid-block location is preferred. A mid-block 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 nearside 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 nearside and one far side can minimize pedestrian activity within the intersection.

Table 10.3 summarizes the advantages and disadvantages of far-side and nearside bus stop placements.

Curb Extension Bus Stops (Bus Bulbs)

A curb extension may be constructed along streets with on-street parking in urban centers (C-5) and urban cores (C-6). Curb extensions may be designed in conjunction with bus stops to facilitate bus operations and passenger access. The placement of a bus stop on a curb extension should follow the same guidelines as those previously stated (a nearside 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 nearside 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 mid-block 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.

Nearside curb extensions are usually about 6 ft. in width and of sufficient length to allow passengers to use the front and back doors of a bus. A nearside curb extension bus stop is shown in Figure 10.19.

Besides reducing the pedestrian crossing distances, curb extensions with nearside 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 amenities, such as a shelter and/or a bench.

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.

Table 10.3 Advantages and Disadvantages of Farside and Nearside Bus Stops

Farside Bus Stops	
Advantages	**Disadvantages**
• Minimizes conflict between buses and right turning vehicles traveling in the same direction. • Minimizes sight distance problems on approaches to the intersection. • Encourages pedestrians to cross behind the bus. • Minimizes area needed for curbside bus zone. • If placed just beyond a signalized intersection in a bus turnout, buses may more easily re-enter the traffic stream. • If a turnout is provided, vehicle capacity through intersection is unaffected.	• 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). • If bus stops in travel lane, could result in rear-end accidents as motorists fail to anticipate stopped traffic. • May cause passengers to access buses further from crosswalk. • May interfere with right turn movement from cross street.
Nearside Bus Stops	
Advantages	**Disadvantages**
• Minimizes interference when traffic is heavy on the farside of an intersection. • Allows passengers to access buses close to crosswalk. • Driver may use the width of the intersection to pull away from the curb. • Allows passengers to board and alight when the bus is stopped for a red light. • Provides the driver with the opportunity to look for oncoming traffic, including other buses with potential passengers.	• Stopped bus may interfere with a dedicated right turn lane. • May cause sight distance problem for cross-street traffic and pedestrians. • If located at a signalized intersection, and if the shoulder width at the stop is such that buses will exit the traffic stream, a traffic queue at a signal may make it difficult for buses to re-enter the traffic stream. • Prohibits through traffic movement with green light, similar to farside stop without a bus turnout. • May cause pedestrians to cross in front of the bus at intersections.

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

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 solve problems not answered by bus turnouts. 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 re-enter the traffic stream. Queue jumpers are able to 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 nearside right-turn lane 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 nearside right-turn lane (buses excepted), nearside bus stop and acceleration lane for buses with a taper back to the general-purpose lanes. The length of the acceleration lane is based on speed and should be designed by an experienced engineer.

Figure 10.19 A curb extension bus stop. Source: Kimley-Horn and Associates Inc.

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 re-enter the traffic stream. Queue jumpers at major urban thoroughfare intersections should be considered when:

1. High-frequency bus routes have an average headway of 15 min. 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).

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References for Further Reading

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Chapter 11

Thoroughfares in Single Land Use or Vehicle Mobility Priority Areas

Purpose

This chapter identifies resources to help practitioners achieve CSS for major thoroughfares in urban areas comprised of homogenous land uses (business park, industrial, etc.) or where vehicle mobility is a priority. Stakeholder involvement continues to be an important part of the planning process that establishes a vision for the corridor/thoroughfare. Although in this case, the vision is a mobility priority character that plays a major mobility/capacity role in the network, thus permitting other thoroughfares to emphasize other roles.

Objectives

This chapter:

1. Defines the types of land use categories applicable to this section of the report;
2. Compares the conventional and CSS processes for determining cross sections for vehicle mobility priority roadways;
3. Identifies the applicability of the guidelines in this report for single land use and vehicle mobility priority areas; and
4. Identifies general design parameters for thoroughfares in single land use and vehicle mobility priority areas.

Single Land Use Categories

This report addresses CSS primarily in walkable, mixed-use residential and commercial urban areas. There are many areas in urban areas that contain homogenous or single type of land use. These areas might be long corridors or large districts which, by their nature, are low intensity and low density and do not provide the mix of uses, development patterns, or roadway networks conducive to walking. Transportation in single land use areas is primarily by motor vehicles, although transit and bicycling can be viable modes. Single land use areas might contain commercial or industrial uses that rely on freight movement and therefore need to accommodate significant numbers of large vehicles.

The following are brief descriptions of some of the land use categories that fall under the single-use definition.

- *Auto-oriented commercial/employment*—These areas are comprised of large, or multiple, commercial developments located within a corridor or a district. They are primarily comprised of:
  - Strip commercial/shopping center or mall (Figure 11.1)—Large commercial sites with surface parking lots adjacent to the thoroughfare right-of-way. Buildings are either at the back of the site away from the thoroughfare or for large centers and malls, in the middle of parcels.
  - Business park/campus office (see Figure 11.2)—Large parcel office/business campus or park. Buildings are set well back from the thoroughfare and surrounded by large landscaped edges and surface parking lots. Roadway pattern and block size are of a nearly unwalkable scale.
- *Single-use residential not fronting on thoroughfare* (Figure 11.3)—Housing units front on side streets or back up to the thoroughfare. Developments are inwardly focused or oriented away from the thoroughfare, often presenting a high wall at the edge of the right-of-way. Residences are buffered from the thoroughfare by roadside width. There are typically no significant complementary uses within walking distance.
- *Industrial/manufacturing* (Figure 11.4)—Similar in description to business park except that developments might be single parcels, characterized by large, low-density buildings, equip-

Figure 11.1 Large retail centers are examples of single uses. Source: Kimley-Horn and Associates Inc.

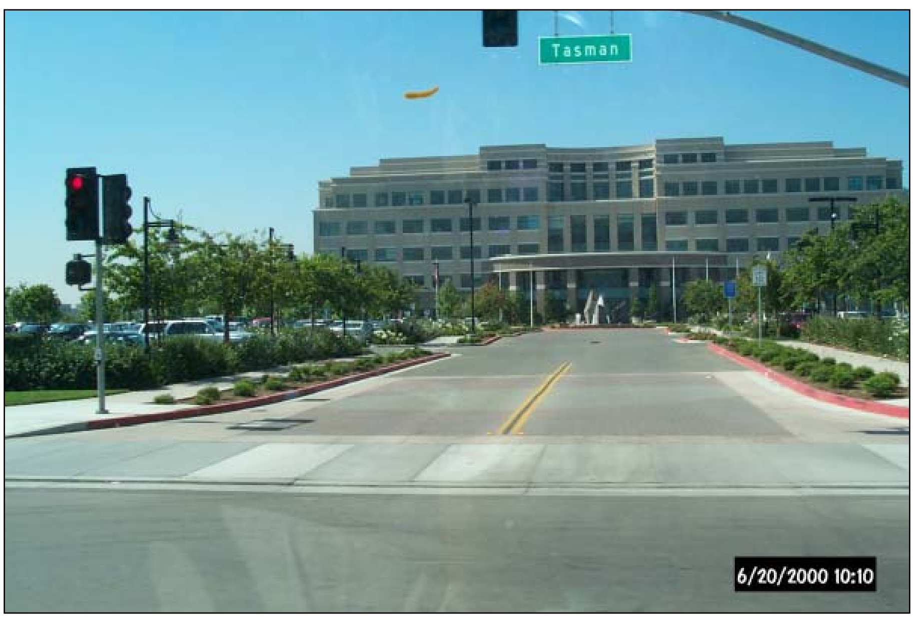


Figure 11.2 Office complexes are often set back away from the thoroughfare creating an auto-oriented environment. Source: Kimley-Horn and Associates Inc.

ment yards and parking. Freight vehicles might dominate roadways.

- *Passive park, natural reserve, or intentional buffer area*—These areas are mainly open space with little human activity. These areas may also include land adjacent to access controlled right-of-way or easements (railroad, freeway, power lines).

Determining Thoroughfare Cross-Sections

Determining thoroughfare cross sections in single use areas uses a similar process to that described in Chapters 5 and 6 for walkable, mixed-use urban areas. This section compares the conventional process for determining cross sections for single land-use areas and vehicle mobility priority thoroughfares with the CSS process.

Conventional Cross-Section Determination

The conventional process for determining initial thoroughfare cross sections typically includes the following steps:

- Identify the functional classification;
- Identify the area type (rural or urban);
- Develop traffic projections and conduct operational analyses;

Figure 11.3 Residential subdivisions adjacent to major thoroughfares are often inwardly focused and separated by walls. Source: Kimley-Horn and Associates Inc.

- Assess right-of-way availability and requirements; and
- Design the initial cross section.

The conventional process begins with identifying the functional classification and area type. Combined, the functional class and area type provide the practitioner with the facility's service characteristics, types of design vehicles, design speed, etc. and often is tied to an agency's geometric design standards. Next, the practitioner projects design year traffic conditions and evaluates the facility's operations and level of ser-

Figure 11.4 Industrial areas may have roadways dominated by large vehicles. Source: Kimley-Horn and Associates Inc.

vice (LOS). This step typically results in the number of lanes needed to accommodate future traffic, meet LOS objectives or standards and identify geometric requirements, particularly at intersections. The practitioner assesses the available or required right-of-way to accommodate the number of lanes and other design features. If right-of-way is constrained, the practitioner evaluates trade-offs and determines the highest priority design elements. This step leads to the development of an initial cross section, upon which the practitioner can begin detailed designs.

The conventional process emphasizes the role of functional classification and traffic operations in the development of cross sections. In vehicle-dominated areas, this process is appropriate for accommodating traffic, but de-emphasizes other modes of travel. Pedestrian, bicycle and transit user needs in single land use and vehicle mobility priority areas, even though demand is less, are often addressed through the provision of minimal facilities.

