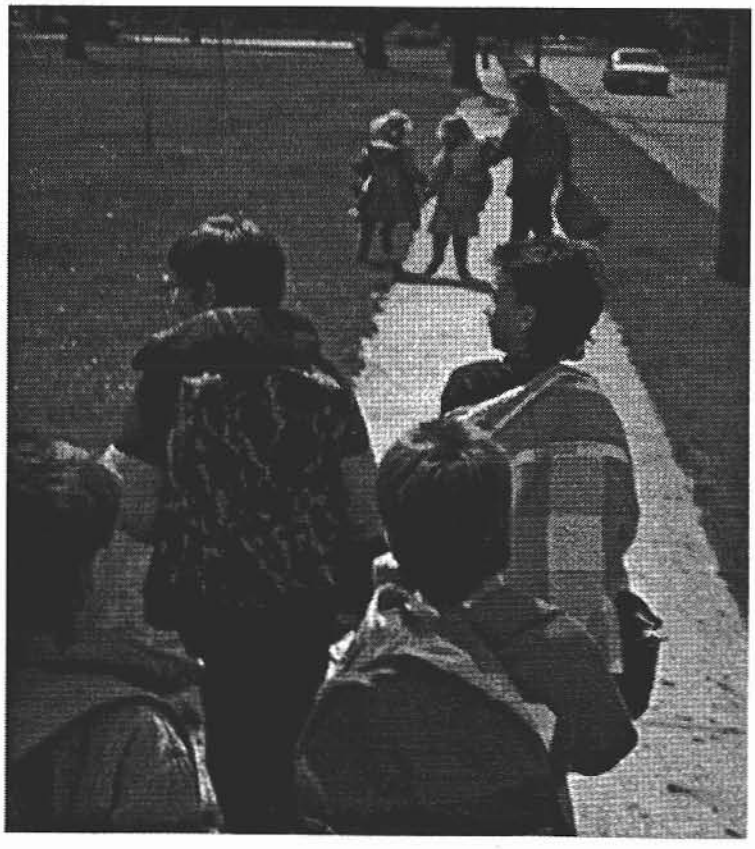
FINAL DRAFT

PLANNING AND DESIGNING

LOCAL PEDESTRIAN FACILITIES



North Carolina Department of Transportation

Office of Bicycle and Pedestrian Transportation

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PLANNING AND DESIGNING LOCAL PEDESTRIAN FACILITIES

North Carolina Department of Transportation
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CHAPTER 1

ABOUT THIS REPORT

This report provides suggestions and guidelines for the planning and design of local pedestrian facilities. These guidelines are intended to assist local planners, pedestrian coordinators, and traffic engineers in enhancing the safety and pedestrian-friendliness of local streets and highways through actions such as sidewalk additions or crosswalk improvements to existing roadways, and incorporating the best practices into the design of new roadways.

This document is provided to North Carolina localities as a tool for information exchange and planning purposes only. It reflects the views of its authors and is not necessarily the official policy or practice of the North Carolina Department of Transportation. Further, this document does not constitute the promulgation of standards, specifications or regulations. However, AASHTO, MUTCD, and ITE pedestrian guidelines are followed where applicable and appropriate.

It is not intended that these guidelines cover all the different factors that must be taken into account in selecting the most effective design or traffic control device for a given situation. The NC DOT assumes no liability for the contents or use of this manual. Judgment by trained engineers with a knowledge of the local conditions is needed to select the optimal pedestrian facility, design feature or traffic control device.

This report provides suggestions and guidelines for the planning and design of local pedestrian facilities.

The manual is structured as follows:

This document was prepared by Charles V. Zegeer, Herman F. Huang, and David Harkey of the University of North Carolina's Highway Safety Research Center, and Michael J. Cynecki, Project Consultant. Some of the material pertaining to various pedestrian facilities was adapted from the Institute of Transportation Engineers Committee 5A-5 report, *Design of Pedestrian Facilities: Recommended Practice.* Mr. Zegeer serves as chairman of this committee, and Mr. Harkey and Mr. Cynecki are committee members. Other resources include the *Manual on Uniform Traffic Control Devices for Streets and Highways*, and *A Policy on Geometric Design of Highways and Streets* published by AASHTO (the American Association of State Highway and Transportation Officials).

