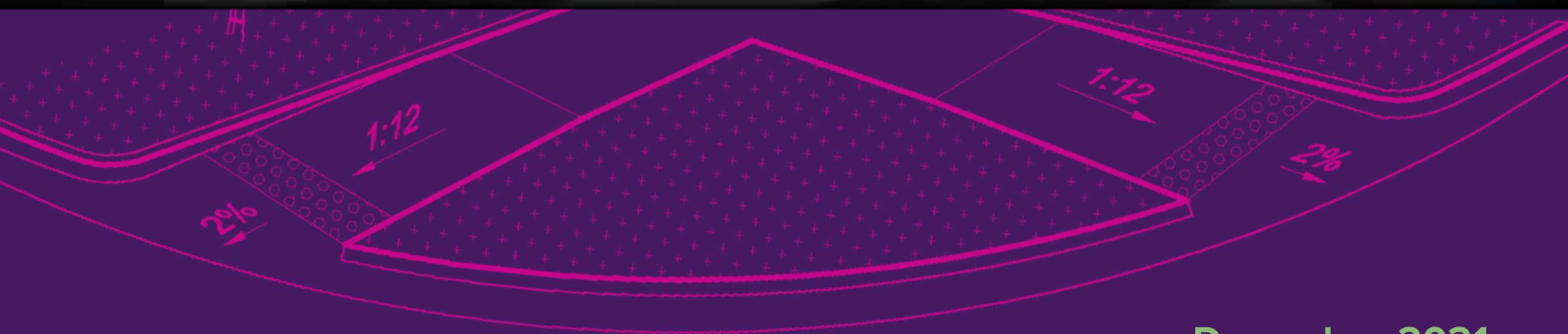


SECOND **2** EDITION

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



December 2021

American Association of State Highway and Transportation Officials

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December 2021

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American Association of State Highway and Transportation Officials
555 12th Street, NW, Suite 1000, Washington, DC 20004

ISBN: 978-1-56051-608-8 Publication Code: GPF-2

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Chapter 1

Introduction

Walking is the oldest and most basic mode of travel and is a fundamental part of the United States transportation system. Walking includes pedestrians of all types, including pedestrians with disabilities and pedestrians using assistive mobility devices. The *Manual on Uniform Traffic Control Devices* (MUTCD) (FHWA, 2009) explicitly defines pedestrians as a mode of traffic. The American Association of State Highway and Transportation Officials' (AASHTO's) *A Policy on Geometric Design of Highways and Streets* (AASHTO, 2018a), known commonly as the AASHTO *Green Book*, encourages roadway designers to provide for pedestrians:

“Interactions of pedestrians with traffic are a major consideration in highway planning and design” (AASHTO, 2018a).

Cooperation among many different stakeholders is needed to reach desired levels of safety, operations, and comfort for pedestrians. Additionally, we need to change how we design streets and highways and how we manage future growth and reshape existing urban areas. In many parts of the country, communities have already begun to change land use planning and urban design practices to accommodate and encourage walking, bicycling, and transit use.

Safety is a key consideration in the planning, design, and operation of pedestrian facilities. Because pedestrians are the most vulnerable of all transportation facility users, particular attention to pedestrian safety is necessary. Designers generally strive to meet objective safety benefits by meeting nominal design standards or through a crash analysis; however, perceived safety should also be considered when planning and designing for pedestrians. Perceived safety is the perception of how safe a person *feels* on the transportation system and can have significant effects on how they use the facilities provided. Assessment of perceived safety for the same site will vary between observers. Perceived safety is analogous to “subjective” safety as defined by the AASHTO *Highway Safety Manual* (AASHTO, 2010).

Accessibility and usability are also key considerations for pedestrian facilities, which should accommodate pedestrians of all ages and abilities. Pedestrians should be provided safe and convenient travel opportunities between traffic generators, such as homes, workplaces, businesses, schools, houses of worship, post offices, libraries, parks, playgrounds, and other destinations. Pedestrians with disabilities using assistive mobility devices must be allowed to go anywhere other members of the public are allowed to go. Power-driven mobility devices may be prohibited where they cannot safely be used as long as alternative methods for persons with disabilities to access specific services are provided (DOJ, 2010).

1.1 Purpose

The purpose of this guide is to provide information on the planning, design, and operation of pedestrian facilities along streets and highways and on independent alignments. The MUTCD (FHWA, 2009) defines a pedestrian as “a person on foot, in a wheelchair, on skates, or on a skateboard.” This is the definition that

will be used in this guide as well. This guide focuses on pedestrian facilities in the public right-of-way and addresses concepts and recommendations for site design and parking area design. This guide also recognizes the profound effect that land use planning and site design have on pedestrian mobility and addresses these topics, as well.

The primary audience for this guide is transportation professionals at the state and local levels: planners, roadway designers, and transportation engineers. These individuals make the majority of the decisions affecting pedestrian facilities on a daily basis.

This guide is not intended to be a detailed design manual to supersede the need for the application of sound principles by knowledgeable transportation professionals, nor is it intended to eliminate the flexibility needed to encourage independent designs tailored to particular situations (FHWA, 2013b). Engineering judgment based upon knowledge of pedestrian facility planning, operations, and design is needed from highway agencies to select appropriate pedestrian facilities.

This guide provides three levels of design guidelines:

1. Where design values are clearly and authoritatively established as requirements either through legislation, such as the American with Disabilities Act (ADA) (U.S. Access Board, 1990), or through standards, such as the MUTCD, design guidelines are provided using words such as *required*, *must*, and *shall*.
2. Where there is a significant body of research to support design guidance on a particular issue or topic, specific design values and recommendations are provided as *guidance*, using words like *should*.
3. Where reliable research is not available to suggest a definitive guidance statement, design *recommendations* are based upon consensus and expert opinion.

There will be instances where it is appropriate for designs to vary from the guidance presented in this guide. In some cases, application of the guidance in this guide will be limited by constraints placed on the design by the environment, budgets, or policy decisions. Designers are encouraged to document the reasons for varying from the guidance presented in this guide in their design files.

1.2 Scope

Information in this guide is presented in four chapters:

Chapter 1, Introduction—This chapter presents the purpose and scope of the guide and its relationship to other documents.

Chapter 2, Planning for Pedestrians—This chapter includes a discussion of pedestrian activity in America, characteristics of pedestrians, transportation planning for pedestrians, and the relationship between land use and pedestrian activity.

Chapter 3, Pedestrian Facility Design—This chapter addresses topics related to pedestrian facility design including the following:

- types of pedestrian facilities;
- the design of longitudinal features such as sidewalks, shoulders, and shared-use paths;
- design of pedestrian crossings; and
- design of intersections.

While the MUTCD serves as the national standard for all traffic control devices installed on any street, highway, or bikeway open to public travel, Chapter 3 includes some discussion of their application. Chapter 3 also includes information on transit, and Chapters 3 and 4 address temporary traffic control zones.

Chapter 4, Pedestrian Facility Operations, Maintenance, and Construction—This chapter addresses the maintenance of pedestrian facilities and ongoing operational concerns such as signal timing and coordination with transit. It also discusses the requirement for maintaining pedestrian access routes during maintenance and construction operations.

The scope of this guide includes planning, design, and operation of both existing and new pedestrian facilities. This guide is not intended to set forth strict standards except those that have been set authoritatively through legislation, but to present sound guidelines that provide for the needs of pedestrians and other roadway users. Where deviations from these standards or from an agency's guidelines are needed, the deviations should be based on an engineering study (and possibly public involvement). The rationale for not conforming to this guide or an agency's guidelines should be documented.

Designing pedestrian facilities involves balancing safety; mobility; preservation of scenic, aesthetic, historic, cultural, and environmental resources; and cost. These considerations should also be balanced within the constraints of design standards and guidelines. Good engineering judgment is needed to achieve this balance and provide pedestrian facilities that are welcoming, safe, and accessible.

Appropriate accommodation of pedestrian travel is a major consideration in roadway planning and design. Pedestrians are a part of every roadway environment, and attention should be paid to their presence in rural as well as urban areas. The urban pedestrian, being far more prevalent, more often influences roadway design features than the rural pedestrian does. Because of the demands of vehicular traffic in congested urban areas, it is often very difficult to make adequate provisions for pedestrians. Yet provisions should be made, because pedestrians are the lifeblood of our urban areas, especially in the downtown and other retail areas. In general, the most successful shopping areas are those that provide the most comfort and pleasure for pedestrians.... Pedestrian facilities include sidewalks, crosswalks, traffic control features, and curb cuts (depressed curbs and ramped sidewalks) and ramps for the older walkers and persons with mobility disabilities. Pedestrian facilities also include bus stops or other loading areas, sidewalks on grade separations, and the stairs, escalators, or elevators related to these facilities.

A Policy on Geometric Design of Highways and Streets, Section 2.6 Pedestrians, Subsection 2.6.1 General Considerations (AASHTO, 2018a)

1.3 Relationship to Other Documents

This guide is not intended to be all-inclusive with regard to pedestrian facility planning and design. The most recent editions of the following documents include pertinent information on pedestrian facility planning and design and should be used in conjunction with this guide. Additional documents are referenced throughout this guide.

A Policy on Geometric Design of Highways and Streets (Green Book)

The current edition of AASHTO's *A Policy on Geometric Design of Highways and Streets* (AASHTO, 2018a), commonly known as the *Green Book*, was published in 2018. The *Green Book* (see Figure 1-1) provides direction to the engineering and planning community on appropriate design measures for roadways. The *Green Book* also provides general direction on pedestrian facility design elements such as sidewalk separation from the roadway, sidewalk widths, curbs, medians, and islands.

Manual on Uniform Traffic Control Devices

The Federal Highway Administration (FHWA), with assistance from the National Committee on Uniform Traffic Control Devices (NCUTCD), adopted the current edition of the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) (FHWA, 2009) (see Figure 1-2) in 2009. Pedestrian provisions in the MUTCD are located in all nine parts of the manual. In general, the manual provides standards for the use of traffic control devices, including the design of pedestrian signs and signals. It includes warrants for the application of traffic signals. The MUTCD is the national standard for all traffic control devices installed on streets, highways, bikeways, and private roads open to public travel. All of the states have adopted the MUTCD or a document in substantial compliance with the MUTCD as their standards for the implementation of traffic control devices.

The text of this guide makes occasional reference to signs. For signs included in the MUTCD, the MUTCD sign designation is shown after the sign name (e.g., stop sign [R1-1]).

Guide for the Development of Bicycle Facilities

The current edition of the AASHTO *Guide for the Development of Bicycle Facilities* (AASHTO, 2012), commonly known as the AASHTO *Bicycle Guide* (see Figure 1-3) was published in 2012. While the *Bicycle Guide*'s main focus is the provision of facilities for bicyclists, it also provides design guidelines for shared-use paths, which also accommodate pedestrians.

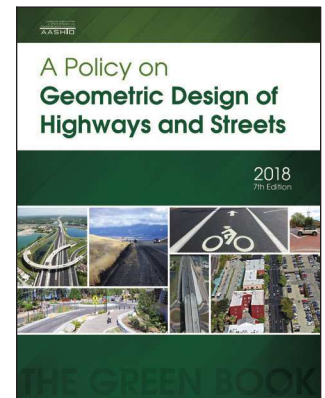


Figure 1-1. AASHTO's *A Policy on Geometric Design of Highways and Streets* (*Green Book*) (AASHTO, 2018a)

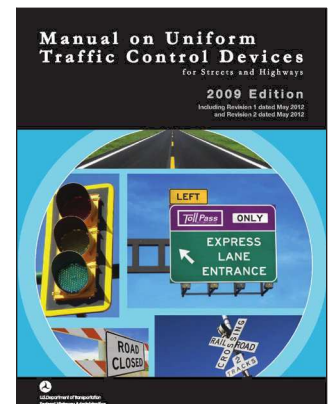


Figure 1-2. *Manual on Uniform Traffic Control Devices* (MUTCD) (FHWA, 2009)

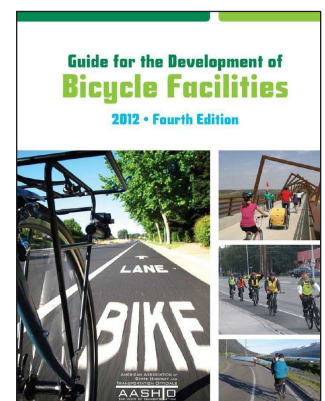


Figure 1-3. AASHTO's *Guide for the Development of Bicycle Facilities* (AASHTO *Bicycle Guide*) (AASHTO, 2012)



LRFD Guide Specifications for the Design of Pedestrian Bridges

The guide specifications in the AASHTO *LRFD Guide Specifications for the Design of Pedestrian Bridges* (AASHTO, 2009) address the design and construction of typical pedestrian bridges that are designed for and intended to carry primarily pedestrians, bicyclists, equestrian riders, and light maintenance vehicles, but not designed and intended to carry typical highway traffic (see Figure 1-4). Pedestrian bridges with cable supports or atypical structural systems are not specifically addressed.