CSS Cross-Section Determination

In contrast to the conventional process, the CSS process for determining thoroughfare cross sections in single land use and vehicle mobility priority areas is similar to any CSS thoroughfare design process. The steps are as follows:

- Determine the local objectives and priorities from stakeholder process;
- Identify the land use category;
- Assess adjacent activity and other conditions;
- Determine the functional classification;
- Determine the thoroughfare type; and
- Design the initial cross section.

The CSS process begins with identifying the local vision, objectives and priorities for the area and thoroughfare. This involves working with stakeholders. The existing and future character of the area and its supporting thoroughfares is determined by assessing land use categories and types of adjacent activities, which result in user needs. For example, the character of a single use business park may be low-intensity development set back amidst large landscaped grounds, but the buildings need to be accessible by pedestrians who arrive by transit or walk between buildings. This may lead to a series of off-street paths that connect the roadside to buildings and connect buildings to each other. User needs can include traffic projections and operations analysis.

Once the practitioner has identified the land use, adjacent activities, user needs and character, the design process is similar to the process described in Chapters 3 and 5 for identifying functional classification and associated thoroughfare type. This leads to the development of an initial cross section.

Applicability of Report to Vehicle Mobility Priority Thoroughfare Design

Most of the guidance presented in this report is applicable to the design of major urban thoroughfares in single land use and vehicle mobility priority areas. Table 11.1 identifies the applicability of each of the chapters and sections that provide design guidelines for the roadside (Chapter 8), the traveled way (Chapter 9) and intersections (Chapter 10). When designing a vehicle mobility priority thoroughfare, the practitioner can use this table to identify the sections with relevant and applicable considerations and guidance. If not identified in the table, the guidance provided in local agency standards or the AASHTO *A Policy for the Geometric Design of Highways and Streets,* otherwise known as the Green Book (2004) is recommended.

Vehicle Mobility Priority Thoroughfare Design Parameters

Table 11.2 and 11.3 present the general design parameters for arterial and collector thoroughfares in single land use and vehicle mobility priority areas. The tables provide general guidance on dimensions and criteria for common elements of the cross section and other vital design elements of major urban thoroughfares. Table 11.2 presents guidance for arterial thoroughfares (boulevards and avenues) and Table 11.3 presents guidance for collector thoroughfares (avenues and streets).

The guidance in these tables does not necessarily reflect the recommended dimensions and/or practices of each of the design criteria presented

Table 11.1 Applicability of Report Sections to Vehicle Mobility Priority Major Urban Thoroughfares

Chapter/Section	Applicable for CSS?
Chapter 8 – Roadside	
Principles and considerations	Yes
Edge zones	Yes
Furnishing zones	Yes
Street furniture	No
Landscaping	Yes
Pedestrian buffers	Yes
Pedestrian throughway zones	Yes
Frontage zones	No
Driveway crossings	Yes
Chapter 9 – Travelway	
Functions/actions to be accommodated	Yes
Access management	Yes
Emergency vehicle operations	Yes
Transition principles	Yes
Medians	Yes
Bicycle facilities	Yes
On-street parking	Only where permitted
Transition design	Yes
Mid-block crosswalks	Yes
Pedestrian refuge islands	Yes
Mid-block bus stops	Yes
Snow removal considerations	Yes
Chapter 10 – Intersections	
Intersection geometry	Yes
Curb return radii	No
Channelized right turns	No
Roundabouts	Yes
Pedestrian treatments	Yes
Curb extensions	Where curb parking is to be provided full time
Bike lane treatments	Yes
Bus stops	Yes

in Chapters 8 through 10 for walkable mixed-use urban areas. Tables 11.2 and 11.3 reflect the more conventional practice and design criteria for auto-oriented roadway design. The primary source of these criteria is *A Policy on Geometric Design of Streets and Highways*, American Association of State Highways and Transportation Officials, Washington, DC.

Works Cited

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

Table 11.2 General Parameters for Vehicle Mobility Priority Arterials

Parameter	Design Characteristics									
	Strip Commercial/Shopping Center		Business Park/ Campus Office		Industrial		Single-Use Residential Not Fronting On Thoroughfare		Passive Park, Nature Preserve, Intentional Buffer Area	
Traveled Way										
Typical ADT	20,000+	<25,000	20,000+	<25,000	25,000+	<25,000	20,000+	<20,000	10,000+	<10,000
Thoroughfare type	Boulevard	Avenue	Boulevard	Avenue	Boulevard	Avenue	Boulevard	Avenue	Boulevard	Avenue
Off-street parking access	Limited from thoroughfare; side street	Limited from thoroughfare; side street	Limited from thor-oughfare; side street	Limited from thoroughfare; side street	Limited from thor-oughfare; side street	Limited from thoroughfare; side street	From side street only	Limited from thoroughfare; side street	From side street only	Limited from thoroughfare; side street
Operating speed (mph) (design speed = 5 mph higher)	35 to 40	35	45	35 to 40	45	35 to 40	35 to 40	30 to 35	45	40
Number of through lanes	4 to 6 typical; 6 to 8 where parallel capacity not avail-able	2 to 4	4 to 6 typical; 6 to 8 where parallel capac-ity not available	2 to 4	4 to 6 typical; 6 to 8 where parallel capac-ity not available	2 to 4	4 to 6 typical; 6 to 8 where parallel capacity not avail-able	2 to 4	4 to 6 typical; 6 to 8 where parallel capacity not avail-able	2 to 4
Lane width	11 to 12 ft.	11 to 12 ft.	11 to 12 ft.	11 to 12 ft.	12 ft.+	12 ft.+	11 to 12 ft.	11 to 12 ft.	11 to 12 ft.	11 to 12 ft.
On-street parking	Depends on need	Depends on need	None	None	None	None	None	None	None	None
Median [1]	16 to 18 ft.	Optional 14 to 18 ft.	16 to 18 ft.	Optional 14 to 18 ft.	16 to 22 ft.	None	16 to 18 ft.	Optional 14 to 18 ft.	16 to 18 ft.	Optional 14 to 18 ft.
Access management [2]	High	Moderate	Moderate	Low	Moderate	Low	High	Low	Moderate	Moderate
Bike Lanes	6 ft. bike lane when needed for bicycle network connectivity; Optional 6 ft. lane where there are nearby parallel facilities									
Roadside										
Minimum/desirable roadside width (incl. 1 ft. clearance behind sidewalk)	6 ft./14 ft.	6 ft./14 ft.	6 ft./14 ft.	6 ft./14 ft.	6 ft./14 ft.	6 ft./14 ft.	6 ft./12 ft.	6 ft./12 ft.	6 ft./14 ft.	6 ft./14 ft.
Pedestrian buffers/planting strip width	0 to 8 ft.	0 to 8 ft.	0 to 8 ft.	0 to 8 ft.	0 to 8 ft.	0 to 8 ft.	0 to 6 ft. [3]	0 to 6 ft. [3]	0 to 8 ft.	0 to 8 ft.
Min. sidewalk width	5 ft.	5 ft.	5 ft.	5 ft.	5 ft.	5 ft.	5 ft.	5 ft.	5 ft.	5 ft.
Street lighting	Safety lighting recommended throughout segment and at intersections									
Intersections										
Traffic signal control	Prioritize signal progression, traffic movement efficiency, transit routes; safely accommodate pedestrian crossings with multi-stage crossings if necessary where medians are provided with adequate pedestrian refuge width (min. 8 ft.).									
Curb radii	30 ft. to 50 ft. or 3-center curves; larger with heavy right turns or truck volumes and corner islands						30 ft.	30 ft.	30-50 ft. or 3-center curves; larger with heavy right-turns or truck volumes and corner islands	
Roundabouts	Optional at low and medium volume intersections where sufficient roundabout capacity can be developed.									

Notes:

[1] Dimensions shown in table are for single left-turn lanes. Major intersections may be sized to accommodate double left-turn lanes.

[2] Access management involves providing (in other words, managing) access to land development in a way that preserves safety and reasonable traffic flow on public streets. See Chapter 9 Traveled Way Design Guidelines (access management section) for more information. Low, moderate, and high designations related to the level of access restrictions. A high level of access management uses medians to restrict midblock turns, consolidates driveways and controls the spacing of intersections. A low level of access management limits full access at some intersections.

[3] If trucks are allowed to park on the street, the planting strip should not contain street trees that extend into the parking lane.

Table 11.3 General Parameters for Vehicle Mobility Priority Collectors

Parameter	Design Characteristics									
	Strip Commercial/Shopping Center		Business Park/ Campus Office		Industrial		Single-Use Residential Not Fronting On Thoroughfare		Passive Park, Nature Preserve, Intentional Buffer Area	
Traveled Way										
Typical ADT	>10,000	>5,000	>10,000	>5,000	>10,000	>5,000	>10,000	>5,000	>10,000	>5,000
Thoroughfare type	Avenue	Street	Avenue	Street	Avenue	Street	Avenue	Street	Avenue	Street
Off-street parking access	Direct from thoroughfare; access management optional									
Operating speed (mph) (design speed = 5 mph higher)	30 to 35	30	30 to 35	30	30	30	30	25 to 30	30 to 35	30
Number of through lanes	2 to 4	2	2 to 4	2	2 to 4	2	2 to 4	2	2 to 4	2
Lane width	11 to 12 ft.	10 to 11 ft.	11 to 12 ft.	10 to 11 ft.	11 to 12 ft.	10 to 11 ft.	10 to 11 ft.	10 to 11 ft.	11 to 12 ft.	10 to 11 ft.
On-street parking	None	Optional	None	Optional	Optional	Optional	Optional	Optional	Optional	Optional
Medians [1]	Optional 14 to 16 ft.	None	Optional 14 to 16 ft.	None	Optional 14 - 16 ft.	None	Optional 14 - 16 ft.	None	Optional 14 to 16 ft.	None
Access management [2]	Moderate	Low	Moderate	Low	Low	Low	Low	Low	Low	Low
Bike Lanes	6 ft. lanes	6 ft. lanes or 13 ft. combined parking/ bike lane	6 ft. lanes	6 ft. lanes or 13 ft. combined parking/ bike lane	6 ft. lanes or 13 ft. combined parking/ bike lane	6 ft. lanes or 13 ft. combined parking/ bike lane	6 ft. lanes or 13 ft. combined parking/ bike lane	6 ft. lanes or 13 ft. combined parking/ bike lane	6 ft. lanes or 13 ft. combined parking/ bike lane	6 ft. lanes or 13 ft. combined parking/ bike lane
Roadside										
Minimum/desirable roadside width (incl. 1 ft. clearance behind sidewalk)	6/14 ft.	6/12 ft.	6/14 ft.	6/12 ft.	6/12 ft.	6/12 ft.	6/12 ft.	6/12 ft.	6/14 ft.	6/12 ft.
Pedestrian buffers/planting strip width	0 to 8 ft.	0 to 6 ft.	0 to 8 ft.	0 to 6 ft.	0 to 6 ft. [3]	0 to 6 ft. [3]	0 to 6 ft.	0 to 6 ft.	0 to 8 ft.	0 to 6 ft.
Min. sidewalk width	5 ft.	5 ft.	5 ft.	5 ft.	5 ft.	5 ft.	5 ft.	5 ft.	5 ft.	5 ft.
Street lighting	Safety lighting recommended throughout segment and at intersections									
Intersections										
Traffic signal control	Time for traffic operations efficiency, transit vehicle priority, safe pedestrian crossings									
Curb radii	15 ft. to 30 ft.	15 ft. to 25 ft.	15 ft. to 30 ft.	15 ft. to 25 ft.	20 ft. to 30 ft.	15 ft. to 25 ft.	15 ft. to 30 ft.	15 ft. to 25 ft.	15 ft. to 30 ft.	15 ft. to 25 ft.
Roundabouts	Optional at low and medium volume intersections where sufficient roundabout capacity can be developed									