CHAPTER 2

PEDESTRIANS WITH DISABILITIES

There are 43 million persons in the United States with disabilities. Virtually all are pedestrians at one time or another. People with disabilities hold jobs, attend school, shop and enjoy the recreation facilities our municipalities have to offer. Anyone can experience a temporary or permanent disability at any time, due to age, illness, or injury.

Design deficiencies frequently can be overcome by an agile able-bodied person. However, when age or functional disabilities reduces a person's mobility, sight or hearing, a good design is very important.

For traffic engineering purposes, a disability can be classified in one or more of three functional categories: mobility impairments, sensory deficits, or cognitive impairments. A person with a *mobility impairment* is a person who, because of a physical problem or circumstance, is limited in their method or ability to move about. This includes people who use wheelchairs and those with braces, crutches, canes and walkers. It also includes persons with balance or stamina problems.

While *sensory deficits* are most often associated with blindness or deafness; partial hearing or vision loss is much more common. Other persons have lost sensation in some part of their body, lost their sense of balance, or lost a body part (except legs, which would be a mobility impairment). Color blindness, especially of red and green, is also a sensory deficit.

Cognitive impairments refer to a diminished ability to process information and make decisions. This includes persons who are mentally retarded or who have a dyslexic type of learning disability and those who are unable to read or understand the English language.

The Americans with Disabilities Act assures that the 43 million persons in the U.S. with disabilities will have full access to all public facilities.

Based on tests conducted by the Veterans Administration, the level of energy required by a wheelchair user is about 30 percent higher than that needed by a pedestrian who is walking. Moreover, a person on crutches or with artificial legs requires 70 percent more energy to go the same distance. If a person using a wheelchair travels a full city block and finds no curb cut, doubles back and travels that same distance in the street, it is the equivalent of an ambulatory person going four extra blocks. This illustrates the importance of removing physical barriers from our street network (Figure 1).

Figure 1.
Pedestrian facilities must be designed to accommodate the special needs of the disabled.

THE AMERICANS WITH DISABILITIES ACT (ADA)

The Americans with Disabilities Act was signed into law on July 26, 1990. This civil rights law assures that a disabled person will have full access to all public facilities throughout the U.S. It is important that all work is not only in compliance with the letter of the law, but also with the spirit of the law.

A prioritized plan for improvements should be in place with resources allocated to those locations where there is the greatest need. A primary concern for public agencies is providing access to public transit and to public buildings and facilities. In most cases this will involve removing barriers to wheelchair access along sidewalks, installing accessible wheelchair ramps, and improving access to bus stops, as well as other features to accommodate pedestrians with various disabilities.

Dimensions and rules in this guide are based on current standards set by the Architectural and Transportation Barriers Compliance Board, the Uniform Federal Accessibility Standards (UFAS), the American National Standards Institute (ANSI), and the North Carolina Department of Transportation codes at the time of

writing of this document. These rules may be updated from time to time, and local codes which are more strict should supersede these codes.

SIDEWALKS

While wheelchairs require 0.9 m (3 ft) minimum clear width for continuous passage, sidewalks should ideally have a minimum clear usable width of at least 1.5 m (5 ft) along major arterials and 1.2 m (4 ft) along some local streets. They should be paved with a smooth, durable material. Sidewalks should be built and maintained in urban areas along all major arterial streets and in commercial areas where the public is invited, and at all transit stops and public areas.

It is desirable to have paved sidewalks on both sides of all streets in urban and suburban areas to provide mobility for disabled (as well as non-disabled) pedestrians. A planting strip which serves as a buffer between on-street vehicles and pedestrians on the sidewalk can be especially beneficial to visually impaired pedestrians and to wheelchair users. Sidewalks should be kept in good condition, free from debris, cracks and rough surfaces.

To the extent practical, sidewalks should have the minimum cross slope necessary for proper drainage, with a maximum of 2.5 cm (1 in) of fall for every 1.2 m (4 ft) of width. A person using crutches or a wheelchair on a cross slope has to exert significantly more effort to maintain a straight course on a sloped surface than on a level surface.

Ramps are defined when the grade exceeds 5 percent along an accessible path. Longitudinal grades should be limited to 5 percent, but may be a maximum of 8.3 percent if required. If steep grades (6 to 8 percent) are longer than 9 m (30 ft), an equivalent level area should be provided. This is advisable because walking down a steeper slope with crutches or artificial limbs is difficult. In areas where it is impossible to avoid steep grades, an alternative route (such as an elevator in a nearby building) should be provided.