Highway Capacity Manual

The Transportation Research Board (TRB) published the most recent edition of the *Highway Capacity Manual* (HCM) (TRB, 2016) (see Figure 1-5) in 2016. The HCM provides direction on calculating the levels of service (LOS) for pedestrians on various widths of sidewalks and crosswalks based upon walking speed. It also outlines the effect of pedestrians on traffic delay at intersections. In addition, the HCM provides an alternative method for calculating the pedestrian LOS, which considers pedestrians' perceived levels of safety and comfort based on separation from the roadway, vehicle speeds and volumes, and intersection delay.

Highway Safety Manual

The AASHTO *Highway Safety Manual* (HSM) (AASHTO, 2010) provides practitioners with current knowledge and methodologies to facilitate roadway design and operational decisions based on anticipated safety performance. The first edition of the HSM (see Figure 1-6) was published in 2010. The HSM provides tools to conduct quantitative safety analyses, allowing for safety to be evaluated alongside other transportation performance measures such as traffic operations, environmental impacts, and construction costs. Data related to pedestrians in the HSM are limited; however, AASHTO and TRB have identified pedestrian research as a priority area for future HSM editions. The HSM incorporates crash modification factors (CMFs) in its predictive methodology and provides estimates of reliable CMFs for a range of facility types. A CMF is an index of the expected change in crash frequency following a modification in design or traffic control. The Crash Modification Factors Clearinghouse includes a web-based database of CMFs and serves as an online repository of CMFs and can be used in conjunction with the HSM to help transportation engineers identify countermeasures for safety considerations. The HSM assists agencies in implementing Vision Zero and Toward Zero Deaths programs.

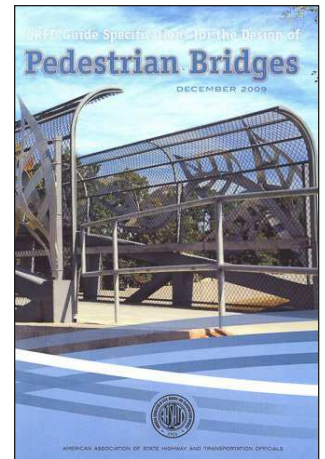


Figure 1-4. AASHTO's *LRFD Guide Specifications for the Design of Pedestrian Bridges* (AASHTO, 2009)

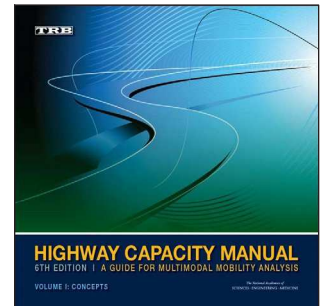


Figure 1-5. *Highway Capacity Manual* (HCM) (TRB, 2016)

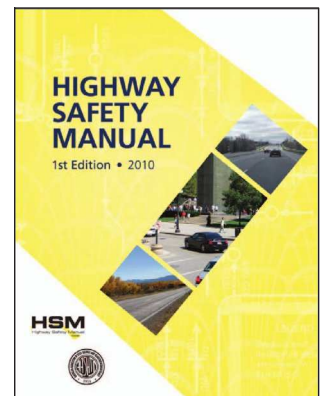


Figure 1-6. AASHTO's *Highway Safety Manual* (HSM) (AASHTO, 2010)

Americans with Disabilities Act (ADA) Standards for Accessible Design

2010 Standards for Accessible Design (DOJ, 2010)

The Department of Justice (DOJ) published revised regulations for Titles II and III of the Americans with Disabilities Act of 1990 in the *Federal Register* on September 15, 2010. These regulations adopted revised, enforceable accessibility standards, called the “2010 ADA Standards for Accessible Design” (sometimes referred to as the “2010 Standards” or just the “Standards”) (Figure 1-7). The 2010 Standards set minimum requirements—both scoping and technical—for newly designed and constructed or altered state and local government facilities, public accommodations, and commercial facilities to be accessible to and usable by individuals with disabilities. Under these ADA standards, where pedestrian facilities are provided, they must be accessible to and usable by pedestrians with disabilities. When an existing pedestrian facility is altered, the altered facility must be made accessible to and usable by pedestrians with disabilities to the maximum extent feasible and to the extent that it is not structurally impracticable to do so. Section 504 of the *Rehabilitation Act of 1973* (*Rehabilitation Act*, 1973), generally referred to as Section 504, includes similar requirements for public entities that receive Federal financial assistance.

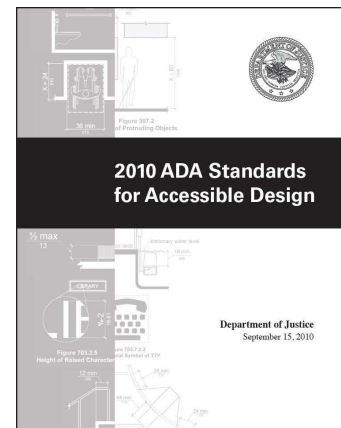


Figure 1-7. 2010 ADA Standards for Accessible Design (DOJ, 2010)

2006 ADA Standards for Transportation Facilities (USDOT, 2006)

These ADA Standards issued by the U.S. Department of Transportation (USDOT or simply DOT) are referenced by DOT’s 504 regulations at 49 CFR 27.3. Consequently, these standards apply to facilities used by state and local governments to provide designated public transportation services, including bus stops, bus stations, and rail stations. These standards are based on the Board’s *ADA Accessibility Guidelines*.

The 2006 edition of these standards is consistent with the U.S. Access Board’s updated ADA (and the Architectural Barriers Act [ABA]) guidelines, but includes a few additional requirements concerning:

- location of accessible routes,
- detectable warnings on curb ramps,
- bus boarding and alighting areas, and
- rail station platforms.

Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG) (U.S. Access Board, 2011)

The U.S. Access Board has proposed accessibility guidelines for the design, construction, and alteration of pedestrian facilities in the public right-of-way, which are often referred to by the acronym “PROWAG.” The guidelines provide accessibility criteria for sidewalks, pedestrian street crossings, pedestrian signals, shared-use paths, and other facilities

The Americans with Disabilities Act (ADA) recognizes and protects the civil rights of people with disabilities... The ADA covers a wide range of disability, from physical conditions affecting mobility, stamina, sight, hearing, and speech to conditions such as emotional illness and learning disorders...

Under titles II and III of the ADA, the Board develops and maintains accessibility guidelines for buildings, facilities, and transit vehicles and provides technical assistance and training on these guidelines... The building guidelines cover places of public accommodation, commercial facilities, and State and local government facilities. The vehicle guidelines address buses, vans, a variety of rail vehicles, trams, and other modes of public transportation. Regulations issued by the Department of Justice (DOJ) and Department of Transportation (DOT) contain standards based on ADA Accessibility Guidelines (ADAAG) and also provide information on which buildings and facilities are subject to the standards. The regulations are to be used along with the design standards they contain or reference.

(U.S. Access Board, 1990)

for pedestrian circulation and use constructed or altered in the public right-of-way. The guidelines propose requiring that a pedestrian access route be provided within sidewalks and other pedestrian circulation paths located in the public right-of-way. A pedestrian access route is defined as a continuous and unobstructed path of travel provided for pedestrians with disabilities within or coinciding with a pedestrian circulation path. Compliance with the accessibility standards within PROWAG will be mandatory once the guidelines are adopted, with or without additions and modifications, as accessibility standards in regulations implementing the Americans with Disabilities Act, Section 504 of the Rehabilitation Act, and the Architectural Barriers Act. Since PROWAG has not yet been adopted as a regulation with which compliance is mandatory, proposed PROWAG requirements are treated in this guide as best practices or guidance that should be implemented.

While the PROWAG guidelines have not yet been adopted, public rights-of-way are still covered by ADA standards. Title II requires nondiscrimination in all programs, services, and activities of public entities. In the absence of a specific Federal standard, public entities may satisfy their obligation by complying with any applicable state or local law that establishes accessibility requirements for public rights-of-way equivalent to the level of access that would be achieved by complying with the *2010 ADA Standards* or *Uniform Federal Accessibility Standards* (UFAS).

Numerous states and some local entities have adopted the proposed PROWAG as their accessibility standards for projects in the public right-of-way.

Uniform Vehicle Code

The *Uniform Vehicle Code* (UVC) (NCUTLO, 2000) was produced by the National Committee on Uniform Traffic Laws and Ordinances until 2000. The UVC was prepared as a suggested guide for state motor vehicle and traffic laws. The UVC reflected the need for uniformity in traffic regulation throughout the United States. Since its inception, the UVC was reviewed periodically and revised where warranted by new developments in state and Federal laws and by practical experience. While the UVC has not been officially updated since 2000 and is no longer being maintained, it is still a useful summary of typical state vehicle and traffic laws, and is referenced in Federal regulations. The National Committee on Uniform Traffic Control Devices has initiated efforts to review and possibly update sections of it more recently.

The UVC is referenced in this guide because it is referred to explicitly in Federal regulations. The exact text from the UVC is not used universally across the United States. However, most state vehicle codes are relatively consistent with the UVC. Consequently, the UVC is considered to represent typical vehicle codes when used as a reference in this guide.

Article V of the UVC is titled “Pedestrians’ Rights and Duties,” and contains the vast majority of information in the UVC related to pedestrians. In addition, Article II of the UVC contains a discussion of pedestrian control signals.

The DOT policy is to incorporate safe and convenient walking and bicycling facilities into transportation projects.

Every transportation agency, including DOT, has the responsibility to improve conditions and opportunities for walking and bicycling and to integrate walking and bicycling into their transportation systems. Because of the numerous individual and community benefits that walking and bicycling provide—including health, safety, environmental, transportation, and quality of life—transportation agencies are encouraged to go beyond minimum standards to provide safe and convenient facilities for these modes.

USDOT Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations (USDOT, 2010)

Designing Walkable Urban Thoroughfares: A Context Sensitive Approach

This report from the Institute of Transportation Engineers (ITE) on *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach* (ITE, 2010) (see Figure 1-8) provides guidance for the design of walkable urban thoroughfares in places that currently support the mode of walking and where the community desires to provide a more walkable thoroughfare. The report focuses on applying the concepts and principles of context sensitive solutions in the planning and design of urban thoroughfares, commonly designated in the conventional functional classification system as arterials and collectors. The report was developed to improve mobility choices and community character through a commitment to creating and enhancing walkable communities.

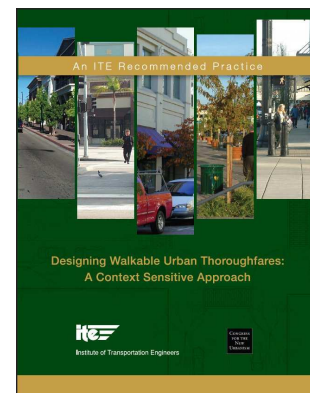


Figure 1-8. ITE's *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach* (ITE, 2010)

U.S. Department of Transportation Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations

On March 11, 2010, the USDOT issued a policy statement entitled *U.S. Department of Transportation Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations* (USDOT, 2010) to reflect the department's support for the development of fully integrated active transportation networks. The establishment of well-connected walking and bicycling networks is an important component for livable communities, and their design should be a part of Federal-aid project developments. Walking and bicycling foster safer, more livable, family-friendly communities; promote physical activity and health; and reduce vehicle emissions and fuel use. Legislation and regulations exist that require inclusion of bicycle and pedestrian policies and projects into transportation plans and project development. Accordingly, transportation agencies should plan, fund, and implement improvements to their walking and bicycling networks, including linkages to transit. In addition, DOT encourages transportation agencies to go beyond the minimum requirements, to proactively provide convenient, safe, and context-sensitive facilities that foster increased use by bicyclists and pedestrians of all ages and abilities and to utilize universal design characteristics when appropriate. Transportation programs and facilities should accommodate people of all ages and abilities, including people too young to drive, people who cannot drive, and people who choose not to drive.

1.4 State and Local Policies

States, metropolitan planning organizations (MPOs), and local jurisdictions have adopted policies and procedures to support pedestrian facilities design. The level of support ranges from standards mandating the inclusion of bicycle and pedestrian facilities to guidance documents that encourage the inclusion of pedestrian facilities.