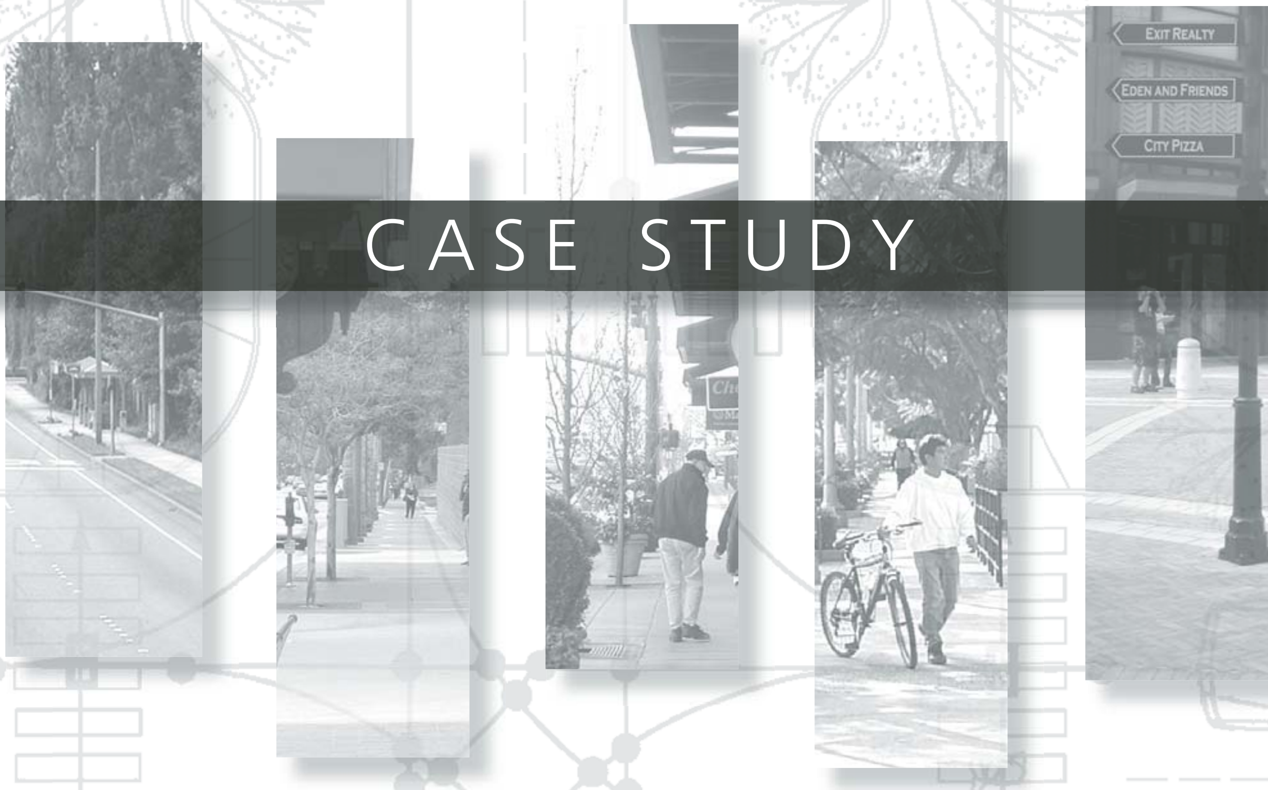
Notes:

[1] Dimensions shown in table are for single left-turn lanes. Major intersections may be sized to accommodate double left-turn lanes.

[2] Access management involves providing (in other words., managing) access to land development in a way that preserves safety and reasonable traffic flow on public streets. See Chapter 9 Traveled Way Design Guidelines (access management section) for more information. Low, moderate, and high designations related to the level of access restrictions. A high level of access management uses medians to restrict midblock turns, consolidates driveways and controls the spacing of intersections. A low level of access management limits full access at some intersections.

[3] If trucks are allowed to park on the street, the planting strip should not contain street trees that extend into the parking lane.

CASE STUDY



Excelsior Avenue, Minneapolis, MN

Case Study: Arterial Avenue in Urban Center

Excelsior Boulevard, St. Louis Park, MN

The avenue characteristics of Excelsior Boulevard are designed to reflect an appropriate speed and incorporate parking and sidewalk design elements that support street-fronting land uses. The width of the thoroughfare supports a four-story enclosure and establishes the build-to lines that will bring future development out to the thoroughfare and move parking to the back.

Context Zone

Evolving CZ-5 in a larger CZ-3 area.

Surrounding Land Uses

Office and residential over retail and service with multi-family residential to north. Main Street on north with public green and a mix of local businesses and national franchises. South side has multi-story office and one-story free-standing retail and auto-related businesses.

Thoroughfare Elements

Functional class:	Minor arterial
Jurisdiction:	County
Through lanes:	4
Turn lanes:	Left turn
Median:	Yes
Sidewalks:	Both sides
Planting strip:	Tree wells in sidewalk
Speed limit:	35 mph
Drainage:	Urban, curb and gutter
Parking:	Parallel, bays
Bicycle lanes:	None
Transit:	Two local/ limited routes
ADT:	19,400

Livability Features

- High level of pedestrian amenity with public green.
- Wide sidewalks.
- Outdoor seating for restaurants.

Mobility Features:

- Off-street parking in mid-block shared parking structures.
- Angled parking is provided on nearby Grand Way.
- Roundabouts are used at intersections with local streets to the north.
- Two local routes on Excelsior, one is also limited stop; shelters provided.
- The current design reflects a compromise between the city and the county to move this segment of the thoroughfare toward an avenue design that supports a CZ-5 pattern.
- Transit stops on the thoroughfare are a combination of near- and far-side in relation to the skewed cross streets east of the study location that take advantage of “left-over” space created by the skew in the grid.

- Stops allows for larger waiting areas and more direct crossing access at intersections. The higher density development at Grand Way is new and transit service patterns do not reflect the potential new demand from this development pattern.

Safety Characteristics

- Paving treatments extended across Excelsior Boulevard to transit stop.
- Curb extensions.

Strengths and Successes

- Excelsior Boulevard is a radial route that supports a suburb-to-city commute pattern from Minneapolis through St. Louis Park and Hopkins out to the Southwest Metro.
- Traffic volumes on Excelsior Boulevard are in the range of 20,000 vehicles per day (higher to the west). The divided four-lane design is consistent with this level of traffic volume.

The design of Excelsior Boulevard contains several features that support the Avenue within the CZ-5 context. These features include:

- Establishing a build-to line on the south side to guide future development to appropriately frame the thoroughfare;
- On-street parking in parking bays;
- Curb extensions at intersections to reduce crossing width;
- Reduced transition rates and two-car turn bays for left and right turns in place of Hennepin County's standard 150 to 300 ft. design requirements; and
- Bicycle accommodation is off route, which is consistent with the existing bicycle network plan.

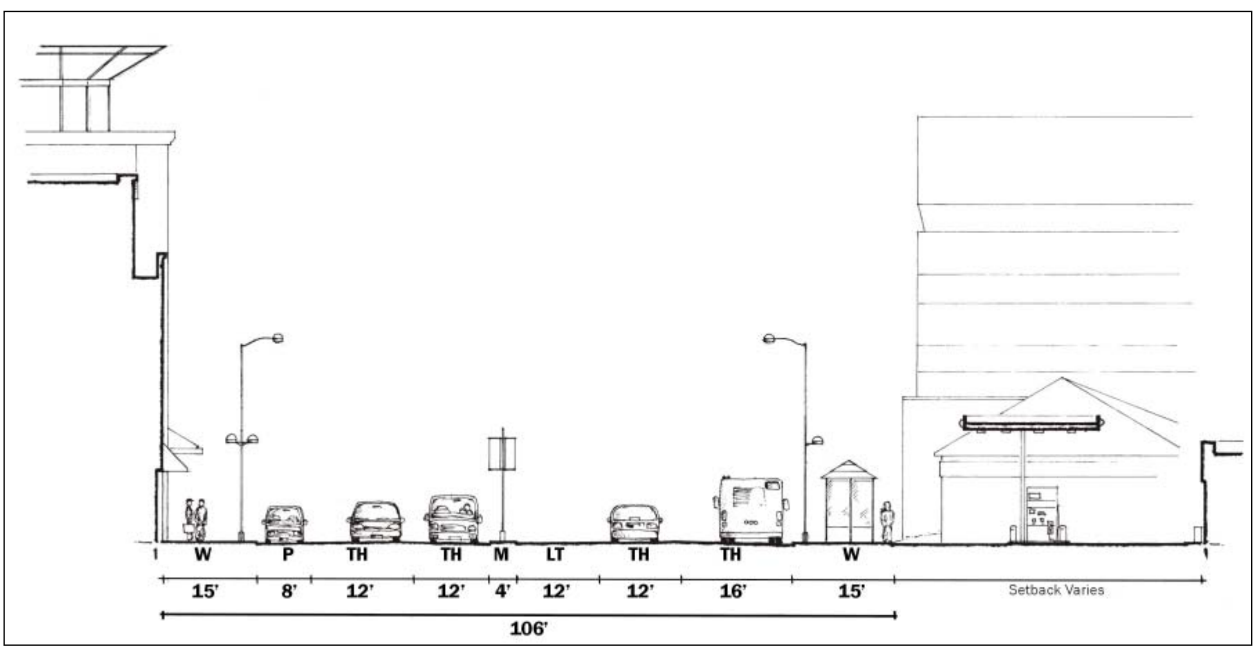
CSD Elements to Strengthen

- Inconsistent with the CZ-5 context, the travel lanes are wider than necessary, which contributes to higher travel speeds than desirable (or posted).
- The median provides for landscaping and left-turn lanes, but the width separates rather than unites the two sides of Excelsior.
- Speeds and travel-way width west of this section increase and the overall street, while technically slowed in the study location and to the