Handrails should be provided along long ramps. Handrails are used by persons in wheelchairs to help pull themselves up and are used by other persons for support. Informational signs, indicating alternative routes or facilities, can be placed at the base of the grade or in a guidebook for the area. Arrangements may be made with the local transit authorities to transport persons with disabilities at reduced (or no) fares where steep grades or other obstacles prohibits or severely impedes access.

STREET FURNITURE

Street furniture, such as benches and bus shelters, should be out of the normal travel path to the extent possible. For greater conspicuity, high contrast colors, such as red, yellow and black is preferable. The following guidelines should be considered in the positioning of street furniture:

- Street furniture should not hang lower than 2.0 m (6.7 ft) over a walking area.
- No object mounted on a wall or post, or free standing should have a clear open area under it higher than 0.7 m (2.3 ft) off the ground.
- No object higher than 0.7 m (2.3 ft) attached to a wall should protrude from that wall more than 10 cm (4 in).
- No protruding object should reduce the clear width of a sidewalk or walkway path to less than 0.9 m (3 ft).

Another common problem for wheelchair users is the placement of street furniture next to on-street parking which can make exiting a car or lift-equipped vehicle difficult. One remedy is to relocate the street furniture towards the end of the parking space instead of the center, or at the back of the sidewalk furthest from the curb.

At least 1.5 m (5 ft) of clear space width along the sidewalk is needed to allow for exiting a vehicle. Other objects, such as street light poles, may be more difficult to move, so consideration may be given to relocating the handicapped parking space or reserving extra handicapped parking spaces.

Some individuals may have difficulty operating pedestrian push buttons. In some instances there may be a need to install a larger signal push button or to change the placement of the push button. Pedestrian push buttons should always be easily accessible to individuals in wheelchairs, and should be no more than 105 cm (42 in) above the sidewalk. The force required to activate the push button should be no greater than 5 lbs.

PARKING

A parking space width of at least 4.0 m (13 ft) is needed to operate a lift equipped van. In off street parking lots, the minimum parking width for a handicapped space should be 2.4 m (8 ft) wide, with an access aisle of 1.5 m (5 ft). Two adjacent handicapped parking spaces may share a common access aisle. In parking structures, some handicapped spaces should have a 3.7 m (12 ft) clearance for use by lift equipped vans with raised roofs. Providing an accessible route to and from all parking spaces is essential.

Handicapped parking spaces in parking lots should also be as level as possible to allow for greater stability for persons in a wheelchair when loading and unloading a vehicle. In snow areas, handicapped spaces should not be used for snow storage, and instead should have a higher level of snow removal to allow for access.

CURB CUTS AND WHEELCHAIR RAMPS

The single most important design consideration for persons in wheelchairs is to provide curb cuts (Figure 2). New and rebuilt streets with sidewalks should always have curb cuts. These also benefit others with mobility disabilities, elderly pedestrians and persons pushing strollers, carts etc. A roll curb is a barrier and will not allow for wheelchair access. Curb cuts should be at least 1.0 m (3 ft 4 in) wide at the base with flared sides that do not exceed a slope of 8.33 percent.

The ramps should be flared smooth into the street surface. Ramps should be checked periodically to make sure large gaps do not develop between the gutter and street surface. There may be a need to remove accumulations of asphalt at the edge of the curb radius.

Single ramps located in the center of a corner are less desirable than a separate ramp for each crosswalk to accommodate disabled pedestrians. Separate ramps can be designed to provide greater information to visually impaired pedestrians in street crossings. Crosswalk markings should be located so that a pedestrian in a wheelchair should not have to leave the crosswalk to enter or exit the street. In some cases a broader single ramp may be used to accommodate pedestrians in wheelchairs.

Figure 2.
Curb cuts are the single most important design consideration for persons in wheelchairs.

Ramps or cut through islands should be provided for marked or unmarked crosswalks at median (or frontage road) islands.

Drainage is important, especially in colder areas where ice can form at the base of ramps, making traction extremely difficult. Standing water can obscure a

drop-off or pothole at the base of a ramp, and makes the crossing messy. Storm drain inlets should be clear of the crosswalk. If this is not possible, the openings in the grate should be no larger than 1.3 cm (0.5 in) in width.