Bicycle and pedestrian ways shall be established in new construction and reconstruction projects in all urbanized areas unless one or more of three conditions are met:

- bicyclists and pedestrians are prohibited by law from using the roadway. In this instance, a greater effort may be necessary to provide facilities for bicyclists and pedestrians elsewhere within the right-of-way or within the same transportation corridor.
- the cost of establishing bikeways or walkways would be excessively disproportionate to the need or probable use. Excessively disproportionate is defined as exceeding twenty percent of the cost of the larger transportation project.
- Where sparsity of population or other factors indicate an absence of need. For example, the *Portland Pedestrian Guide* requires "all construction of new public streets" to include sidewalk improvements on both sides, unless the street is a cul-de-sac with four or fewer dwellings or the street has severe topographic or natural resource constraints.

USDOT Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations (USDOT, 2010)

Complete Streets policies are one way that agencies can promote pedestrian facilities. When adopting a Complete Streets policy, states or communities direct their transportation professionals to make accommodation of all users common practice. The intent of these policies is to have every transportation project improve the street network for drivers, transit users, pedestrians, and bicyclists (NCSC, 2011). Actual policies vary with respect to states' or communities' desires, but all support pedestrian planning and design. Local and state Complete Streets policies should be reviewed and complied with when designing pedestrian facilities.

In addition to policies supporting pedestrian design, ADA Transition Plans help public agencies implement programs to upgrade pedestrian facilities that are inaccessible. The ADA required state and local governments to complete a self-evaluation of their facilities, programs, policies, and practices by January 26, 1995. The self-evaluation was to identify and correct policies and practices inconsistent with Title II's requirements. Self-evaluations were to consider all of an agency's programs, activities, and services, as well as the policies and practices an agency had put in place to implement its various programs and services. Remedial measures necessary to bring the programs, policies, and services into compliance with Title II were to be specified. These could include but were not limited to the following:

- relocation of programs to accessible facilities,
- offering programs in an alternative accessible manner,
- structural changes to provide program access,
- policy modifications to avoid discrimination, and
- auxiliary aids needed to provide effective communication.

Additionally, the ADA Transition Plans included components of public input and direct coordination with groups representing those with disabilities (DOJ, 2006).

A comprehensive Complete Streets policy:

- includes *a vision* for how and why the community wants to complete its streets.
- *specifies "all users"* to include pedestrians, bicyclists, and transit passengers of all ages and abilities, as well as trucks, buses, and automobiles.
- applies to both *new and retrofit projects*, including design, planning, maintenance, and operations, for the entire right-of-way.
- makes *specific exceptions* and sets a clear procedure that requires high-level approval of exceptions.
- encourages *street connectivity* and aims to create a comprehensive, integrated, connected network for all modes.
- is understood by all agencies to cover *all roads*.
- directs the use of the *latest and best design guidelines* while recognizing the need for flexibility in balancing user needs.
- directs that Complete Streets solutions will *complement the context* of the community.
- establishes *performance standards* with measurable outcomes.
- includes *specific next steps* for implementation of the policy.

National Complete Streets Coalition
(NCSC, 2011)



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Chapter 2

Planning for Pedestrians

2.1 Background

Walking provides immediate, healthy, energy-efficient motion. All travelers are pedestrians at some point during any trip they take. Some travelers make their entire trip on foot, while others walk to catch the bus or walk between their parking spaces and the front doors of their destinations.

Walking as a form of personal transportation falls within two general categories: (1) walking as a utilitarian mode (possibly replacing a trip in a motorized vehicle) and (2) walking as a form of exercise and recreation. Utilitarian trips may provide environmental and personal health benefits to the extent that motor vehicle trips are replaced with walking trips. As dependence on the motor vehicle is reduced, air quality is improved through lower emissions of greenhouse gases, and dependence on nonrenewable fossil fuels is reduced. These trips also provide economic benefits for individuals by reducing expenses for fuel or transit fees.

Perhaps the most obvious benefit of recreational trips is improved health for the individual, and to the public health overall. These health benefits can be wide-ranging and may include decreased obesity, for example (Bridging the Gap, 2012). Additional quality-of-life benefits resulting from increased walking and decreased motor vehicular traffic include reduced congestion, lowered noise levels, and increased opportunities for social interaction. ADA-compliant accessible facilities also provide additional travel opportunities for persons with mobility disabilities, enhancing their quality of life through increased choice and access.

Pedestrian facilities provide basic mobility. They provide transportation options in areas where use of other modes is limited by economic circumstances or where a significant number of people choose not to drive personal automobiles. Pedestrian facilities are also an important link to transit service.

Land use and infrastructure planning policies at the local, county, regional, and state level can help expand recreational opportunities by encouraging pedestrian and bicycle systems to interconnect with park and recreational facilities.

According to the 2017 National Household Travel Survey (NHTS), walking accounted for 10.5 percent of all trips reported (FHWA, 2018b). By 2017, the number of reported walking trips had more than doubled since 1990, from 18 billion to 38.9 billion (FHWA, 2018b). Annual walking trips per household have increased 40 percent over the same period (see Figure 2-1).

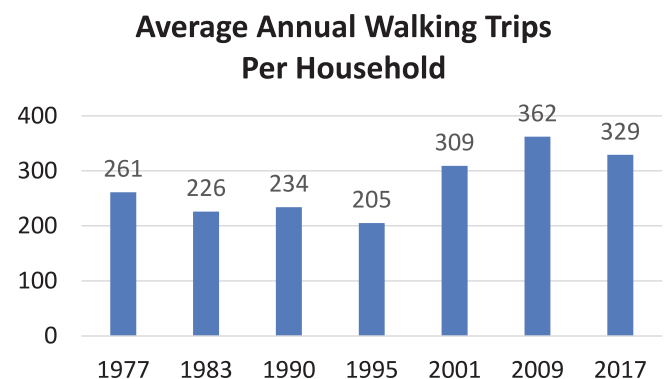


Figure 2-1. Summary of Travel Trends: Average Annual Walking Trips Per Household (FHWA, 2018b)

The U.S. Census' American Community Survey (ACS), which measures motorized and non-motorized modes, releases data each year on the numbers of workers over the age of 16 who walk or ride a bicycle to work as their primary commuting method. An analysis of the 2005–2015 national data set reveals an increase from 2.5 to 2.8 in the percentage of individuals who identified themselves as walking commuters. Many urbanized areas have greater than 5 percent pedestrian commute mode share, and some have more than 10 percent pedestrian commute mode share (Census Bureau, [undated]).

For more than 20 years, fatalities resulting from crashes involving pedestrians have consistently represented more than 11 percent of traffic fatalities (NHTSA, [undated]). While pedestrian facilities have always been an important part of transportation systems, the combination of fatality data and increasing walking trips suggests that even more emphasis needs to be placed on planning and design for safe pedestrian travel.

This chapter discusses transportation planning for pedestrians and its relationship to other transportation planning efforts.

In addition to the compelling social and economic reasons for promoting walking, state and Metropolitan Planning Organization (MPO) planning regulations of the United States Code and the Code of Federal Regulations (CFR) describe how walking is to be accommodated throughout the planning process for projects that use Federal funds. Non-motorists should be allowed to participate in the planning process, and transportation agencies are required to integrate walking facilities and programs into their transportation plans to improve the operability of an intermodal transportation system. Key sections of these regulations include the following:

The scope of the metropolitan planning process “will address the following factors...(2) Increase the safety for motorized and non-motorized users; (3) Increase the security of the transportation system for motorized and non-motorized users; (4) Protect and enhance the environment, promote energy conservation, improve the quality of life...” (23 CFR 450.306[a]). See 23 CFR 450.206 for similar state requirements (23 CFR 450.306[a]; 23 CFR 450.206).

Metropolitan transportation plans “...shall, at a minimum, include...existing and proposed transportation facilities (including major roadways, transit, multimodal and intermodal facilities, pedestrian walkways and bicycle facilities, and intermodal connectors that should function as an integrated metropolitan transportation system...” (23 CFR 450.322[f]). See 23 CFR 450.216(g) for similar state requirements (23 CFR 450.322; 23 CFR 450.216).

The plans and transportation improvement programs (TIPs) of all metropolitan areas “shall provide for the development and integrated management and operation of transportation systems and facilities (including accessible pedestrian walkways and bicycle transportation facilities)” (23 U.S.C. 134[c] and 49 U.S.C. 5303[c]). 23 CFR 450.324(c) states that the TIP “shall include ...trails projects, pedestrian walkways; and bicycle facilities...” (AASHTO, 2018a; 23 U.S.C. 134; McMillan et al., 2006).

23 CFR 450.316(a) states that “The MPOs shall develop and use a documented participation plan that defines a process for providing...representatives of users of pedestrian walkways and bicycle transportation facilities, and representatives of the disabled, and other interested parties with reasonable opportunities to be involved in the metropolitan planning process.” 23 CFR 450.210(a) contains similar language for states. See also 23 U.S.C. 134(i), 23 U.S.C. 135(f), 49 U.S.C. 5303(i), and 49 U.S.C. 5304(f) for additional information about participation by interested parties (23 CFR 450.316; 23 CFR 450.210; 23 U.S.C. 134; 49 U.S.C. 5303; 23 U.S.C. 109; 49 U.S.C. 5304).

2.2 Continuum of Walkability

Nearly all roadways, except some freeways and expressways not open to pedestrian traffic, provide some level of pedestrian accommodation. At the other end of the spectrum from freeways and expressways are pedestrian malls or plazas, which exclude most motor vehicle traffic (possibly allowing for delivery vehicles). Between the two extremes are roadways that provide varying levels of pedestrian and vehicular priority. To describe these varying levels, the Institute of Transportation Engineers (ITE) and the Congress of New Urbanism created a Continuum of Walkability (ITE, 2010). This continuum can be used to classify roadways on their potential use by pedestrians. Where a roadway falls in this continuum is a function of what facilities the community or agency decides to provide for the different modes of transportation. The depiction of this continuum of walkability is shown in Figure 2-2.

Figure 2-3 represents this continuum of walkability as it applies to roadway functional classifications. Features promoting pedestrian mobility are not required on freeways that prohibit pedestrians. Along rural highways and suburban highways, provision of pedestrian facilities may be considered, where needed. As the functional classification trends toward rural town, suburban, and urban land uses, greater accommodation for pedestrian mobility, i.e., better facilities and linkages, is increasingly likely to be needed.

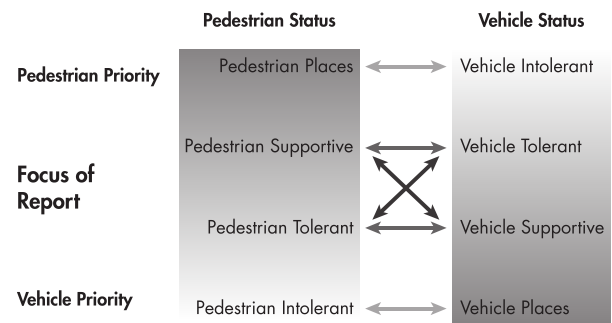


Figure 2-2. Continuum of Walkability (ITE, 2010)

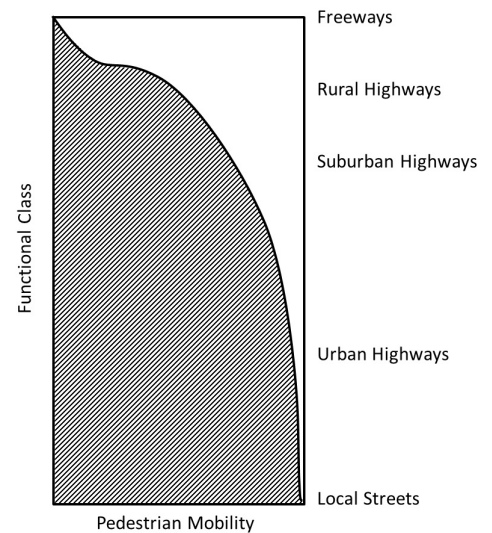


Figure 2-3. Pedestrian Mobility with Respect to Roadway Type

2.3 Walk Decision Factors

The current level of walking in the United States is low compared to the number of people who say they would walk if safe facilities were available. A 2002 telephone random sample survey of more than 800 Americans over the age of 18 showed that more than half (55 percent) of the respondents would rather walk than drive more throughout the day in order to exercise or to access destinations. Almost two-thirds (63 percent) of the respondents said they would like to walk more to stores and other places when running errands. Additionally, 84 percent stated they favor using part of the transportation budget to design streets with sidewalks, safe crossings, and other strategies to reduce motor vehicle speeds in residential areas and make it more comfortable to walk, even if this means driving more slowly (48 percent “strongly supported”) (Belden Russonello & Stewart, 2003).