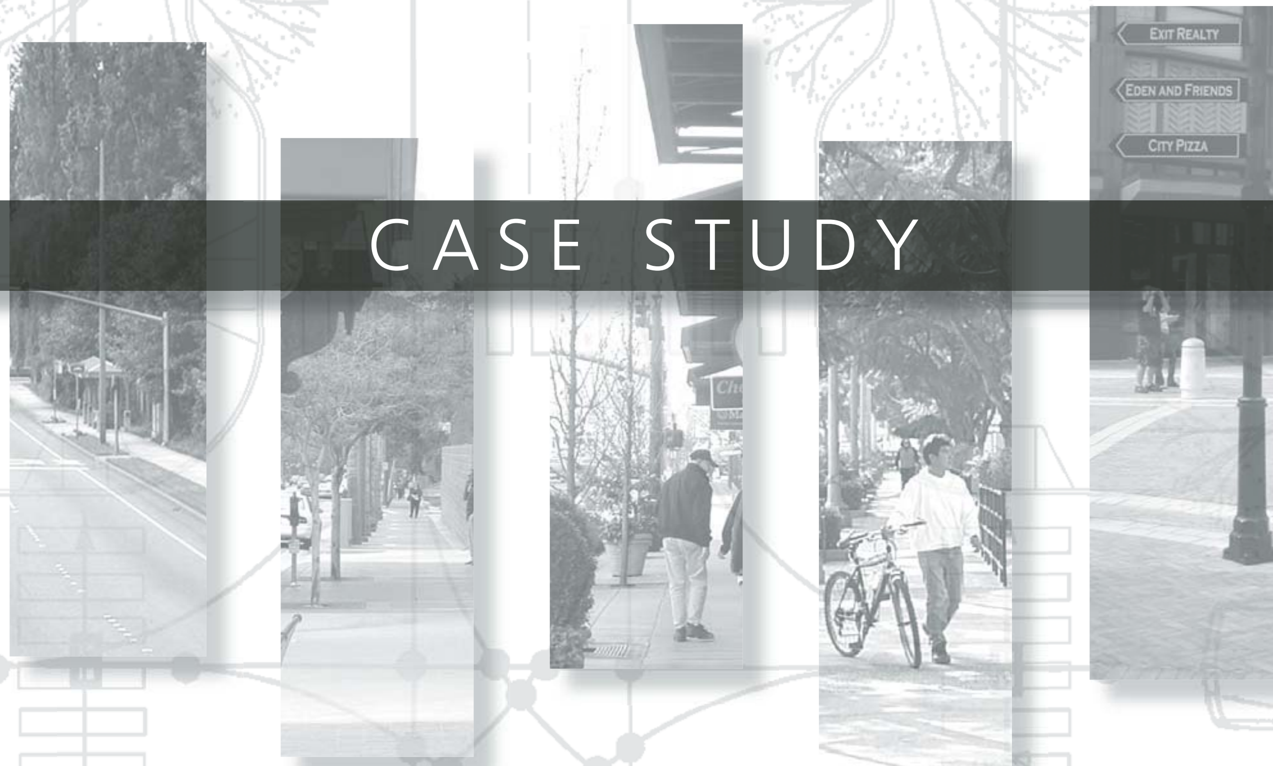
east, is designed for higher speed operation than is necessary for a CZ-5 pattern. Movement priority is given over to longer distance trips and Excelsior functions more like a boulevard than an avenue.

- Transit service levels on the street reflect an inner suburban route structure that currently does not provide sufficient service to support higher density development. The service pattern currently matches the lower density characteristics of the surrounding area and fits into the hub-to-hub strategy used in the suburban area of the Twin Cities.

Typical Cross-Section



CASE STUDY



Culver Boulevard, Culver City, CA

Case Study: Arterial Boulevard in Urban Center Context

Culver Boulevard, Culver City, CA

Regional Location

Culver City is located in the Los Angeles Metropolitan Area between Santa Monica and East Los Angeles. The case study focuses on four blocks of Culver Boulevard in downtown Culver City.

Local Network Context

Map of local street system highlighting length of subject street.

Functional Classification

Culver Boulevard is classified as a major arterial in Culver City's General Plan.

Context Zone

Culver Boulevard is located in a general urban (CZ-4) context area.

Surrounding Land Uses

Culver Boulevard is one of Culver City's primary commercial corridors and travels through downtown. The study segment of Culver Boulevard encompasses two of the city's redevelopment areas. Land uses along Culver Boulevard are a mix of office, retail, general commercial and the city's civic center. Commercial uses include entertainment uses such as a cinema and numerous restaurants and cafes. Nearby are the Brotman Medical Complex and Sony Studios. Within several blocks of Culver Boulevard commercial uses transition into low- and medium-density residential.

Thoroughfare Elements:

Functional Class:	Major arterial
Jurisdiction:	City
Through Lanes:	4 to 6
Turn Lanes:	Median turn lanes
Median:	Raised with left-turn pockets
Sidewalks:	Both sides (approximately 30-ft. wide on north side, approx. 8–10-ft. wide on south side)
Planting Strip:	Tree grates in sidewalk near storefronts, landscaping planters near curb with benches and bicycle racks; walkways located between planters and treewells and between treewells and building fronts
Speed limit:	35 mph
Drainage:	Urban curb and gutter
Parking:	Parallel
Bicycle Lanes:	None
Transit:	Four local routes/one express route
ADT:	34,700

Land Use/Street Integration

Livability Features

- Sidewalks vary from 8 to 12 ft. in width on the south side and 15 to 30 ft. in width on the north side.
- Building entries are located at back of side-walk.
- Good street connectivity. The angular inter-section of Washington Boulevard makes the street network in the area more complex with restricted vehicular movement and reduced opportunities for pedestrian crossings at the intersection.
- Many street cafes, some with outside seating in the sidewalk area.
- Pedestrian scaled lighting.
- Benches.
- Bicycle racks.
- Street trees are located approximately every 25 ft. on the sidewalk.

- On street parking buffers sidewalk from travel lanes, but is prohibited during the hours of 7–10 a.m. or 4–7 p.m.
- No curb extensions (bulb-outs) at street cross-ings.

Mobility Features

Four local routes and one express route:

- Culver City bus Line 1 (Washington Blvd.).
- Culver City bus Line 4 (Jefferson Blvd.).
- Culver City bus Line 5 (Braddock Drive).

- MTA Line 220 (Culver Blvd./Robertson Blvd.).
- LADOT Commuter Express Line 437 (Cul-ver Blvd.).

Frequent bus stops located at the following inter-sections:

- Culver Blvd./Lafayette Place.
- Culver Blvd./Main Street.
- Culver Blvd./Cardiff Ave.

Access management features:

- No driveways are located on Culver Boulevard.
- Some alleyways are located in back of buildings for loading.
- Culver Boulevard has center medians that act both as traffic control devices and opportunities for landscaping and signage.

Signals are located at every intersection in this area (five signals within one-fourth of a mile)

Safety Characteristics

- High visibility ladder-style crosswalks.
- Countdown pedestrian signal heads at some locations.
- Large push buttons for pedestrian signal phase recall.

Strengths and Successes

The section of Culver Boulevard in the downtown serves many functions. It is the central retail and business corridor for the downtown Culver City area. It also serves as a connector between the two segments of Washington Boulevard and carries large volumes of through traffic along the Culver and Washington corridors. Four local bus lines and one express line converge on this segment of roadway. The roadway has been designed for large volumes of traffic, but the many traffic signals in this segment allow for the movement of pedestrians to cross the street at reasonable intervals. Sidewalks are very wide to facilitate pedestrian movement and the large amounts of plantings create a pleasant walking atmosphere. Crosswalks lack curb extensions that would reduce the crossing distance for pedestrians. Parking prohibition during peak periods is not for utilization of parking lanes as travel lanes, but appears to be a method of reducing friction on traffic flows during peaks.

Intersection approaches do not have advance stop bars that would improve the visibility between vehicular traffic and pedestrians at crosswalks. The sidewalk areas work well because there are no driveways to cross and building entrances are located on the sidewalk. Parking is provided on the street as well as in parking structures in back of the stores and shops. Some of the restaurants and cafes have outdoor seating on a portion of the sidewalk. Street trees have decorative lights to create a festive atmosphere in the evening. A farmers' market occurs on Main Street adjacent to Culver Boulevard every Tuesday afternoon. This weekly event brings pedestrians to the downtown area and contributes to the active and pedestrian-friendly nature of the downtown Culver City area.