BUS STOPS

All transit vehicles will eventually be able to accommodate wheelchairs. There are three major types of wheelchair accessible buses that may be used by a local transit authority:

Front Door Wheelchair Lift - This type of lift will not operate well with a heightened crown, high curb or gutter depression. It is better to pave the bus stops so that a stopped bus will be approximately level. The sidewalk should be less than 20 to 25 cm (8 to 10 in) above the street surface. Newer buses are designed to accommodate an 20 to 28 cm (8 to 11 in) high curb.

Center Door Bus - Center door lift designs require the door of the bus to be positioned within 30 cm (12 in) of the curb. This usually requires a longer bus stop than buses with front door lifts need and more stringent parking enforcement near the bus stop.

Low Floor Bus - This bus is built so that the entryway is 28 to 33 cm (11 to 13 in) high and there are areas in the bus that can be accessed without going up any steps. The physical design requirements of the bus stop is virtually identical to the first two designs, however, an 28 cm (11 in) curb height works best.

Not only should the sidewalk network be accessible with curb ramps, but the bus stop must be accessible from the sidewalk. This may require removing obstacles such as bushes and street furniture between the sidewalk and bus waiting area, and paving an accessway to the bus stop.

RESOURCES

The following Federal agencies are responsible for providing information about the Americans with Disabilities Act. The agencies and organizations are sources for obtaining information about the law's requirements and informal guidance for complying with the ADA. They are not sources for obtaining legal advice or legal opinions about your agency's rights or responsibilities under the ADA.

Architectural and Transportation
Barriers Compliance Board
1331 F Street, NW
Suite 1000
Washington, DC 10004-1111
1-800-872-2253 (voice and TDD)

Equal Employment Opportunity Commission
1801 L Street, NW
Washington, DC 20507
Questions and Documents -1-800-669-3362 (voice)
1-800-800-3302 (TDD)

Federal Communications Commission
For ADA documents and general information:
202/632-7260 (voice)
202/632-6999 (TDD)
President's Committee on Employment of People with Disabilities Information Line:
ADA Work
1-800-232-9675 (voice and TDD)

U.S. Department of Justice
Civil Rights Division
Public Access Section
P.O. Box 66738
Washington, DC 20035-6738
202-514-0301 (voice)
202-514-0383 (TDD)

U.S. Department of Transportation
Federal Transit Administration
400 7th Street, SW
Washington, DC 20590
202-366-1656 (voice)
202-366-2979 (TDD)

Office of the General Counsel
202-366-9306 (voice)
202-755-7687 (TDD)

Regional Disability and Business Technical Assistance Centers - Region IV (Includes North Carolina)
404-888-0022 (voice)
404-888-9098 (TDD)

CHAPTER 3

SIDEWALKS, WALKWAYS & PATHS

Areas that are designed to allow pedestrians to efficiently and safely move from one location to another can typically be classified as one of the following:

Sidewalk — This is a paved area (typically concrete) which normally runs parallel to vehicular traffic and is separated from the road surface by at least a curb and gutter. Sidewalks are common in urban areas, may be used in some suburban locations such as residential areas, and are not often present in rural areas, primarily due to the high installation cost and low anticipated use.

Path — This is a temporary or permanent area that is normally dirt or gravel, although some paths are asphalt. A path typically indicates the common route taken by pedestrians between two locations and often indicates the need to provide a sidewalk or at a minimum a paved surface.

Walkway — This is an area for general pedestrian use such as courtyards, plazas, and pedestrian malls.

This chapter primarily focuses on the design criteria for sidewalks. However, many of the same criteria may apply to planned pedestrian paths. Walkways are part of exclusive pedestrian facilities (Chapter 9).