The decision of whether to walk usually takes into account the distance of the trip, perceived safety of the route, and the comfort and convenience of walking versus using an alternative mode. However, for many Americans, walking is the only available option. According to the 2009 National Household Travel Survey (NHTS), 9.8 million U.S. households (approximately 9 percent) do not own a car (FHWA, 2018b). This proportion is often higher in urban areas—as population density increases, the percent of households without a motor vehicle increases (see Table 2-1).

Furthermore, the NHTS reports 32 percent of the total population does not have a driver’s license, and 15 percent of the population was reported as under 16 years of age. Based on data from 1983 to 2014,

recent decreases in the proportion of persons with a driver's license have been observed across all age groups (Sivak and Schoettle, 2016). For this large portion of the population who do not regularly drive, access around their communities by foot is particularly vital, whether these trips are to school, the store, healthcare, or a nearby transit stop.

Quality pedestrian environments include more than the provision of accessible sidewalks—attention to subtle design features is needed to encourage pedestrian activity. In conventional design practice, different entities are responsible for various parts of the pedestrian environment. For example, city planners lay out the overall roadway network and influence land use, roadway engineers design roadways, landscape architects enhance the visual character of the roadway, law enforcement promotes security along roadways, and architects and site engineers design the parcels along the streets. Compatibility between the roadway and the adjoining space involves coordination between developers, property owners, public agencies, and a variety of design professionals, and is key to creating desirable conditions for pedestrians.

Generally, areas with high levels of walking share the following characteristics:

- a mix of land uses;
- direct and convenient pedestrian connections between destinations;
- pedestrian facilities adequately separated from fast-moving vehicular traffic;
- low-speed, low-volume alternatives to high-speed arterials;
- safe and convenient street crossings;
- short block lengths;
- presence of shade during daylight hours;
- adequate lighting at night;
- a pleasant visual environment;
- perceived high level of safety;
- perceived high level of personal security;
- well-maintained facilities; and
- public transit.

Table 2-1. Percent of Households without Motor Vehicle Availability by Population Density (FHWA, 2018b)

Population density (persons per square mile)	Percent of households with no motor vehicle availability
Less than 2,000	4.38
2,000 to 4,000	6.39
4,000 to 10,000	8.43
10,000 or more	28.44

2.3.1 Distance and Densities

Distance is the primary factor in the initial decision to walk. The majority of pedestrian trips are 0.25 mi (0.40 km) or less, with 1 mi (1.6 km) generally being the limit that most people are willing to travel on foot—87 percent of walking trips are less than 1 mi (1.6 km) (FHWA, 2018b). Walking trips as part of a commute are longer; the average walking commute length is approximately 1 mi (1.6 km). Most people are willing to walk 5 to 10 minutes at a comfortable pace to reach a destination. Since approximately 25 percent of all transportation trips are 1 mi (1.6 km) or less in distance (30 percent in urban areas) (FHWA, 2018b), walking has the potential to serve a significant portion of trips. The frequency of roadway crossings, including midblock crossings, can significantly affect the distance that pedestrians walk to access destinations.

Land-use patterns, community design, and population density have a significant effect on trip distance. Higher density communities or compact communities with mixed land-use patterns, or both, have higher levels of walking because destinations are more likely to be located within walking distance of homes and businesses. Reducing block lengths and increasing connectivity in urban areas can increase pedestrian mobility. Chapter 3 addresses in more detail the effect that land-use patterns, community design, and population density have on pedestrian facility design.

2.3.2 Route Directness

Pedestrian routes should provide access to destinations without the need for pedestrians to travel excessively out of their way. Direct access is important for those with mobility disabilities, but it also affects the utility of pedestrian trips for all users. Direct access may encourage more pedestrian trips. If pedestrians perceive the route to their destination as too long or too difficult, they may choose another mode. Alternatively, they may not make the trip at all.

2.3.3 Personal Safety and Security

Personal safety and security are key factors in the decision to walk, and walkway design can affect safety and security. Narrow sidewalks, or those not separated from moving traffic by space or buffering elements, result in poorer perceptions of safety for pedestrians (TRB, 2016). Signalized intersections with confusing signal indications, excessive crossing distances, fast-turning vehicles, or vehicles turning across the crosswalk on the walk phase directly affect both the perceived and actual safety of pedestrians. Long block lengths and a lack of midblock crossing locations also degrades the perceived pedestrian safety of a roadway corridor. Section 2.7.2 provides a more detailed discussion of crash types and locations.

A dark street with driveways, doorways, overgrown vegetation, and alleyways without illumination discourages walking, while a street with pedestrian-scale lighting, open spaces, and the presence of other pedestrians tends to encourage walking and create a sense of safety and security. Pedestrian-scale lighting, placed over sidewalks, is lower in height (12 to 16 ft) (3.7 to 4.9 m) than standard street lighting and is spaced closer together (about 60 ft or 18 m) (PBIC, 2017). Diversified land use can also extend the period of day in which pedestrian activity is high. While a downtown with mostly office and office support uses may have an active pedestrian environment during work hours, it may become empty during evenings and weekends. Mixed-use buildings that include residential space or activity generators, such as restaurants and shops on ground floors, add to the sense of security and activity on the street. Ideally, pedestrian facilities include “crime prevention through environmental design” (CPTED) concepts to enhance the urban environment and reduce opportunities for crime and nuisance activity. The concepts include providing opportunities to see and be seen (surveillance), using design to attract people and vehicles to some places and channel them away from others (access management), and making clear boundaries between private and public spaces to clearly establish the legitimacy of users and uses in a given location (territorial reinforcement). Additionally, CPTED concepts include maintaining an attractive physical environment that supports surveillance and promotes positive and appropriate behavior in an area (National Crime Prevention Council).

2.3.4 Personal Comfort and Attractiveness

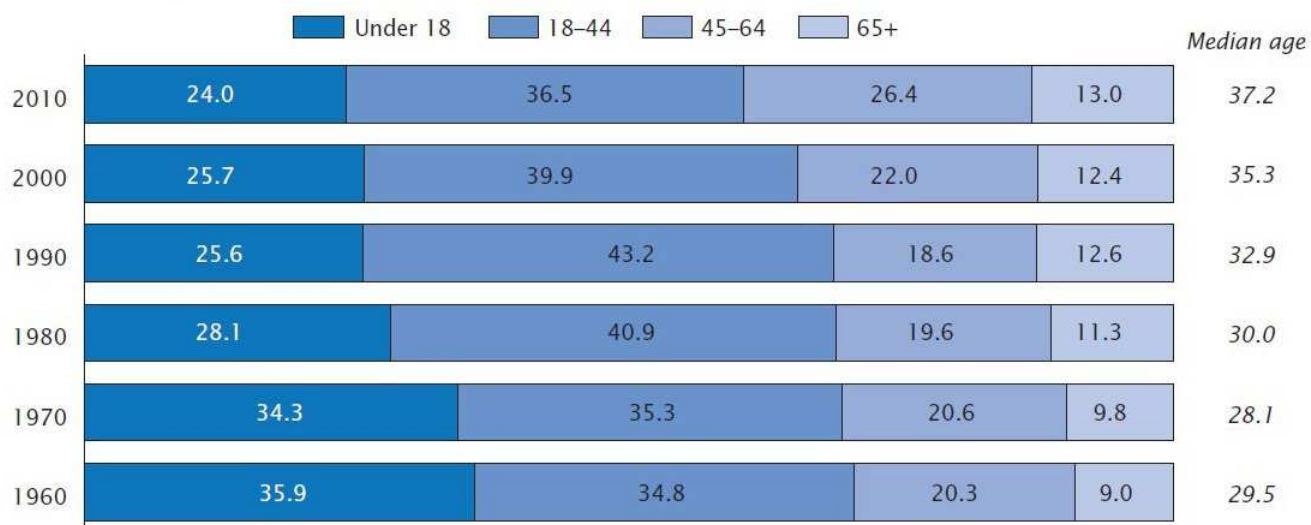
A decision to walk can be influenced by the comfort, convenience, and visual interest of the route, as well as the presence of other potential destinations along the route. Since pedestrians travel more slowly than

motor vehicles, they are more likely to prefer greater detail in their environment; and because they are not protected within a vehicle, their immediate physical environment may have a profound effect on their level of comfort. Elements such as shading along the route, separation by space or barrier from vehicle traffic, attractive buildings nearby, visually appealing landscape, and the availability of benches and areas to rest typically increase their level of comfort.

2.4 Characteristics of Pedestrians

There is no single “design pedestrian.” Pedestrians exhibit a wide range of physical, cognitive, and sensory abilities. Many have significant mobility disabilities. Additionally, many pedestrians have temporary mobility disabilities at some point during their lives. Transportation professionals should remember that pedestrians are part of the transportation mix, and a wide range of capabilities should be considered in the design and operation of pedestrian facilities. For example, children sometimes walk more slowly than adults and have a lower eye height. While many older adults are as physically and cognitively able as their younger counterparts, as a population, older adults need more time to cross streets, desire uniform surfaces, benefit from handrails in steep areas, and need places to rest along their route.

The median age of the population in the U.S. is increasing. In 2010, 13 percent of the population (40 million people) was older than 65 (Census Bureau, 2011), and more than 25 percent of this group (11.2 million people) was older than 80. The change in the age distribution of the U.S. population from 1960 to 2010 is shown in Figure 2-4. Older pedestrians are an increasing cohort of pedestrians, and the need to accommodate older pedestrians will continue to increase. Given the slower walking speeds and greater needs of older pedestrians mentioned above, it is critical to consider their needs when planning and designing pedestrian facilities.



Sources: U.S. Census Bureau, 2010 Census Summary File 1, Census 2000 Summary File 1, 1990 Census Summary File 2C, 1980 Census Summary File 2C, 1970 Census of Population, Vol. 1, Characteristics of the Population, Chapter B, Table 50, and 1960 Census of Population, Vol. 1, Characteristics of the Population, Chapter C, Table 156.

Figure 2-4. Age Distribution of U.S. Population from 1960 to 2010 (Census Bureau, 2011)

2.4.1 Temporal Characteristics

2.4.1.1 Walking Speeds

Pedestrian walking speeds range from approximately 3.0 to 4.0 ft/s (0.9 to 1.2 m/s) (AASHTO, 2018a). The MUTCD recommends and PROWAG proposes using a normal walking speed of 3.5 ft/s (1.06 m/s) or less for calculating pedestrian clearance intervals for traffic signals (FHWA, 2009; U.S. Access Board, 2011). In areas where the population includes a large proportion of older pedestrians or pedestrians with physical disabilities, a slower walking speed, such as 3.0 ft/s (0.91 m/s), may be used for design. The HCM provides criteria for slower walking speed consideration (TRB, 2016). Other factors that affect walking speed include air temperature, precipitation (rain, snow, and ice), time of day, and trip purpose. Walking speeds are typically faster at midblock locations than at intersections.

2.4.1.2 Pedestrian Flow Rate

Pedestrian flow rate is a measure of how many pedestrians travel along a sidewalk per unit of time and is often measured in terms of pedestrians per minute per foot of sidewalk width. Where there are few pedestrians on a walkway, pedestrians can choose faster walking speeds. As sidewalk congestion increases, walking speeds decrease with closer interactions among pedestrians (TRB, 2016). As the volume of pedestrians increases, pedestrian flow rate can increase until the point when volumes become so high that pedestrian walking speed is slowed, at which point the flow rate begins to fall.

The relationship between walking speed and pedestrian congestion is shown in Figure 2-5. This graphic assumes linear flow. However, in urban environments, pedestrian traffic is often much more complicated than simply two flows moving in opposite directions. Cross-flows, for example, can occur at intersections, building entrances, or on-street parking locations. Stationary pedestrians can become obstructions to the sidewalk flow and should be accounted for when calculating effective sidewalk width. Pedestrian flow rates should be considered when determining the width of the pedestrian zone on a sidewalk.

2.4.1.3 Pedestrian Start-up Time

When crossing the street, there is a delay between when the WALKING PERSON indication appears and when pedestrians step off the curb to begin crossing. The pedestrian start-up time allows pedestrians to perceive, and then react to the changing indication, and to scan the environment for encroaching vehicles. Pedestrian perception-reaction times can vary from 0.8 to 3 seconds (Fugger et al., 2000; Knoblauch et al., 1996). The HCM suggests 3 seconds as a reasonable value for pedestrian start-up time (TRB, 2016).