CSD Elements to Strengthen

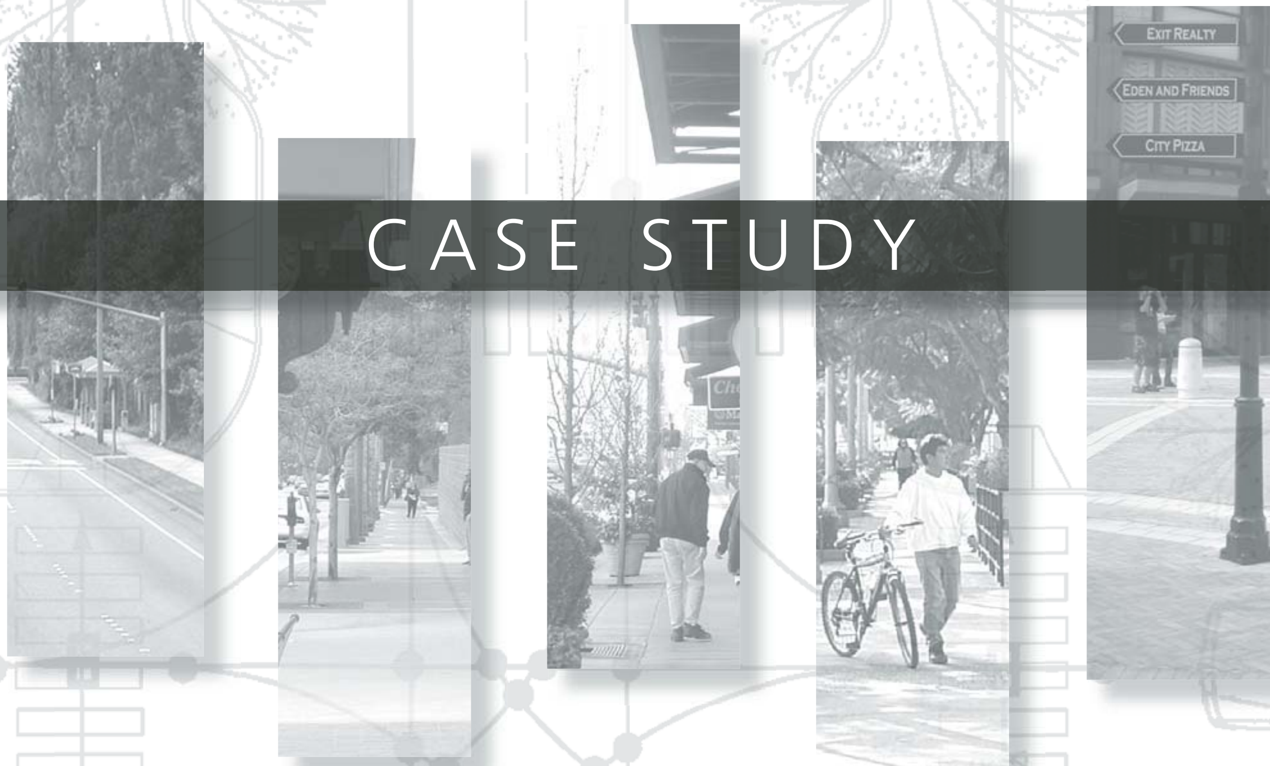
- Elimination of peak period parking prohibitions.
- Curb extensions at intersections.
- Introduction of high-density housing into the corridor.

Typical Cross-Section

North side of street only:

• Sidewalk width:	8–30 ft.
• Planting strip:	8.5 ft. (South side)
• Treewells:	6.5 ft. (North side)
• Parking lane:	8 ft.
• Outside travel lane:	13 ft.
• Inside travel lane(s):	13 ft.
• Turn lane:	10 ft.
• Median:	16 ft.

CASE STUDY



Addison Circle, Addison, TX

Case Study: Arterial Avenue in Urban Center Context

Quorum Drive, Addison, TX

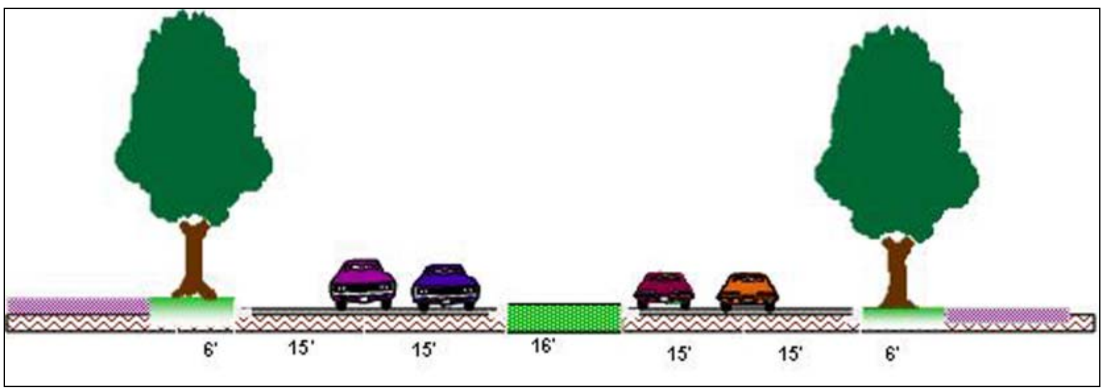
Regional Location

The Town of Addison is a first-ring, edge-city suburb north of Dallas. The town enjoys strategic transportation advantages, such as having an airport that caters to corporate clientele, good access from the Dallas North Tollway (a major north-south link to downtown) and IH 635 (Lyndon B. Johnson or the outer loop).

Addison has a large employment base (45,649), but a disproportionate share of households (7,879). This means that during the working hours of the weekday the population will swell to more than 50,000 people only to dwindle to around 14,000 by close of business day. This case study concentrates on Quorum Drive and the development that has occurred around it during the last 20 years.

Functional Classification

Quorum Drive is designated as a minor arterial according to the Town of Addison's thoroughfare plan. The roadway was constructed in 1983 as a reliever route for construction that was taking place on the Dallas North Tollway. Therefore the roadway was designed for through-movement of automobile traffic. The original roadway as depicted in Figure 1 had a typical four-lane median divided cross section. It was not until a few years later (early 1990s) that the street started to add the attributes that make it livable. These attributes are discussed further in the land use/street integration section.



Context Zone—Urban Center (CZ-5)

The section of Quorum Drive from Goodman Road to the North to 400 ft. south of the roundabout is within an urban center (CZ-5) area called Addison Circle. The town center type development has the following characteristics: Commercial mixed use (office over retail/service) with medium- to high-density residential. The area contains some ground floor cafes with street seating. Retail consists of specialty shops (book, music, dress and beauty stores). There are also many insurance, financial and other service-related storefronts that add to the character and activity level of the area. Building facades are two to four stories with some taller buildings. No setbacks and parking is on the street or in the rear of buildings in parking structures.

Surrounding Land Uses

Addison Circle is an 80-acre high density, mixed-use town center. First proposed in the town's 1991 comprehensive vision plan, the town center was a joint effort by the property owner, Gaylord Properties and two development firms, Post Properties and Champion Partners. When built-out the area will contain 3,500 residential units and up to 4 million sq. ft. of office, hotel and retail space. Typical land uses within Addison Circle and along Quorum Drive include: residential over office, residential over retail and office over retail.

Thoroughfare Elements

Functional class:	Minor arterial
Jurisdiction:	City
Through lanes:	4
Turn lanes:	Center left-turn lane
Median:	Raised
Sidewalks:	Both sides
Planting strip:	Tree grates in sidewalk
Speed limit:	35 mph
Drainage:	Urban, curb and gutter
Parking:	Parallel
Bicycle lanes:	None
Transit:	Six local/limited routes
ADT:	12,000

Land Use/Street Integration

Livability Features

- Sidewalks vary from 8 to 24 ft. in width.
- Building entries at back of sidewalk.
- Good street connectivity.
- Street cafés.
- Pedestrian scaled lighting/urban design features.
- Healthy and closely spaced street trees.
- On-street parking buffers sidewalk from travel lanes.
- Unique fountains and public art.
- Frequent benches, movable chairs and shady spots.
- Trash receptacles are hidden.
- Abundance of park space.
- Attention to detail in streetscape amenities.

Mobility Features

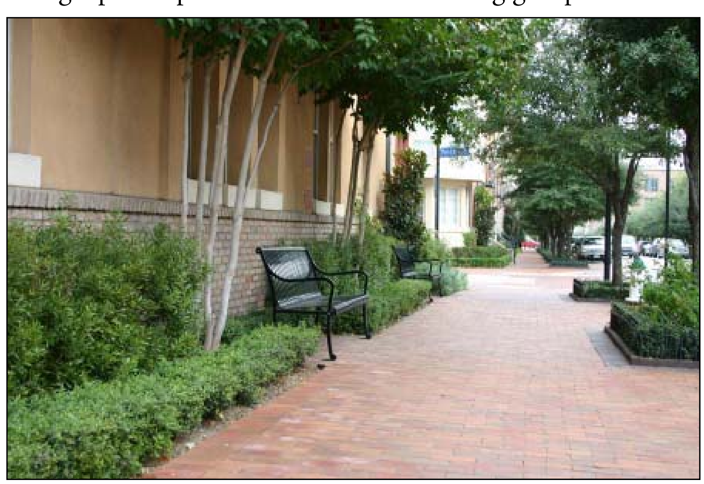
- Three local routes and one express route.
- Local bus routes (31, 36, 183).
- Express bus (205).
- Suburban bus routes (333, 341, 344, 350, 361).
- Cross-town buses (400, 463, 488).
- Access management (buildings are rear accessed, median, grid system and mews).
- Bicycle parking.
- Excellent access to the Dallas North Tollway and IH 635.
- Local circulator bus that is unique in character (trolley) could feed transit center and relieve lunchtime traffic.

Safety Characteristics

- Curb extensions at intersections.
- High visibility bricked crosswalks.
- Roundabout reduces conflict points for pedestrians (from 36 to 16).
- Street trees, planters and parallel parking shelter pedestrians from passing cars.
- Lack of driveways reduces conflicts for pedestrians, bicyclist and autos.