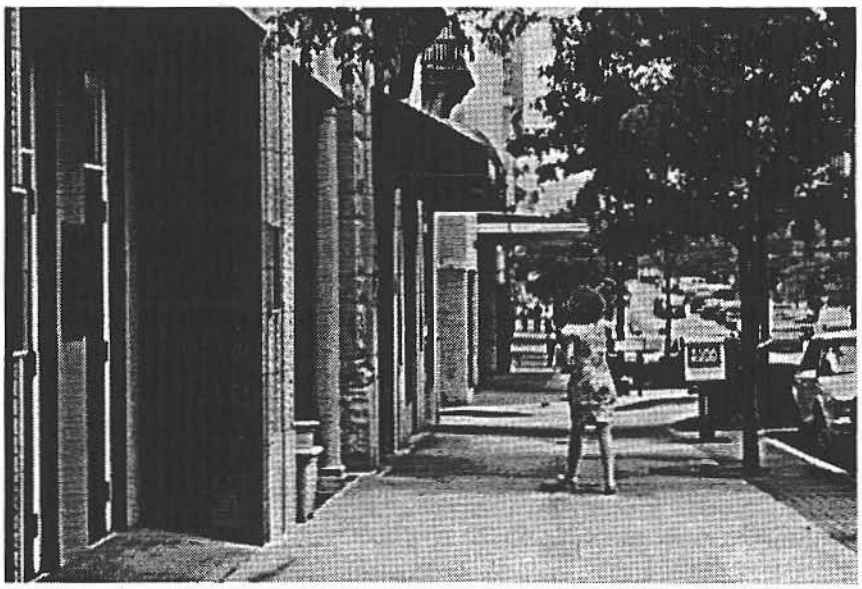


Figure 3.
Properly built sidewalks are essential for increasing pedestrian mobility, accessibility, and safety.

Properly planned, designed, and constructed sidewalks are essential for increasing pedestrian mobility, accessibility, and safety, especially for persons with disabilities, the elderly, and children. Sidewalks increase pedestrian safety by separating pedestrians from vehicle traffic. One recent FHWA study cited the presence of sidewalks in residential areas as the one physical factor in the roadway environment having the greatest effect on pedestrian safety.[1]

PLACEMENT

The inclusion of sidewalks is often determined by the engineer or planner on a site-by-site or project-by-project basis, without specific criteria for determining where sidewalks should be used. The most specific guidance provided by the American Association of State Highway and Transportation Officials (AASHTO) is for urban collectors and local streets as follows:

"Sidewalks used for pedestrian access to schools, parks, shopping areas, and transit stops and placed along all streets in commercial areas on both sides of the street. In residential areas, sidewalks are desirable on both sides of the streets but need to be provided on at least one side of all local or collector streets."[2]

The most complete guidance regarding when and where to install sidewalks was developed as part of an FHWA study and is based on type of area, type of roadway, and the number of dwelling units per acre.[1] These guidelines are shown in Table 1.

In addition to the guidelines shown in Table 1, there are some other general principles to consider in the placement of sidewalks.[1,3]

All roadways where pedestrian travel is expected should have a walking area that is out of the vehicle travel lanes. While a separate sidewalk or path is preferred, a roadway shoulder, particularly in rural areas, often serves the need.

Efforts should be made to provide direct connections between residences and activity areas such as shopping centers and transit stops.

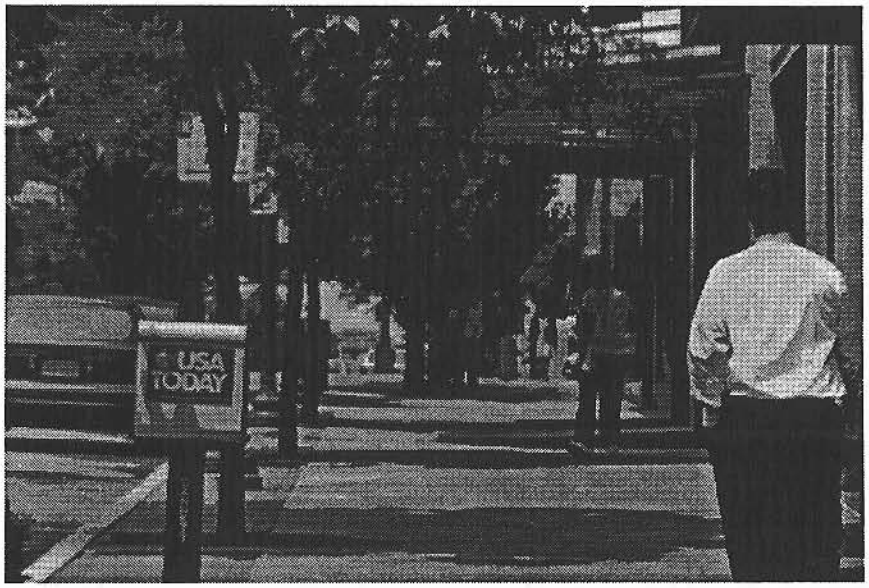


Figure 4.
Sidewalks should be properly maintained, free from obstructions and potential problems for pedestrians.