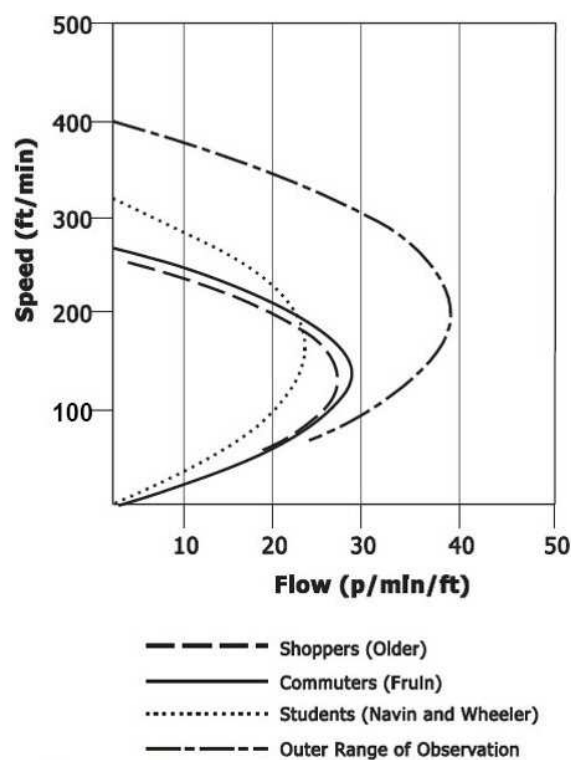


Figure 2-5. Relationships between Pedestrian Speed and Flow (TRB, 2016; adapted from Pushkarev and Zupan, 1977)

2.4.1.4 Pedestrian Stopping Distances

Pedestrian stopping distance is the distance traveled by a pedestrian while perceiving the need to stop, reacting to that need, and stopping. While many pedestrians can stop quickly when walking, others, such as persons using crutches or walkers, may have difficulty stopping quickly, particularly on a downgrade. Some wheelchair users may need up to 20 ft (6.09 m) to react and stop (Petritsch et al., 2004). Stopping distance increases on downhill slopes.

2.4.2 Spatial Characteristics

2.4.2.1 Spatial Needs of Pedestrians

In general, a simple ellipse of 1.5 by 2 ft (0.46 by 0.61 m) can be used to approximate minimum spatial needs for a single standing pedestrian (see Figure 2-6). In the design of pedestrian facilities, an area of 8 ft² (0.74 m²) should be used to provide for personal comfort with regard to the proximity of other pedestrians and to facilitate orderly flow of traffic on the walkway (TRB, 2016), but the context of the facility should also be considered when deciding special requirements. For example, in larger urban areas, less space tends to be available or expected by pedestrians, so it may be possible to reduce the space provided.

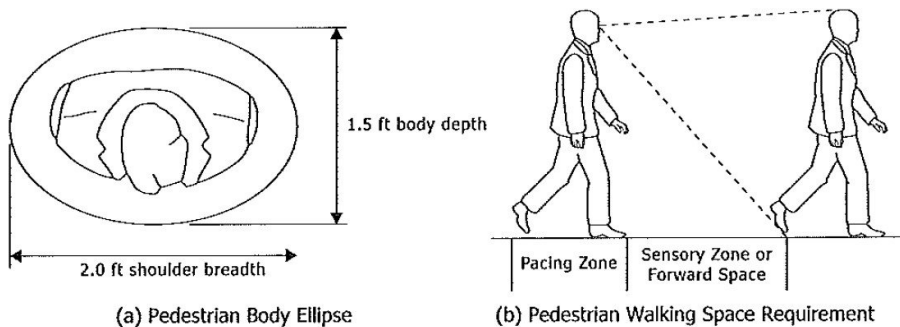


Figure 2-6. Pedestrian Body Ellipse for Standing Areas and Pedestrian Walking Space Needs [adapted from (TRB, 2016)]

The space available in front of a pedestrian affects pedestrian walking speed and flow rates. This space includes the pacing zone (space in which to make the next step) and the sensory zone (buffer space to the next pedestrian) (TRB, 2016).

Two people walking side-by-side, or passing one another, generally need 4.7 ft (1.4 m) of lateral space, while two persons in wheelchairs need a minimum of 5 ft (1.5 m) to pass one another. When pedestrian volumes increase within a given amount of space, walking rates become slower due to the decreased square footage available per person. A means of conveying this principle is the spatial bubble, which is the preferred distance of unobstructed forward vision while walking under various circumstances. Figure 2-7 illustrates the

Spatial Bubbles

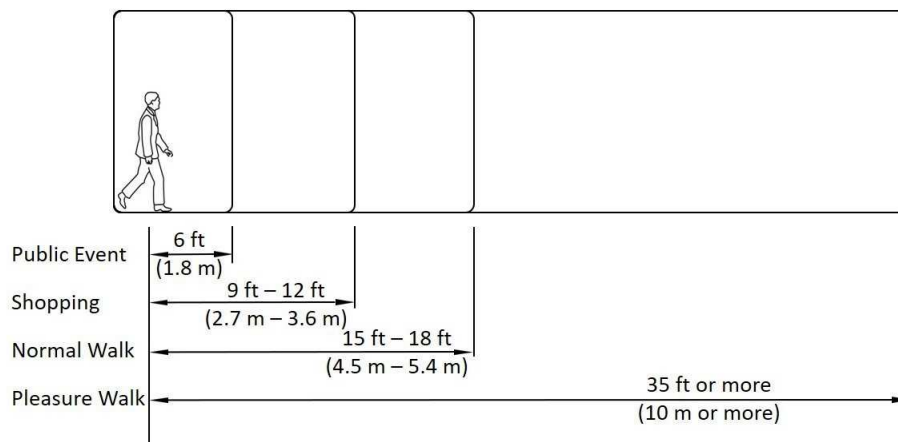


Figure 2-7. Preferred Distance of Unobstructed Forward Vision Based on Different Types of Walking (Washington State DOT, 1997)

spatial bubbles that are comfortable for pedestrians attending a public event, shopping, walking under normal conditions, and walking for pleasure (Washington DOT, 1997).

The space needed for pedestrians to turn should also be considered during the design of pedestrian facilities. A 5-ft by 5-ft (1.5-m by 1.5-m) area is the minimum space required for a person using a wheelchair to make a 180-degree turn (see Figure 2-8). Additional space enables a person using a wheelchair to turn more easily (U.S. Access Board, 1991).

2.4.2.2 Vertical Clearance for Pedestrians

The minimum vertical clearance that should be provided for pedestrians is 80 in. (2.03 m) (U.S. Access Board, 2011). Children represent a cohort whose height also needs to be considered; the height of children is particularly important at intersections and midblock crossings where parked cars or plantings can restrict sight distances for pedestrians looking for traffic and motor vehicle drivers who should be able to see them.

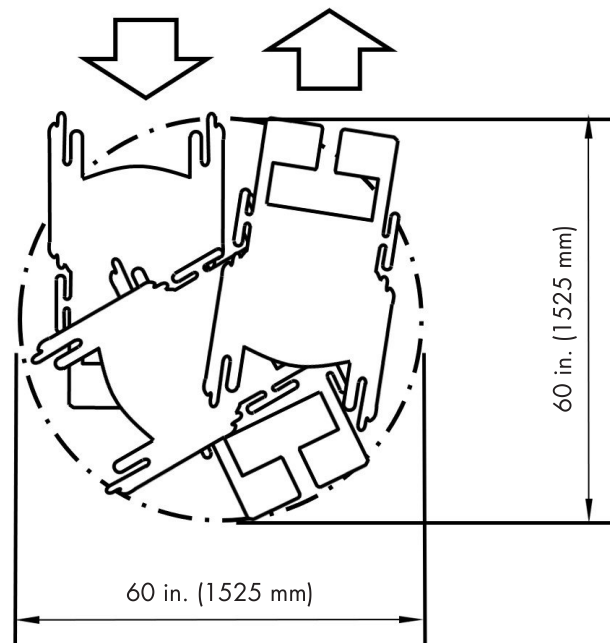


Figure 2-8. Wheelchair Turning Space (U.S. Access Board, 1991)

2.4.2.3 Surface Needs

Because wheels, canes, and crutch tips are difficult to propel over uneven or soft surfaces, ADA standards require the surfaces of pedestrian access routes and the surfaces at accessible elements and spaces that connect to pedestrian access routes be firm, stable, and slip-resistant (U.S. Access Board, 2011). A pedestrian access route is a continuous and unobstructed path of travel provided for pedestrians with disabilities within or coinciding with a pedestrian circulation path in the public right-of-way. Transitions from one surface or one element to another should be a continuous plane because warped or uneven surfaces can cause instability for pedestrians using walkers or wheelchairs (U.S. Access Board, 2011). Surface quality significantly affects ease of travel for pedestrians using walking aids. Wide grates and cracks can catch the tip of a cane or crutch, while icy or uneven surfaces can further reduce stability of those using walking aids (U.S. Access Board, 2011).

2.4.3 Mobility Issues

In 2010, 56.7 million people (18.7 percent of the 303.9 million in the civilian noninstitutionalized population in the U.S.) reported having a disability; 38.3 million people (12.6 percent of the 303.9 million) reported having a severe disability. These numbers have increased since 2005 when 49.1 million people reported having a disability and 32.8 million people reported having a severe disability (Census Bureau, 2012). As members of the “baby boom generation”—people born between 1946 and 1964—grow older,

the proportion of the population with disabilities is expected to increase. For example, people age 65 and older are three times more likely to have a disability than those ages 21 to 64 (Census Bureau, 2012). Given these realities, the need for accommodating pedestrians with disabilities within our transportation system will increase dramatically in the coming years.

Not all disabilities are permanent. Disabilities include broken limbs, hand or foot injuries, or short-term disabilities following surgery or medical treatments. Temporary reduction in visual acuity or hearing can result from various illnesses or medical procedures. Therefore, even people without a permanent disability may benefit from features designed to accommodate those with disabilities from time to time.

2.4.3.1 Pedestrians with Ambulatory Disabilities

Pedestrians with ambulatory disabilities may use devices such as wheelchairs, scooters, crutches, canes, walkers, and/or prosthetic limbs to enhance their mobility. Using such assistive devices requires hard, smooth, level, gap-free surfaces for easier maneuverability and sufficient space to get around barriers. People with ambulatory disabilities may also have limited ranges of motion or strength and balance. Specific accommodations for such disabilities include curb ramps, cross slope limitations, and touch-sensitive pushbuttons.

Wheelchair and Scooter Users

In 2010, 3.6 million Americans age 15 or older identified themselves as wheelchair users (Census Bureau, 2012). Because wheelchairs and scooters are often difficult to propel over uneven or soft surfaces, users need firm, stable surfaces and structures, such as ramps or beveled edges, where surface elevation changes. Curb ramps are required at street crossings where a pedestrian route crosses a curb or other barrier.

The stability and controllability of wheelchairs and scooters that are being used as an assistive device are affected by cross slopes and grades of facilities. Cross slopes steeper than 2 percent may cause wheelchairs to veer downhill, and manual wheelchair users need to exert additional effort to continue traveling in a straight line (FHWA, 1999a).



Figure 2-9. Wheelchair User with Assistive Animal. (Photo by Dan Burden)

Sidewalks should be constructed from non-vibratory surfaces. Vibratory surfaces, such as cobblestones, can be painful for some wheelchair users to traverse. In addition, rough decorative surfaces, such as stamped concrete, can be very uncomfortable for some wheelchair and scooter users. The use of such surfaces should be limited to areas outside the intended pedestrian access route.

Wheelchair and mobility scooter users need a wider path of travel than most pedestrians (see Figure 2-9). Sufficient width should be provided to allow for traveling together, passing, and turning around. Powered wheelchairs and mobility scooters, which are generally longer than manual chairs and need more maneuvering space, should be anticipated in walkway design.

Pedestrians with Vision Disabilities

In 2010, over 2 million people age 15 years or older in the United States reported having severe difficulty seeing, and a total of 8.1 million people reported having some difficulty seeing (Census Bureau, 2012). Loss of visual acuity is often associated with aging; conditions such as cataracts and macular degeneration become more common as people age. Most of these people are not totally blind, and may not use a white cane, dog guide, or other mobility aid. Individuals who have vision disabilities often travel independently. Pedestrians with vision disabilities may share the following characteristics (FHWA, 1999a):

- have limited perception of the path ahead (preview);
- navigate with limited information about surroundings, which provides less protection against obstacles and other dangers;
- rely on memory and unchanging conditions in familiar terrain; and
- rely on nonvisual sources such as sound and texture for information.

White Cane Users

Persons with vision disabilities may use long white canes to navigate. In the sidewalk environment, cane users typically swing the cane in an arc in front of themselves to detect objects or changes in texture or grade along their path (see Figure 2-10). Cane users benefit from “shorelines,” changes in texture, or borders adjacent to sidewalks that can be detected underfoot or by cane to identify pedestrian access routes. Detectable warnings installed at the sidewalk-street boundary convey a message to persons with vision disabilities that they are entering or leaving a vehicular route. Once the user has identified the crossing or boundary, he or she can determine how to proceed. Detectable warning installations must be designed in accordance with ADA criteria (USDOT, 2006) (refer to Section 3.6.1 for additional design information).