Strengths and Successes

Addison Circle is an excellent example of a new suburban town center that is integrated into the existing community. More importantly, a pedestrian-friendly street grid, a series of public parks and a landmark sculpture have defined a focus for community life. Adjacent to a traffic-calming roundabout, three mid-rise buildings wrap structured parking, embracing a public park created from an existing group of trees. A public esplanade and adjacent retail, residential and office uses reach towards the Dallas North Tollway to establish a highly visible commercial presence.



Factors in the Success of the Development in Addison Circle

- Within walking distance of major centers of employment, retail and entertainment.
- Adjacent to a proposed Dallas Area Rapid Transit (DART) station location.

- Near the Town of Addison's conference and arts center, the nearest manifestation of a community center that exists in Addison today.
- Addison Circle is being used as the temporary home for community activities, art fests, festivals and special events.
- The parcels surrounding Addison Circle are large enough to create a special district that will have mixed housing with employment.

Factors in the Success of the Re-Design of Quorum Drive

- The original roadway was modified based on a traffic impact analysis and the new roadway section is a result of high-quality public infrastructure costing three times the normal city allocation for streetscape and landscape elements. This framework incorporated a district-wide, pedestrian-friendly, street grid made up of residential collector streets and a series of more randomly spaced garage access mews, wide sidewalks, paved crosswalks, neck downs, shade trees, benches, signage and outdoor lighting.
- The key-planning imperative was to avoid the isolated self-contained development pattern of the typical North Dallas garden apartment complex. The plan therefore extends this road/sidewalk framework in all directions to surrounding activity generators, creating meaningful links to centers of employment, entertainment and shopping.
- The land-use plan has two sub-areas. The first, the interior mixed-use zone, was planned for approximately 3,000 to 4,000 residential units with life support retail and community services. This zone also called for restrictions on large-scale commercial uses in order to avoid traffic generation that impacts the scale and character of the pedestrian friendly street system. The second sub-area fronted a major highway and is planned as a mixed-use zone. It permits up to 4 million sq. ft. of commercial space, ranging from high-density office, residential, hotels and commercial uses, creating a potential employment base for approximately 10,000 jobs.
- An urban form that uses mid-rise buildings, corridor streets and the layering and mixing of uses with residential development over street level supports retail and "in-home" offices. The increased activity creates a sense of neighborhood by reclaiming the public street space and building up a self-policing street life.
- Development controls that go beyond typical zoning and building code requirements set standards for exterior finishes, site landscaping, the compatibility of building scale, setbacks and lot coverage, and enclosure and screening of parking for all categories of land use.
- A public open space system is designed to reflect the likely "renters-by choice" tenant profile, including urban parks, jogging trails, a large public space for the town sponsored special events and the central feature of the district, a circle or round point. This landmark feature will ultimately becomes a special place within the community and an opportunity to create a unique signature for the town that will be recognized as

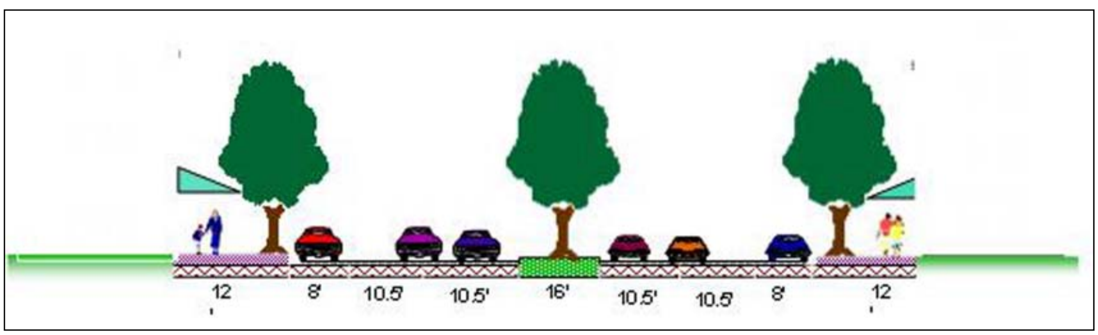
one of the major landmarks in the Dallas/Ft. Worth Metropolitan area.

CSD Elements to Strengthen

- No transit shelters present or defined stops.
- Area needs better pedestrian access to transit station.
- Too many dull service related businesses (insurance, travel and financial) at street level.

Typical Cross-Section

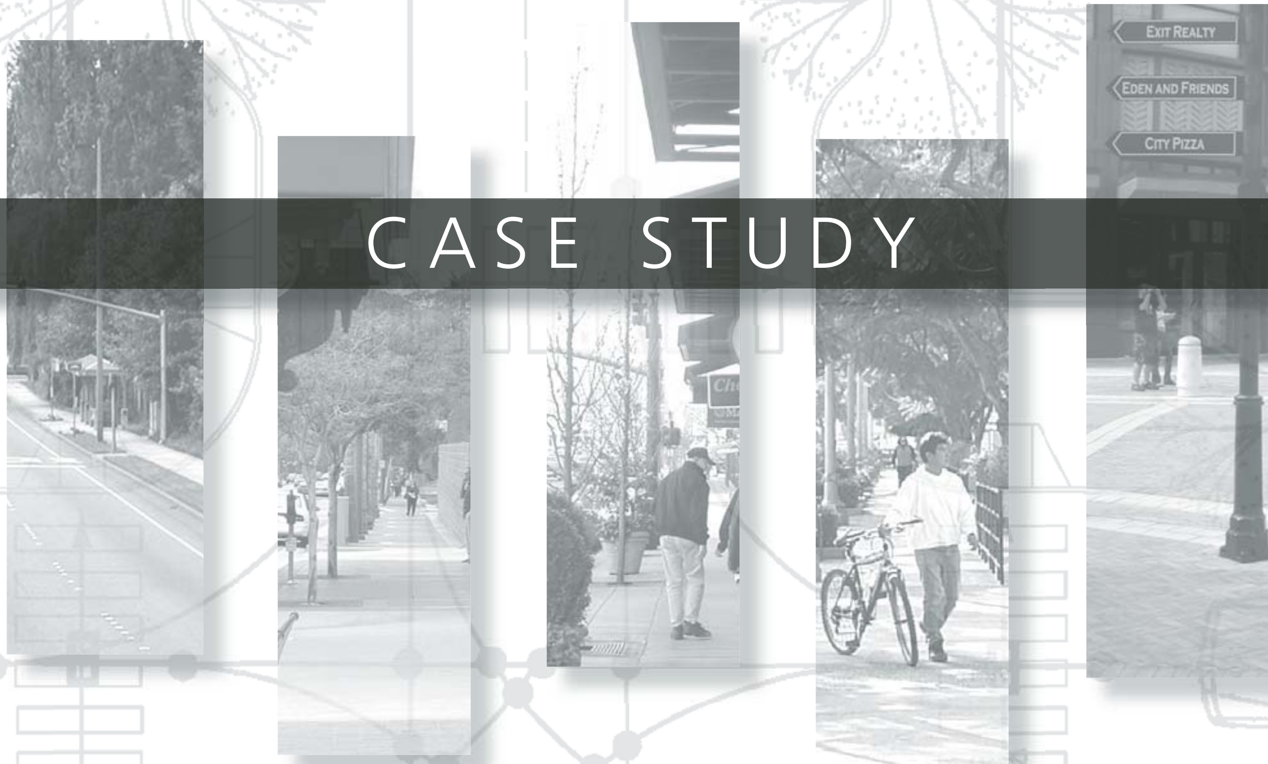
Sidewalk width residential areas:	8 ft.
Retail areas:	12–24 ft.
Planting strip or treewells on both sides:	5 ft. by 5ft.
Parking lane:	8 ft.
Outside travel lane:	10.5 ft.
Inside travel lane:	10.5 ft.
Median/turn lane:	16 ft. median, 10.5 ft. turn lane



Acknowledgments

Aerial Photographs—Ron Greteman owner of Aerial Photomaps
"ADDISON CIRCLE—BEYOND NEW URBANISM," John R. Gosling ARIBA, AICP Vice President, RTKL Associates Inc.
Town of Addison Transportation Plan, Parsons Transportation Group, June 1998
Carmen Morano, Town of Addison
Photographs, Bill Nygard, KHA
Transportation Planner, Andrew Howard, KHA

CASE STUDY



Washington Avenue, Miami, FL

Case Study: Arterial Avenue in General Urban/Urban Center

Washington Avenue, Miami Beach, FL

Washington Avenue is located in the Southpointe development of Miami Beach. It is in a mix of uses that transition from retail/commercial to commercial/residential, in a new urban center adjacent to the Historic Art Deco District. Innovative design treatments include a raised intersection with adjacent public plaza, on street parking and wide sidewalks to building front (includes planting/treewell). There is high pedestrian movement along the corridor as well as perpendicular to the corridor (from residential neighborhood to the ocean). Metro Dade County bus lines serve the corridor, including a local electric bus that runs from a major regional park to major commercial corridor and terminates in an interactive fountain on the intracoastal waterway. The park will connect into a bay walk that proceeds along the intracoastal waterway.

Context Zone

CZ-4 and CZ-5.

Surrounding Land Uses

Medium- to high-density residential, mixed use and commercial.

Thoroughfare Elements

Functional class:	minor arterial
Jurisdiction:	county
Through lanes:	4
Turn lanes:	none
Median:	yes
Sidewalks:	both sides (13-ft. Wide)
Planting strip:	tree wells in sidewalk
Speed limit:	30 mph
Drainage:	urban, curb and gutter
Parking:	parallel
Bicycle lanes:	none
Transit:	local city electric bus route
ADT:	15,000

Livability Features

- Wide sidewalks (up to 15 ft.) provide for outdoor seating opportunities, allow for comfortable walking areas and bicycling.
- Buildings are located at zero lot lines that engage the sidewalk and increase the level of activity and use of the public realm.