Type of Area (land-use, roadway functional classifications, or number of dwelling units)	Sidewalk Placement Recommendations On . . .	
	. . . new urban and suburban streets?	. . . existing urban and suburban streets?
Commercial and industrial -- all streets.	On both sides of these streets.	On both sides of these streets -- make every effort to add them and to complete missing links.
Residential -- major arterials	On both sides of these streets	On both sides of these streets.
Residential -- collectors.	On both sides of these streets.	For multi-family dwelling -- on both sides of these streets. For single family dwellings -- on at least one side of these streets.
Residential -- local streets with more than 4 units per acre.	On both sides of these streets.	Preferred on both sides, but required for at least one side.
Residential -- local streets with 1-4 units per acre.	Required on one side, but preferred on both sides.	Preferred on at least one side. At least 1.2 m (4 ft) shoulder required on both sides.
Residential -- local streets with less than 1 unit per acre.	On one side of these streets preferred, but shoulder on both sides required.	Preferred on at least one side. At least 1.2 m (4 ft) shoulder required on both sides.

Notes:

1. You must have a sidewalk on at least one side of any local street that is within two blocks of a school and that is a walking route to that school.
2. You may omit a sidewalk on one side of any new street when that side of the street clearly cannot be developed and when there are no uses or planned uses for that side of the street that would encourage people to walk there.
3. When a main road has a service road, you may eliminate the sidewalk next to a main road if you replace it with a sidewalk on the far side of the service road.
4. When you have a rural road that is not likely to serve development, you must provide a shoulder at least 1.2 m (4 ft) in width. If the road serves as a primary highway, the shoulder should be 2.4 m (8 ft) wide. The shoulder should be made of a material that provides a stable, must-free walking surface.

Table 1.
Guidelines for installing sidewalks based on area type, roadway type, and number of dwelling units per acre.[1]

The most direct, and thus preferred, routes can usually be determined during the planning stages of a development. Incorporating these direct routes into the developments through easements or other means is preferred by residents and most cost effective when done at the planning stages.

Developers should be required to incorporate sidewalks into every residential, commercial, and industrial project. Where undeveloped areas exist between already developed areas, local jurisdictions should fill in the gaps by connecting the developments with properly designed sidewalks.

Local agencies can design and install sidewalks along locally-maintained streets and can petition the North Carolina DOT for sidewalks along the State highway system. Sidewalks or paths should not be installed on fully controlled-access highways.

One additional factor that must be considered when determining sidewalk placement is the requirement to comply with the Americans with Disabilities Act (ADA). The ADA specifically states that: "At least one accessible route within the boundary of the site shall be provided from public transportation stops, accessible parking, accessible passenger loading zones, and public streets or sidewalks to the accessible building entrance they serve."[4]

If any part of this accessible route is part of a public sidewalk or other public pedestrian facility, efforts must be made to comply with requirements of the ADA. Many of these requirements are addressed in the design elements that follow.

DESIGN ELEMENTS

Width

The width required for a sidewalk will depend on where it is installed and its anticipated level of use. When determining sidewalk width, it is important to remember two things: 1) a pedestrian requires a specific amount of lateral and longitudinal space for walking, and 2) the determined width is the "effective width," exclusive of any obstructions.

The width required for two pedestrians to comfortably pass each other on a sidewalk is estimated to be 0.8 m (2.5 ft) for each.[5,6] This width decreases slightly when the pedestrians know each other or when crowded conditions exist. For persons in wheelchairs, the minimum clear width required is 0.9 m (3 ft).[4]

The "effective width" of a sidewalk can simply be defined as the total width minus the width for shy distances from buildings, the street, and other objects, and

minus the width for objects placed on the sidewalk such as light poles, parking meters, newspaper stands, trash cans, mail boxes, and other street furniture. Recommended effective widths based on type of area, type of roadway, and number of dwelling units are shown in Table 2.[7]

Setback Distance

The distance of the sidewalk from the roadway is defined as the setback distance and is an important design element. Sidewalks built close to the travel lane, particularly where vehicle speeds are high, discourage pedestrian travel due to increased noise levels and perceived safety risks. Although it is sometimes not feasible, sidewalks should be built as far from the road surface as physically possible, ideally near the right-of-way line.