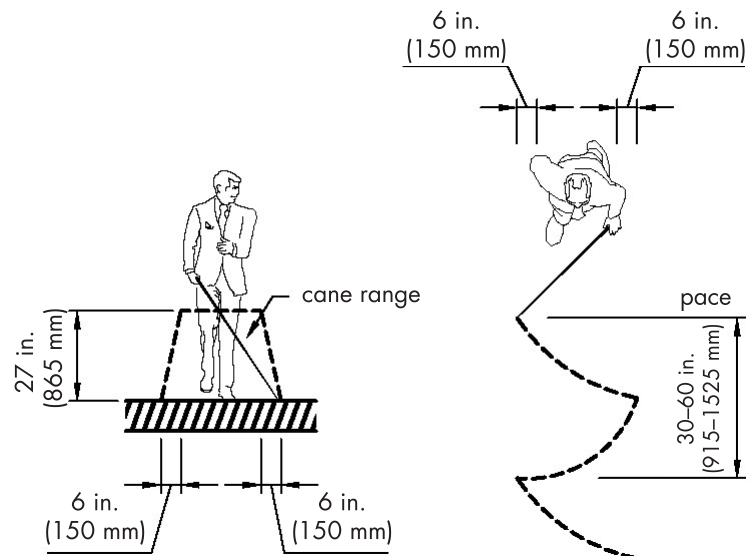


Figure 2-10. Cane Technique

Individuals with Guide Animals

Persons with vision disabilities may use guide animals (usually dogs) to aid their travel, in addition to or in place of white canes. Guide animals are not capable of making decisions for their owners but are trained to respond to a specific set of commands given by voice and hand signals. The guide animal stops to indicate stairs, curbs, and other significant changes in elevation and waits for a command from the person being guided before proceeding. Guide animals do not respond to traffic signals and may not be able to distinguish where the sidewalk ends and the street begins at a curb ramp. Intersections at which pedestrians need to deviate from a straight path to take refuge on an island or median may not provide adequate cues for persons guided by animals because guide animals are not trained to follow marked crosswalks and may view medians as obstacles. Intersections are easiest for persons guided by animals to negotiate when the line of travel from the edge of the sidewalk to the opposite curb is straight rather than skewed.

Providing Information for Persons with Vision Disabilities

Auditory, vibratory, and other cues can be used to maintain directional orientation to a destination for a person with vision disabilities. These cues can include the sound of traffic movement, the slope of curb ramps and the street, sounds and movements of other pedestrians, alignment of the sidewalks, and contrasting color and surface textures. Supplemental cues should be provided for pedestrians with vision disabilities along pedestrian routes, particularly those with unique intersection configurations, pedestrian detours, locations where pedestrians are prohibited, meandering sidewalks, or pedestrian access routes across open areas. Useful information for pedestrians with vision disabilities includes:

- detectable edge to assist in wayfinding,
- visual and textural contrast used in a consistent manner,
- accessible text messages (larger print and raised text),
- accessible pedestrian signals (APS),
- detectable warning surfaces at sidewalk–street boundaries,
- detectable barriers at locations such as sections with missing sidewalks or construction-related work, and
- adequate lighting at pedestrian level.

Information should be presented in a consistent manner, particularly when using contrasting colors and/or textures, so pedestrians with vision disabilities may interpret the intended messages correctly. If used inconsistently, strips of varying colors and textures in the sidewalk, often used as a decorative element, can be confusing to individuals with low visual acuity who may perceive a color change as a change in level or slope. Persons with vision disabilities may be confused by a texture change and may not be able to determine if it is decorative or informational.

Pedestrians with Vision Disabilities at Intersections

Pedestrians with vision disabilities typically take the following steps to cross a signalized intersection:

1. Detect arrival at an intersection by using a combination of cues such as a raised curb, the slope of a curb ramp, the absence of a building front, detectable warnings, landmarks, traffic sounds, and other wayfinding cues.
2. Orient themselves toward the crosswalk by using cues such as traffic noise, audible signals, and physical features of the environment (such as the boundary between a sidewalk and an adjacent planting strip) that are known to be (from previous experience) parallel to the crosswalk, or curb lines that are known to be perpendicular to the crosswalk.
3. Determine whether a pedestrian signal needs to be actuated, actuate it if necessary, and return to the edge of street and realign.
4. Determine when it is appropriate to begin crossing by using traffic or pedestrian surge noise cues or accessible traffic signal indications.
5. Navigate to the opposite curb through any medians, islands, crosswalk angles, or other obstacles using the sound of parallel traffic or crossing beacon.

Where pedestrian signals are not audible, persons with vision disabilities might wait for the sound of parallel traffic and/or other crossing pedestrians to identify the crossing interval and start to cross an intersection later than other pedestrians. Additionally, they might have difficulty identifying and maintaining a correct alignment across the intersection. Quiet, electric vehicles can compound these difficulties. In combination, these factors increase the time persons with vision disabilities need to cross the street. At locations without actuated pedestrian signals (where the pedestrian signals are pretimed) that are regularly used by pedestrians with vision disabilities, directional or operational information should be provided to pedestrians with vision disabilities by a sign (using raised lettering or braille) or an audible message.

At an unsignalized location, a pedestrian who has vision disability may have difficulty determining a gap in traffic. To discern a gap by hearing alone needs sufficient periods of all quiet so that the sound of a receding vehicle is not masking the sound of an approaching vehicle. Even when long gaps are available, pedestrians using hearing to judge a gap might be unable to hear approaching traffic well enough to discern an adequate gap in traffic to cross the street. Traffic control devices supplemented with audible messages can help mitigate these difficulties.

Pedestrian street crossings at roundabouts can be difficult to identify for pedestrians with vision disabilities because the crossings are located to the side of the pedestrian circulation path around the street or highway. PROWAG proposes requiring that pedestrian-activated signals or pedestrian hybrid beacons be provided for each multilane segment of each crossing, including in the splitter islands that separate the entering and exiting vehicle traffic (U.S. Access Board, 2011). PROWAG also proposes requiring multilane channelized turn lanes to have activated signals or pedestrian hybrid beacons.

2.4.3.2 Pedestrians with Cognitive Disabilities

Cognition is the ability to perceive, recognize, understand, interpret, and respond to information; it involves complex processes such as thinking, knowing, memory, learning, and recognition. Cognitive disabilities can hinder the ability to think, learn, respond, and perform coordinated motor skills, but vary tremendously among individuals. Often, persons with cognitive disabilities have limited opportunity to learn and practice navigating in pedestrian environments. Intersections with complex signals, signs, and configurations can be especially challenging.

Difficulties associated with cognitive disabilities can be partially mitigated through thoughtful design. Locating signal hardware in consistent locations at intersections makes pushbuttons and pedestrian signal indications easier to find. Similarly, consistency in curb ramp locations makes navigation through intersections easier. Extended walk intervals or other signal enhancements (e.g., leading pedestrian intervals, No Turn on Red signs, and exclusive pedestrian phases) can assist those who have difficulty discerning traffic patterns. At uncontrolled crossing locations, additional sight distance (beyond minimums) should be provided along with measures to induce motorists to drive at speeds appropriate for the situation. Wayfinding should be applied consistently, and signs should be placed in obvious locations. Signs that use pictures, universal symbols, and colors convey meaning to a broad range of people.

2.5 Documenting Pedestrian Activity

Transportation agencies can benefit from pedestrian monitoring programs that gather, store, and disseminate pedestrian data. Pedestrian monitoring programs typically include volume counts but can include behavioral and demographic data, as well. Analogous to motor vehicle traffic monitoring programs,

pedestrian monitoring programs can provide transportation agencies with ways to accurately quantify and establish existing and historical system usage as well as provide pedestrian volume trends. Pedestrian volume data provide agencies with information to support policy and planning decisions, investment decisions, design of facilities and infrastructure, operations/maintenance activities, and measuring performance and progress towards overall agency missions and goals. Without a monitoring program, agencies have to guess at the pedestrian system usage and traffic patterns on their systems when making planning, operation, and maintenance decisions to provide pedestrian facilities.

Programs to monitor pedestrian traffic by transportation agencies are relatively new but are developing rapidly. Many agencies that have conducted motorized traffic monitoring programs for decades are now developing parallel programs for pedestrian and bicycle traffic. When establishing these programs, or simply when conducting isolated pedestrian counts, agencies should be aware that monitoring programs for pedestrians and motorized activity are distinct in several ways. A significant difference is often the scale of data collection. Pedestrian data collection programs typically have a smaller number of monitoring locations than motorized vehicle count programs. Because of the smaller number of count locations and the relatively short length of pedestrian trips, the potential for extrapolating pedestrian counts across a community is limited. Pedestrian count locations are often chosen based on highest usage levels or strategic areas of facility improvement, but there are also many locations with relatively low pedestrian activity. Thus, limited location samples might represent a biased estimate of overall usage and trends for a city or state (FHWA, 2013d). Other ways pedestrian monitoring programs differ from motorized traffic monitoring include the types of facilities to be monitored (e.g., pedestrians frequently travel on shared-use paths and local streets), the data collection technologies available and their limitations, the effect that weather has on pedestrian activity levels, the unpredictability in travel movements, and the travel occurring in groups.

Coincident with the growing interest in collecting pedestrian activity data is the widespread availability of count technologies and devices. While pedestrian counts have traditionally been performed manually in the field, other generally reliable technologies now available include infrared devices (both active and passive), video-based computer imaging, and pressure pads.

For more information on pedestrian traffic count data and technologies, refer to the FHWA *Traffic Monitoring Guide* (FHWA, 2013d).

For additional information on methods and technologies for collecting pedestrian count data and uses of the data, refer to NCHRP Report 797, *Guidebook on Pedestrian and Bicycle Volume Data Collection* (Ryus et al., 2014).

2.5.1 Uses of Pedestrian Volume and Behavior Data

Pedestrian activity data refer to information about the number of pedestrians traveling at or along a facility over a time period. The collection of pedestrian activity data is a burgeoning area of interest, particularly given recent emphasis on performance measures and the desire of agencies to make transportation investments justifiable through tangible benefits.

Just as with motor vehicle traffic monitoring programs, pedestrian monitoring programs serve numerous purposes, including the following:

- *Safety Studies*—Pedestrian crash data are typically reported either as an absolute number of crashes or as a rate of pedestrian crashes per unit of population (typically, 100,000 people). Neither of these measures is necessarily correlated to the number of pedestrians using a transportation system or the

New York State DOT Capital Projects Complete Streets Checklist

The Capital Projects Complete Streets Checklist is just one example of a tool that can be used during project initiation and scoping to accommodate pedestrian needs. The checklist highlights the importance of evaluating the potential for pedestrian activity at the project location, focusing on the existence of pedestrian generators and destinations rather than on existing pedestrian activity, since the lack of facilities may be the root cause of the lack of pedestrian activity. When generators of pedestrian activity are present or planned, provision of a pedestrian facility is needed.

Information for the checklist may be obtained through methods such as:

- observation and discussions with local governments and planning organizations;
- public informational meetings, crash reports, and questionnaires; and
- organizations addressing pedestrian needs, including advocates for people with disabilities.

Checklists should be reviewed during the initial planning stages and at multiple points during the course of a project, especially if the project encounters delay, as relevant conditions may change. Items on the checklist may include:

- existing and expected land-use patterns and generators of pedestrian traffic;
- existing and anticipated pedestrian characteristics;
- presence of an existing or planned crosswalk;
- presence of transit stops nearby;
- presence or evidence of regular pedestrian activity;
- presence of existing or proposed generators, including:
 - schools
 - parks
 - playgrounds
 - places of employment
 - places of worship
 - post offices
 - municipal buildings
 - restaurants
 - shopping centers
 - other commercial areas
 - shared-use paths
 - campgrounds
 - outdoor recreation areas
 - amusement parks
- record of pedestrian facilities having been previously removed;
- likelihood of continued growth in the nearby area;
- indication of desired pedestrian facilities in an adopted planning document; and
- pedestrian crash history.



extent to which pedestrians use the system (exposure). This can lead to improper conclusions being drawn from the crash data. Pedestrian count data can be used to normalize crash data by translating crash counts into crash rates that consider exposure. While calculating pedestrian distance traveled from pedestrian counts would be difficult, general trends can be identified and used to evaluate a program's effect on safety.