- Streets are well lit at night by decorative pedestrian lighting. This provides a safer environment and encourages nighttime, as well as daytime, use.
- Mix density and uses along the street provide for a variety of attractions and level of interaction.
- Canopy trees are spaced no more than 30 ft. on center, providing an almost continuous canopy cover now, and in the future, an entirely continuous canopy cover.
- 12-ft. wide median with up-lit palm trees and lush planting softens the streetscape and adds a higher level of finish to the corridor.
- The street opens up to include a plaza that offers many gathering opportunities.
- The street is anchored by another plaza, which includes a fountain and is adjacent to a park and views of the ocean.
- On street parallel parking buffers travel lanes from sidewalk.

Mobility Features

- Frequently placed crosswalks at signed intersections.
- Local bus route with three stops along project.
- Wide sidewalks offer mobility for pedestrians as well as bicyclists and roller bladers.
- Access management features—the streetscape is paralleled by an alley way on the east side that offers access opportunities for the properties located on that side.

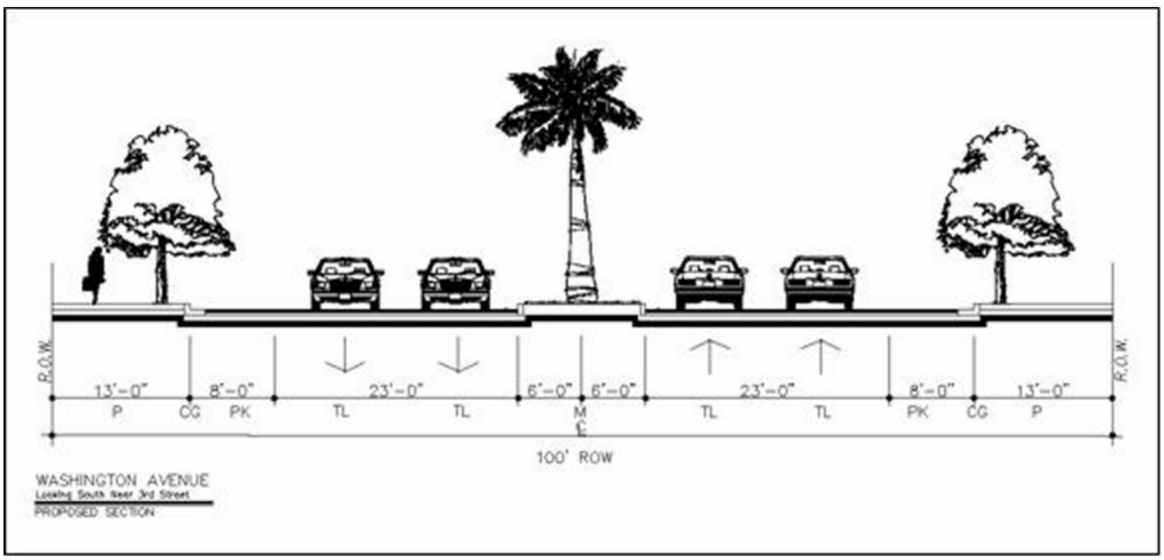
Safety Characteristics

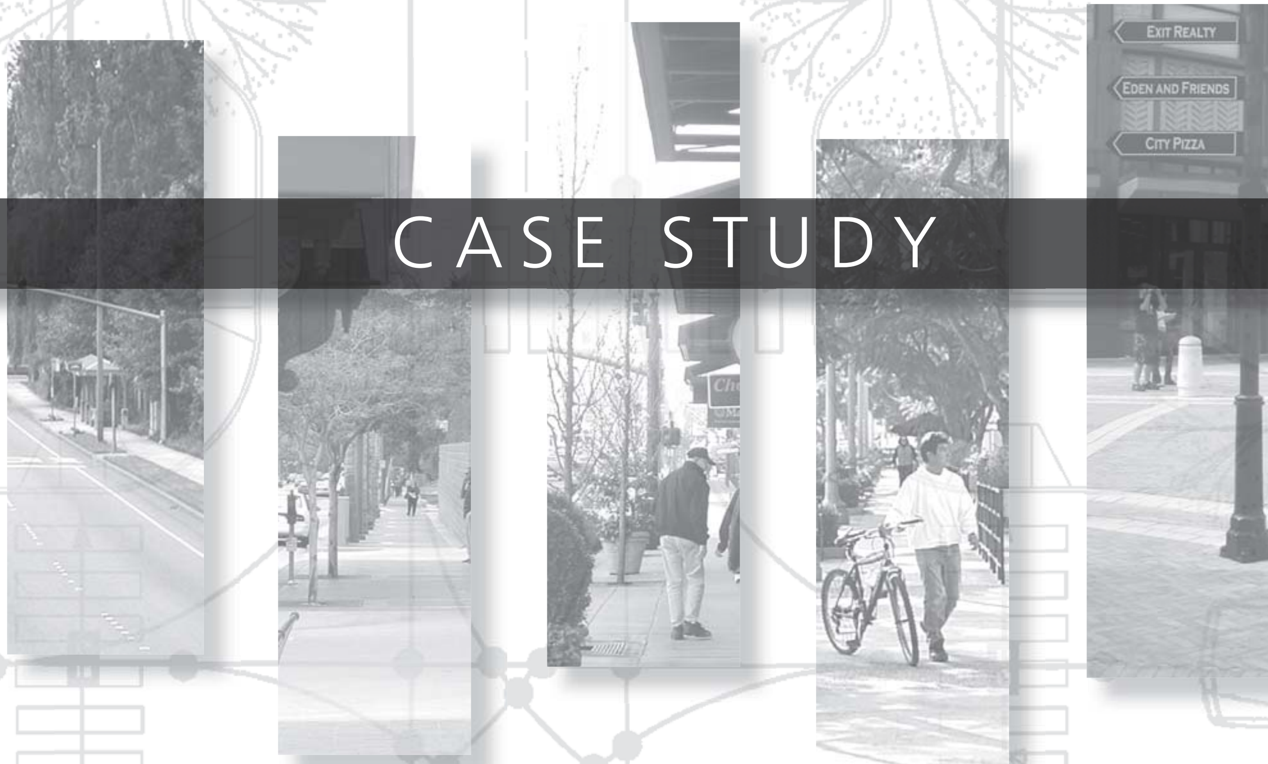
- Planting is kept below 30 in. at site triangles for clear pedestrian/vehicular visibility.
- Corridor is well lit with metal halide fixtures.
- Stop bars set back from intersections.
- Intersection with plaza is raised and has a material change to encourage slow down of traffic.
- Building placement directly at back of sidewalk offers many “eyes on the street” opportunities that provide for “natural surveillance.”

Strengths and Successes

- Overall the streetscape is a success in becoming a boulevard for the South Pointe community. Since the inception of the streetscape 3 years ago, many buildings have sprung up, which adds to the urban quality of the neighborhood. The streetscape is indeed a spine for this redevelopment.
- One element that could be strengthened in the streetscape is the addition of a light rail system that is planned to go straight down the street and have two stops along the length of the project. One stop in particular, which is planned to be located at the central plaza, will be a great amenity to attract more use to that area.

Typical Cross Section





CASE STUDY

A Avenue, Lake Oswego, OR

Case Study: Arterial Avenue in General Urban Context

A Avenue, Lake Oswego, OR

Regional Location:

The City of Lake Oswego is a suburb of Portland, OR nestled between the Willamette and Tualatin Rivers with a population of about 36,000 people. Located south of Portland, Lake Oswego is accessed by Interstate 5 and several state highways. The transportation system is comprised of a hierarchy of suburban arterials, collectors and local streets. The case study roadway, A Avenue, is located in Lake Oswego's downtown. The downtown is comprised of a grid system originally plated in the late 1800s.

Functional Classification:

A Avenue is designated as an arterial according to Lake Oswego's Transportation System Plan. Metro, the Portland region Metropolitan Planning Organization, classifies A Avenue as a major arterial serving an urban center. Metro designates A Avenue as a regional boulevard that defines the street design elements. A Avenue is included in the National Highway System.

The East End Redevelopment Plan, adopted as an ordinance in 1986, included a beautification plan for A Avenue. The plan called for landscaped medians to "soften the perceived barrier, which this very wide street creates between two main commercial areas of the East End." The beautification plan was based on a vision statement for the redevelopment area and included:

- Modifications to the left turn system (lanes in medians);
- Traffic signal system improvements;
- Overall circulation of commercial and residential streets and alleys;
- Curb extensions to reduce crossing width;
- Special pavement to "improve the visual and psychological connection between the two sides of the street;"
- Undergrounding of utilities;
- Sidewalk extensions and improvements with pedestrian amenities; and
- Street trees, street furniture, pedestrian scaled lighting and directory signage.

The A Avenue reconstruction was completed in the 1990s.

Context Zone—Urban Center (CZ-5)

The section A Avenue from 4th Avenue to State Street (Route 43) is within an urban center (CZ-5), Lake Oswego's downtown, central business district and civic center area. The downtown has the following characteristics: low to medium density commercial mixed use (office over retail/service) with low to medium density residential located one block from A Avenue. There are several free-standing office buildings and the city's civic center is located at one end of the study corridor. The downtown contains intensive ground floor retail with cafes with street seating. Retail consists of primarily local specialty shops and some national retailers. Upper floors are a mix of professional offices and personal services. Building height is primarily single story but newer development is two to three stories. Older buildings have a 5–20-ft.setback (with small parking lots in front), but all of the new development has no setback with parking located in rear lots, or structures.

Surrounding Land Uses

The downtown core is surrounded by older low-density single-family residential and medium density multi-family development. The A Avenue corridor transitions from an urban center at the east end to a single family residential at its west end. Adjacent and cross streets contain a mix of retail, hotel, restaurant and residential uses.