- *Before/After Evaluations*—Before/after evaluations are performed for infrastructure or programmatic projects when agencies want to know the effects of their investments. Changes in pedestrian volumes or behavior might be metrics included in these evaluations.
- *Travel Volume Trends Analysis*—Understanding how pedestrian volumes and behaviors change over time is valuable for evaluating long-term effects of transportation programs. Pedestrian volume count data provide a way to calculate percentage of increase or decrease in pedestrian travel over time. These travel volume trends can be evaluated over several time periods, such as from month to month, year to year, season to season, and so on. Twenty-four-hour pedestrian volume count data can reveal the pedestrian traffic patterns in commuter or recreational traffic at a specific location. Data from sites with similar characteristics and traffic patterns can be grouped together to support the development of factor groups and overall traffic statistics.
- *System Usage Evaluations*—Overall system or network usage is a determinant in understanding pedestrian behavior. Pedestrian volume data can provide the scale of pedestrian activity occurring in one part of the system and for comparison with another.
- *Infrastructure Investment Prioritization*—One factor often considered when prioritizing pedestrian improvement projects is the actual number of pedestrians walking along various roadways or in localized areas. While pedestrian volumes may not provide a true representation of pedestrian demand (see Section 2.9.3), pedestrian volume data can be used to identify locations where high usage deserves special attention. Alternatively, counts can help prioritize where facilities should be provided for pedestrians who need to walk because of a lack of transportation options.
- *Mobility Evaluations*—Traditionally, vehicle throughput has been the primary measure of mobility along corridors and in central business districts, but in recent years more agencies have been concerned about both person and vehicle throughput. With more emphasis on person throughput, agencies are interested in moving more pedestrians, bicyclists, and transit users in addition to drivers and passengers in motor vehicles.
- *Model Development and Validation*—Many agencies want to be able to forecast future pedestrian volumes. Pedestrian activity data along existing facilities in given environments is useful to the development of travel demand models. NCHRP Report 770, *Estimating Bicycling and Walking for Planning and Project Development: A Guidebook* (Kuzmyak et al., 2014) contains methods and tools for practitioners to estimate walking (and bicycling) demand as part of regional-, corridor-, or project-level analyses.
- *Project Design*—Existing pedestrian volumes and behaviors, as well as trends in volumes and behaviors, can be used to inform pedestrian facility design and operations. Sidewalk and street crossing widths can be designed to accommodate design volumes at a given level of service (LOS). Alighting areas at transit stops may need to be expanded to meet demand. The volume of pedestrians also affects the minimum green time for pedestrian traffic signals.
- *Operations and Maintenance*—Agencies can use pedestrian volume data to determine signal timing operations, especially where a path might cross a major arterial roadway. For example, using peak

pedestrian volumes to establish longer green times at a major arterial roadway crossing could make the crossing safer. Pedestrian volume data by time of day can also be used to efficiently schedule and establish sweeping and plowing activities so maintenance activities can be completed during nonpeak pedestrian hours.

2.5.2 Pedestrian Count Duration, Sampling Techniques, and Scaling Factors

Pedestrian counts tend to be conducted over shorter time periods than motor vehicle counts because of the prevalence of labor-intensive manual pedestrian counts or simply because of continued agency priority on motorized traffic monitoring. As a result, 2- and 4-hour counts are quite common. Caution should be used in applying the results of short counts to other time periods or facilities. Doing so can introduce significant errors when pedestrian activity is temporally variable. If short-duration pedestrian and bicycle counts are to be used, longer counts should be taken at some locations to establish hourly patterns and a statistical basis for calculating annualized volumes and applying scaling factors to short-term counts (FHWA, 2013d). Agencies should strive to routinely conduct 24-hour automated and 12-hour manual counts, and should also develop up to five permanent or continuous pedestrian count sites to establish scaling factors for common groups of sites. Refer to the *Traffic Monitoring Guide* for more information (FHWA, 2013d).

Selection of both short-duration and continuous count sites should employ sampling techniques for representative geographic and activity-level coverage. Ideally, continuous count stations are combined to form factor pattern groups in which the counters within a group have similar traffic patterns. This allows for the pedestrian volume of a particular facility where a short-duration count is conducted to be calculated using factors from a group of sites with similar characteristics. Pedestrian factor pattern groups should be formed with a particular emphasis on combining common facility types (shared-use paths, local streets, and arterial/collector streets) and common user types (predominately utilitarian travel versus recreational travel) because of the associated disparities in temporal pedestrian travel patterns.

A critical reason for collecting pedestrian volume data from continuous counting stations is to develop factoring statistics such as time-of-day (TOD), day-of-week (DOW), month-of-year (MOY), and seasonal factors. Without such factors, short-duration count data cannot be annualized. Once these factors are applied to short-duration counts, annualized statistics per site can be generated for overall system and network usage. Figure 2-11 illustrates variations in hourly volume over the period of a day. TOD, DOW, MOY, and seasonal factors can also be used to extrapolate an intra-day pedestrian count to an average annual daily pedestrian volume at a particular location. For example, a pedestrian count may be conducted on a shared-use path on an August Thursday morning from 8:00 AM to 12:00 PM. The TOD factor considers how much of the daily travel occurs during those hours to produce an estimated daily volume. The DOW and MOY factors are then used to adjust the daily volume based on the relative amount of travel occurring at that location on a Thursday in August.

FHWA Traffic Monitoring Guide (FHWA, 2013d)

“If automatic counters are used, then the minimum suggested duration is 7 days (such that all weekday and weekend days are represented). Depending on several other factors (e.g., day-to-day count variability, the total number of short-duration monitoring sites, and the number of automatic counters), the preferred duration of automatic counts could be as long as 14 days at each location.

“The use of manual observers will limit the duration of short-duration counts. However, the minimum suggested duration for manual observers is 4 to 6 hours and should be scheduled to coincide with the heaviest non-motorized use. ... The preferred length for short-duration counts is 12 hours, which permits calculation of time-of-day use profiles. However, it is recognized that available resources may limit the collection of 12-hour counts.

“... There is recognition that 2 hours of count data is better than no data; however, 2 hours of count data may lead to high error rates when annualizing counts and could lead to erroneous conclusions. If manual observers are the only possibility for short-duration counts, then agencies are encouraged to count for longer periods at fewer locations.”



Documents

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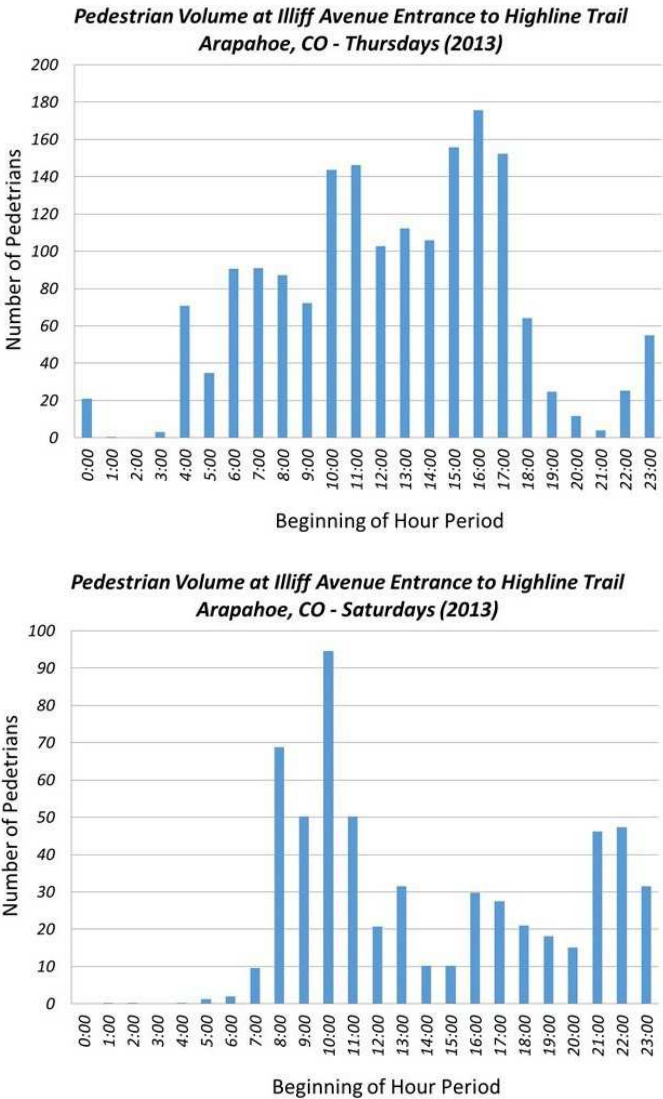


Figure 2-11. Examples of 24-Hour Count Data

2.5.3 Pedestrian Data Elements and System Usage

There are a number of data elements that may be collected in support of a pedestrian monitoring program. Some data elements may be more critical than others depending upon the goals and objectives of the program. Table 2-2 provides a list of data elements as an initial effort to distinguish between “critical” and “optional” data elements that could be collected to support a pedestrian monitoring program (FHWA, 2013c), recognizing that some of the data elements cannot be collected easily using permanent count technologies but rather would have to be collected through intercept surveys to obtain information about trip purpose, behaviors, perceptions, and demographics.

Pedestrian traffic monitoring programs should recognize that pedestrian street-crossing facilities are an important factor in pedestrian transportation. They should be included in the locations where pedestrians are monitored.

The FHWA *Traffic Monitoring Guide* (FHWA, 2013d) provides standardized data fields and formats for data to be reported to FHWA. These standardized fields include information about the count site and the pedestrians counted. The FHWA *Traffic Monitoring Guide* may serve as a model to agencies in terms of the types and formats of pedestrian data to collect.

Table 2-2. Critical and Optional Data Elements for Pedestrian Monitoring Program (FHWA, 2013c)

Critical Data Elements		Optional Data Elements	
• Location • Counts • Date • Direction	• Duration • Day of week • Time of day • Weather conditions	• Age • Gender • Race • Group size • Trip purpose • Trip length	• Crosswalk usage • Signal timing adequacy • Perceived comfort • Perceived safety • Reason for trip

As described in the *Traffic Monitoring Guide*, there are two types of data files needed for pedestrian volume data collection programs: station record files and count files. Station records contain information about the station location at which pedestrian activity counts are observed. Station information is common to all count data for a specified duration and, potentially, the portion of the facility being observed (i.e., lane and/or direction). For example, FHWA’s Non-Motorized Count Station Description file contains one record per traffic monitoring station per year. Station record data include items such as station identifier, station location, facility type, count type, and type of count sensor. The station record file allows multiple

data collection files for different time periods to be identified with or linked to the same location. Station record files can be considered static data files and are rarely changed unless major construction changes the characteristics or alignment of the location.

The second type of data file may be referred to as a count file. Count records contain data associated with a particular activity count that is conducted over a given period of time. Count record data typically include a station identifier (to link the count to the station record data described above), weather-related information, temporal information, and the actual count data organized into specified time intervals. The *Traffic Monitoring Guide* also provides a Non-Motorized Count Station Description Record, the use of which is required for data submittals to FHWA, that includes at least 22 critical or optional data fields (the number of fields increases depending on the number of count intervals). The data submittal will come to FHWA via the Travel Monitoring Analysis System (TMAS).

2.5.4 Counting Equipment and Technologies

There is no standardized technology for conducting pedestrian counts. Most pedestrian monitoring programs use periodic manual counts. Intercept surveys are sometimes used to collect trip or demographic data. Continuous monitoring programs are becoming more commonplace with infrared counters being the most popular technology. Some jurisdictions use piezometric pads or seismic sensors. Automated video- and laser-counting technologies appear to be promising. Each of these methods has its applications for given operational, geometric, and weather-related conditions. The most appropriate technologies for a given agency are dependent on the agency's setting, resources, and needs (FHWA, 2011).

All count technologies, including manual counts, are subject to error. Adjustment factors may be appropriate for many applications but would necessarily vary based on the source of the error for the given data collection methodology. Additional adjustment factors might need to be developed as well. For instance, pedestrians are undercounted when occlusion occurs as a result of traveling in groups; supplemental data collection may be needed to determine the degree to which this occurs, and count volumes adjusted to reflect the undercounting. Weather can cause counting errors for some automated count technologies; these and other potential sources of errors should be addressed with appropriate adjustments to reported volume data.

2.6 Traffic Principles for Pedestrians

Planning activities for pedestrian facilities should promote pedestrian activity and encourage legal and safe behavior by pedestrians, motorists, and other users. This section describes pedestrian behaviors that are anticipated, and sometimes required, of pedestrians operating on the transportation network.