Thoroughfare Elements

Functional class:	Major arterial
Jurisdiction:	City
Through lanes:	4
Turn lanes:	Center left-turn lane
Median:	Raised
Sidewalks:	Both sides
Planting strip:	Tree grates in sidewalk and planting strips
Speed limit:	25 mph
Drainage:	Urban, curb and gutter
Parking:	Parallel
Bicycle lanes:	None
Transit:	Local/limited routes
ADT:	24,000

Land Use/Street Integration

Livability Features

- Sidewalks vary from 8 to 15 ft. in width.
- Each block contains several pieces of public art.
- Ample and well-placed street furniture, benches.
- Most building entries at back of sidewalk.
- Good street connectivity on older grid of streets.
- Some cafes with outdoor seating (mostly on side streets).
- Pedestrian scaled lighting/urban design features including monuments, walls and built in plazas.
- Well-maintained street trees and indigenous landscaping in median, planting strips and grated treewells.
- On-street parking, street trees and urban design features buffer sidewalk from travel lanes.
- Attention to detail in streetscape amenities.

- Public and private investment in streetscape, including private provision and maintenance of planters and landscaping.

Mobility Features

- Local bus routes.
- Access management (buildings are rear accessed, median, grid system and some alleys).
- Access to historic Willamette Trolley connecting Lake Oswego to Portland.

Safety Characteristics

- Use of alternative paving for crossings and parking lanes.
- Curb extensions.
- Raised intersection at central cross street.
- Raised median serves as pedestrian refuge.
- Street trees, planters and parallel parking shelter pedestrians from passing cars.
- Bollards and low iron fencing separate pedestrians at curb returns and narrow segments of sidewalk.

Strengths and Successes

A Avenue is a functional and highly attractive major urban thoroughfare that may be considered an exemplary application of streetscape and urban design. While the context and adjacent land uses continue to evolve, the thoroughfare provides a popular multimodal community asset.

Factors in the Success of A Avenue

- Adoption of a redevelopment plan that included a beautification plan for A Avenue.
- Careful attention to the urban design, public art and aesthetics of the street creating a desirable walking environment.
- Maximization of on-street parking (parallel on A Avenue and diagonal on some cross streets).
- Private participation and investment in streetscape and care and maintenance of landscaping.
- The downtown is part of the East End Commercial Zoning District.

CSD Elements to Strengthen

The design of the thoroughfare is very well done and little improvement can be made. Over time redevelopment of the adjoining land will need to reduce setbacks, intensify uses and increase building height to create a more defined street enclosure.

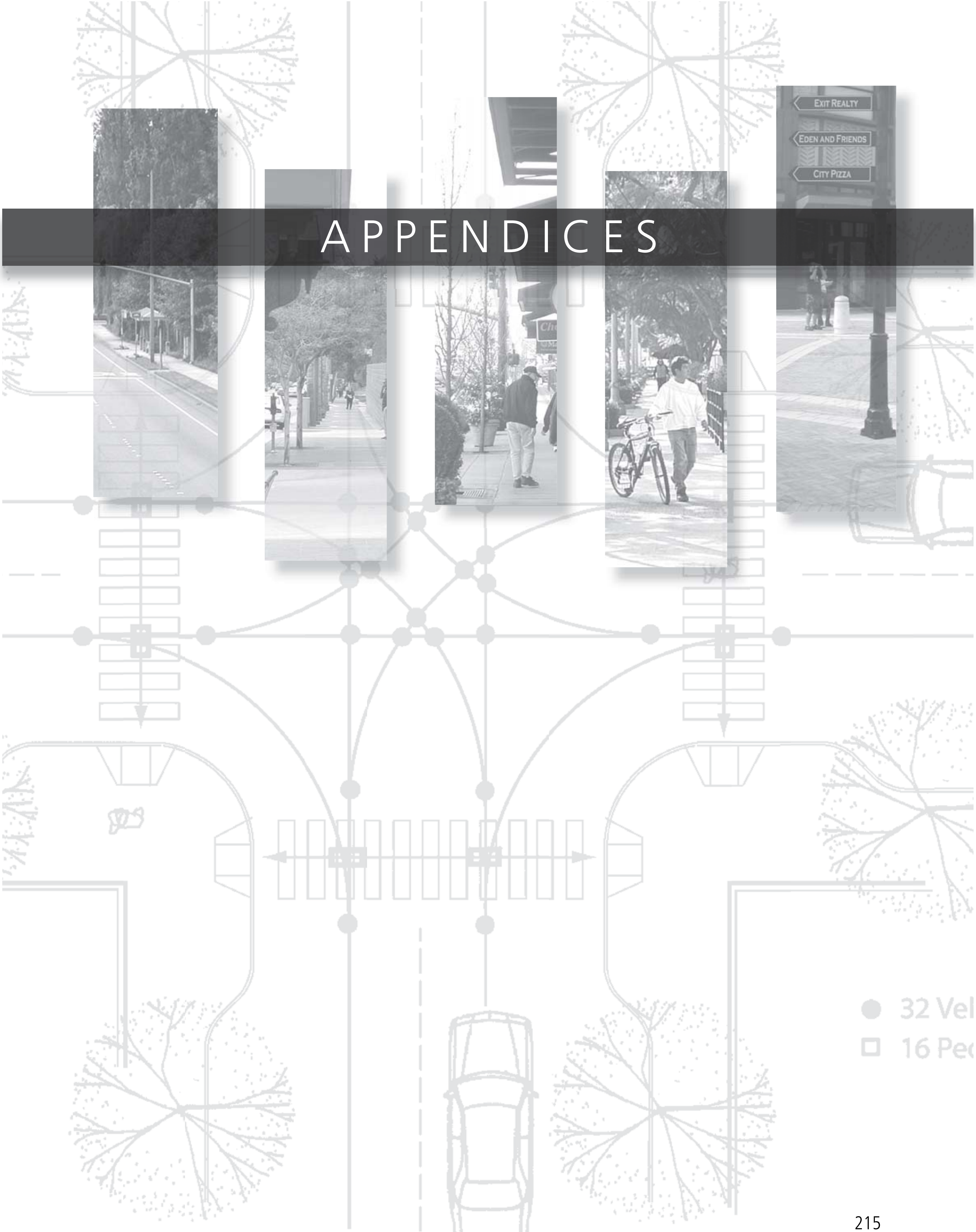
Typical Cross-Section

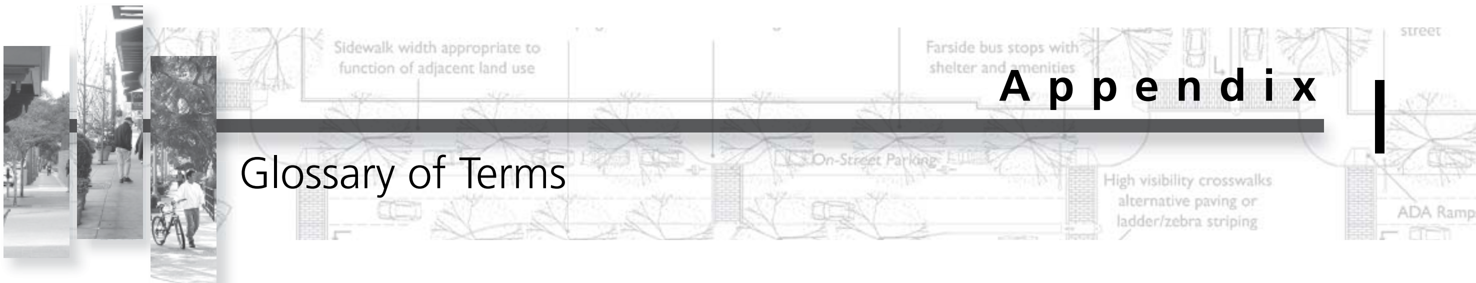
Sidewalk width retail areas:	8–15 ft.
Planting strip	4–7 ft.
and treewells on both sides:	4 ft. by 4 ft.
Parking lane:	8 ft.
Outside travel lane:	11 ft.
Inside travel lane:	10 ft.
Median/turn lane:	10–12 ft. median, 10 ft. turn lane

Acknowledgments

City of Lake Oswego Community Development, Redevelopment and Engineering Departments
Tom Kloster, Metro

APPENDICES





Glossary of Terms

Accessibility—The ability to physically reach desired destinations, services and activities.

Access Management—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 access to land. 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, but it 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 access to land. Collector streets provides both land access service 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 entity 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 socio-economic 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 (such as, 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 (such as, 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 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 (such as, 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).

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.

New Urbanism—A multi-disciplinary movement dedicated to restoring existing urban centers and towns within metropolitan regions, re-configuring 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.

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 have a strong civic character.

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.

Roadside—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.

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.

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.

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 (for example, 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.

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.

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 (such as, 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 (such as, urban design, streetscapes, architecture of adjacent buildings).

Walkable Communities—Walkable communities are desirable places to live, work, learn and play, and therefore a key component of smart growth. Their desirability comes from two factors. First, locating, within an easy and safe walk, 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 drivers. To foster walkability, communities must mix land uses and build compactly, and ensure safe and inviting pedestrian corridors.

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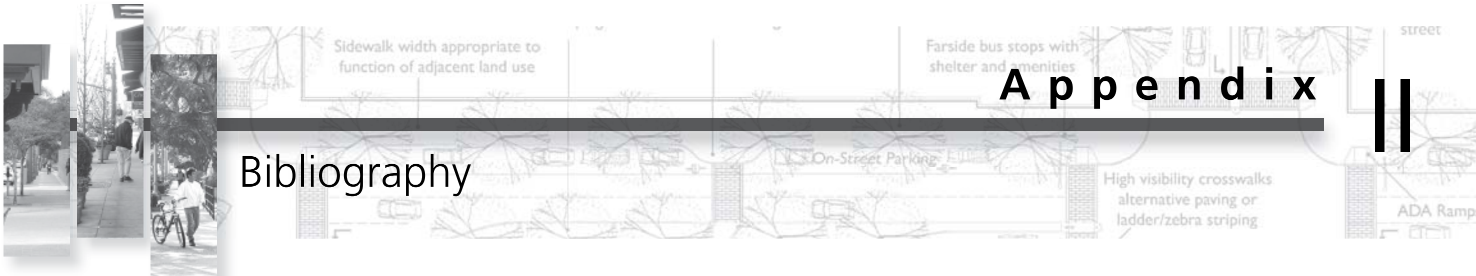

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