The National Committee on Uniform Traffic Laws and Ordinances (NCUTLO) developed the *Uniform Vehicle Code* (UVC) as a guide for use by state legislatures (NCUTLO, 2000). The purpose of the UVC is to create a model set of motor vehicle and traffic laws for application nationwide for the safety of all highway users across the country. Article V of the UVC is titled "Pedestrians' Rights and Duties" and contains the vast majority of the information in the UVC related to pedestrians. In addition, Article II of the UVC contains a discussion of pedestrian control signals. Most state traffic codes are generally consistent with the UVC; consequently, the UVC forms the basis of this discussion. Practitioners should also become familiar with traffic codes within their jurisdictions.

The UVC defines some terms differently than they are defined for general use in this guide. Two terms of particular importance to the discussion of pedestrian rules are the definitions of *roadway* and *sidewalk*. The UVC defines them as follows:

Roadway—That portion of a highway improved, designed, or ordinarily used for vehicular travel, exclusive of the sidewalk, berm, or shoulder even though such sidewalk, berm, or shoulder is used by persons riding bicycles or other human-powered vehicles. In the event a highway includes two or more separate roadways, the term “roadway” as used in the UVC refers to any such roadway separately but not to all such roadways collectively (NCUTLO, 2000).

This UVC definition of the roadway does not include the shoulder as part of the roadway; however, when designing a roadway, the shoulder is a design element that is part of the roadway under AASHTO *Green Book* criteria (AASHTO, 2018a).

Sidewalk—That portion of a street between the curb lines, or the lateral lines of a roadway, and the adjacent property lines intended for use by pedestrians (NCUTLO, 2000).

The UVC definition for a sidewalk lacks the stipulation from the MUTCD, and thus ADA, that to be considered a sidewalk, the area intended for use by pedestrians must be “paved or improved.” According to the UVC, if the space next to the fence shown in Figure 2-12 is “intended” for use by pedestrians, then it is a sidewalk. The UVC is not clear about whose intent establishes the sidewalk.

State and local laws based on the UVC, while providing rules for who has to yield to whom under certain conditions, require that every driver of a vehicle exercise “due care” to avoid colliding with any pedestrian (NCUTLO, 2000). Regardless of location along or crossing a roadway, the operator of a vehicle is required to yield the right of way to any vision-disabled pedestrian carrying a visible white cane or accompanied by a guide animal.



Figure 2-12. Pedestrian Walking Adjacent to a Fence along an Unpaved Area

2.6.1 Walking Along a Facility

2.6.1.1 Walking in the Roadway

Where no sidewalk or shoulder is available, state and local laws based on the UVC require pedestrians walking along the roadway to walk as near as practicable to the outside edge of the roadway. On a two-way roadway, pedestrians are to walk on the left side of the roadway (NCUTLO, 2000). Some states allow pedestrians to walk on the right side of the roadway if it is not practicable to cross the street. Where this allowance is not provided, the lack of a sidewalk on one side of the street would result in two legally required roadway crossings for any round trip a pedestrian would make along the road. Any pedestrian walking on a roadway must yield the right-of-way to vehicles on the roadway (NCUTLO, 2000).

State and local laws based on the UVC require pedestrians to use a sidewalk if it is present (NCUTLO, 2000); however, some states allow wheelchair users to use the roadway if the sidewalks are “unsafe” or “not practicable.”

Play Streets

Some state statutes allow for the designation of “play streets” (Hart et al., [undated]). A play street is a portion of a residential roadway that meets specific physical criteria and is designated through consistent signing and pavement marking. A play street is where children may play in the roadway but yield the right-of-way when motor vehicle traffic is present, and where motor vehicle operators should have a heightened level of awareness for pedestrians in the roadway. Play streets should be considered only on local residential roadways, fronting only residential land use. The speed limits on play streets should be a maximum of 20 mph (32 km/h) and preferably lower. Play streets should be consistently signed for motorists. In advance of the beginning of the designated play street, minimum stopping sight distance should be provided, and motorists should be able to see the entire length of the designated play street. The entirety of a play street is not required to be ADA compliant; however, a pedestrian access route must be provided.

The Woonerf

A woonerf is a street designed to control automobile speeds in neighborhoods. State and local laws concerning woonerfs typically give pedestrians priority, such that motorists must yield to pedestrians. Motorists are not restricted from entering a woonerf; in fact, woonerfs provide motor vehicle access and parking for residences that abut them. Access to and from the surrounding road network is typically maintained. Vehicle speeds are restricted to approximately walking speeds.

Woonerfs have distinctive entryways and are signed. Continuous curbs are typically not present along woonerfs. Traffic calming measures such as trees, bollards, and furniture are placed in the pavement area to reduce vehicle speeds. However, the traffic calming devices should not present obstacles for emergency responders (FHWA, 2006a). As with play streets, the entirety of a woonerf is not required to be ADA compliant; however, a pedestrian access route must be provided. The path of the pedestrian access route should be defined through curbing or tactile edges to provide positive guidance to those with vision disabilities (see Figure 2-13).

2.6.1.2 Walking on Shoulders

Where sidewalks are not available, but a grass or paved shoulder is available, pedestrians are typically required to walk on the roadway shoulder, as far from the travel lane as practicable (NCUTLO, 2000).

2.6.1.3 Walking on Sidewalks

State and local laws based on the UVC require motorists to yield the right-of-way to pedestrians walking on a sidewalk (Kuzmyak, 2014). Consequently, conflict points where motorists cross sidewalks should be designed to (a) provide adequate sight distance to the crossing and (b) limit vehicle speeds to promote yielding behavior.

Under state and local laws based on the UVC, bicyclists, who may be allowed to operate on a sidewalk, must yield the right-of-way to pedestrians on the sidewalk (NCUTLO, 2000). While a wide

sidewalk should not be considered a bicycle facility, where occasional bicyclists are expected, a wider sidewalk can encourage bicyclists to pass pedestrians with greater clearance (AASHTO, 2012). Where shared use with bicyclists is expected, the facility should be designed as a shared-use path using the guidance provided in the *AASHTO Guide for the Development of Bicycle Facilities* (AASHTO, 2012).

2.6.1.4 Walking on Shared-Use Paths

Shared-use paths are multi-use facilities designed primarily for use by bicyclists and pedestrians that are physically separated from motor vehicle traffic. Therefore, they should be considered similar to sidewalks when considering right-of-way priority. This includes how users behave when moving along the path as well as interactions at intersections. However, the vehicular codes of states vary; signs and pavement markings might be necessary to clarify or communicate desired behaviors. As an example, in some states a shared-use path falls under the definition of a roadway. Thus, pedestrians are required to walk on the left, facing bicyclist traffic. This is not normal path behavior; paths usually operate with slower traffic (pedestrians) keeping to the right. The Shared-Use Path Restriction sign (R9-7) can be used to designate the pavement area and direction of travel for path users (FHWA, 2009).

When volumes on shared-use paths increase to congested levels, the comfort associated with using the facility decreases. As more user groups are added to the traffic mix, the number of passing events increases (FHWA, 2006b). Consequently, it may be desirable to separate pedestrians and other users onto separate path surfaces. Mode-specific guide signs (D11-1a, D11-2, D11-3, D11-4) or selective exclusion signs (R5-3, R5-6, R9-13, R9-14) can be used to designate path surfaces for the users or the types of users that may use the path (see Figure 2-14) (FHWA, 2009).

2.6.1.5 Walking in Parking Lots

Generally, state vehicle codes do not apply on private land (Eubanks and Hill, 1998). Parking lots in the U.S. are, by nature, a shared-use area in which, at any given period, there could be as many pedestrians walking as there are motor vehicles circulating. In general, all users are expected to exercise due care. Backing motorists are expected to be especially vigilant. The elevated need for vigilance should translate to reduced backing speeds and enhanced scanning behaviors.



Figure 2-13. Example of a Woonerf (Photo by Dan Burden)

2.6.2 Pedestrians Crossing Roadways

Roadway crossings are part of many pedestrian trips. However, pedestrians are not allowed to cross at all locations, and who must yield to whom varies with respect to where the crossing takes place.

2.6.2.1 Crossing in Crosswalks

Unsignalized Crosswalks

In most states, drivers are to yield the right-of-way to pedestrians crossing within a marked or unmarked crosswalk. This includes slowing down, or stopping if needed, to yield to a pedestrian crossing the roadway within a crosswalk when the pedestrian is upon the half of the roadway upon which the vehicle is traveling, or when the pedestrian is approaching so closely from the opposite half of the roadway as to be in danger. Some states have dropped the “upon the half of the roadway” language from their yield to pedestrian law. Some states require motorists to stop rather than yield.

The UVC (NCUTLO, 2000) defines a crosswalk in two parts. First, a crosswalk is “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, that part of a roadway included within the extension of the lateral lines of the existing sidewalk at right angles to the centerline.” State laws vary, and interpretations of this law vary, but this suggests that roadways along which pedestrians are intended to walk have crosswalks at all intersections, regardless of whether they are designated with pavement markings. The second part of the definition states that a crosswalk is “any portion of a roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by lines or other markings on the surface.” This second half of the definition generally addresses midblock crossings.

Pedestrians, for their part, are not allowed to suddenly leave a curb or other place of safety and walk or run into the path of a vehicle that is so close as to constitute an immediate hazard (NCUTLO, 2000).

Signalized Crosswalks

At signalized crosswalks, motorists must yield the right of way to pedestrians who are lawfully within the crosswalk. Pedestrians lawfully within the crosswalk include any pedestrian(s) who entered the crosswalk on the WALK pedestrian phase or, in the absence of pedestrian signals, on the green phase for the parallel vehicular traffic. During the flashing UPRAISED HAND and countdown indication (i.e., the pedestrian change interval), pedestrians on the sidewalk are not to start crossing the roadway in the direction of the signal indication, but any pedestrian who started to cross during the WALK pedestrian phase is to proceed to the far side of the street (unless directed by a traffic control device to proceed only to the median of a divided highway or some other island or pedestrian refuge area) (FHWA, 2009). Some pedestrians may walk too slowly to clear an intersection prior to the end of the pedestrian clearance interval and prior to the signal turning green



Figure 2-14. Mode-Specific Guide and Selective Exclusion Signs (FHWA, 2009)

for opposing motor vehicle traffic. Despite the fact that motorists may have a green signal, they are required to yield to those pedestrians who have not yet cleared the intersection (NCUTLO, 2000).

Between two adjacent intersections with traffic signals, pedestrians are not allowed to cross at any point other than within a marked crosswalk (Knoblauch et al., 1996). Consequently, in dense urban areas where every intersection might be signalized, crosswalks at signals should be marked at all intersections so that a pedestrian never has to travel more than half a block to legally cross the roadway. Just as at unsignalized crosswalks, regardless of the presence of a crosswalk, pedestrians are not allowed to suddenly leave a curb or other place of safety and walk or run into the path of a vehicle that is so close as to constitute an immediate hazard.

2.6.2.2 Crossing Outside of Crosswalks

Other than between two consecutively signalized intersections, pedestrians are generally allowed to cross outside of crosswalks. When crossing outside a crosswalk, pedestrians must yield the right of way to vehicles on the roadway. Pedestrians crossing outside a crosswalk are to cross perpendicular to the roadway and as close to a 90-degree angle as possible (NCUTLO, 2000).

2.6.2.3 Crossing Railroads

Railroads should only be crossed at designated crossings approved by the railroad authority. Under state and local laws based on the UVC, it is illegal for any pedestrian to pass through, around, over, or under any crossing gate or barrier at a railroad grade crossing when the gate or barrier is closed or is being opened or closed (NCUTLO, 2000).

2.7 Pedestrian Crash Types and Countermeasures

Pedestrian safety should be a primary focus during the planning and design processes. In 2017, 5,977 pedestrians were killed (see Figure 2-15) (NHTSA, [undated]), and approximately 70,000 pedestrians were injured in traffic crashes. An understanding of crash types in terms of the common environmental factors correlated to pedestrian crashes and locations of the crashes within the transportation network can help transportation professionals better plan and design for pedestrians.

2.7.1 Environmental Factors Related to Pedestrian Crashes

Numerous environmental factors can be correlated with the incidence of pedestrian crashes or the severity of pedestrian crashes. Among these factors are area type, traffic speeds, number of lanes on the roadway, and lighting conditions (Figure 2-16) (National Center for Statistics and Analysis, [undated]). The lack of pedestrian crash history does not necessarily indicate an effective and accessible condition exists for pedestrian traffic of all ages and abilities.

Pedestrian crashes occur more frequently in urban areas because of increased pedestrian and motor vehicle traffic. Crashes on urban roads account for more than two-thirds of pedestrian crash-related fatalities. Although the overall number of pedestrian crashes is fewer in rural areas than in urban areas, pedestrian