Setbacks of 1.5 m (5 ft) or greater are recommended for purposes of:[8]

- Providing a margin of safety between the pedestrian and passing vehicles.
- Minimizing vehicle/pedestrian conflicts.
- Reducing potential splashing of pedestrians by passing vehicles.
- Providing space for utilities, parking meters, traffic control devices, landscaping, street furniture, and snow storage.
- Preventing driveway slopes from encroaching into the sidewalk, which may present a

Although it is sometimes not feasible, sidewalks should be built as far from the road surface as physically possible, ideally near the right-of-way line.

Type of Area (land use, roadway functional classification, or number of dwelling units)	Recommended Effective Width of Sidewalk
Central Business District (CBD)	Wide enough to meet the level of service based on methods found in the 1985 Highway Capacity Manual, with a minimum width of 2.4 m (8 ft)
Commercial and Industrial -- outside the CBD	1.5 m (5 ft) wide with a 0.6 m (2 ft) planting strip or 2.1 m (7 ft) wide without a planting strip
Residential -- Arterials and collectors outside the CBD	1.5 m (5 ft) wide with a 0.6 m (2 ft) planting strip
Residential -- local streets, multi-family and single family (>4 dwelling units/acre)	1.5 m (5 ft) wide with a 0.6 m (2 ft) planting strip
Residential -- local streets, multi-family and single family (1-4 dwelling units/acre)	1.2 m (4 ft) wide with a 0.6 m (2 ft) planting strip

Table 2. Recommended effective sidewalk widths based on area type, roadway type and number of dwelling units per acre.[7]

problem for the elderly or persons in wheelchairs.

- Where setbacks cannot be provided, it is recommended that wider sidewalks be constructed.

Grades

Grades on sidewalks should not exceed five (5) percent, which is the desirable maximum slope established by the ADA for an accessible route.[4] Where grades exceed five percent, special textures and handrails may be required. Specifications for ADA approved handrails can be found in the Americans with Disabilities Handbook.

Once installed, sidewalks need to be maintained to avoid creating obstructions and potential problems for pedestrians.

Pavement Surfaces

Sidewalks are typically constructed of concrete. However, other materials may be used to create a smooth walking surface, including asphalt and various materials. Care should be taken to insure that the material selected does not become overly slippery when it gets wet and that required maintenance is minimal.

On pathways, inexpensive materials such as well compacted limestone screenings or wood chips can be used to create a functional facility. The use of materials other than concrete can often produce aesthetically pleasing environments that are well received by local residents.

MAINTENANCE

Once installed, sidewalks need to be maintained to avoid creating obstructions and potential problems for pedestrians. A program of inspection and cleaning should be established by local maintenance, traffic engineering, or public works department. Assistance in reporting problems may be requested from other government personnel such as police or letter carriers who are commonly on the sidewalks.

Local ordinances should be passed requiring adjacent property owners to be responsible for minor maintenance of sidewalks along their property; requirements may include debris removal, and clearing of overgrown trees and bushes. Care should also be taken to make sure private landscaping, such as fences or decorative walls, does not create vision obstructions, and thus sight distance problems, at driveways, alleys or intersections. While the public agencies are not the caretakers of private property, a system to notify individuals who create vision obstructions (when detected) and require corrective action, can greatly enhance the pedestrian environment.

REFERENCES

1. R.L. Knoblauch, B.H. Tustin, S.A. Smith, and M.T. Pietrucha, *Investigation of Exposure-Based Pedestrian Accident Areas: Crosswalks, Sidewalks, Local Streets, and Major Arterials*, Report No. FHWA-RD-77-142, Federal Highway Administration, Washington, DC, December 1977.

2. *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials, Washington, DC, 1990.

3. S.A. Smith, K.S. Opiela, L.L. Impett, M.T. Pietrucha, R. Knoblauch, and C. Kubat, *Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas*, National Cooperative Highway Research Program Report 294A, Transportation Research Board, Washington, DC, June 1987.

4. *Americans with Disabilities Act Handbook*, U.S. Equal Employment Opportunity Commission and the U.S. Department of Justice, Washington, DC, October 1992.

5. B. Pushkarev and J. Zupan, *Urban Space for Pedestrians*, Massachusetts Institute for Technology, Cambridge, MA, 1975.

6. R.K. Untermann, *Accommodating the Pedestrian: Adapting Towns an Neighborhoods for Walking and Bicycling*, Van Nostrand Reinhold Co., New York, NY, 1984.

7. *Design of Pedestrian Facilities: Report of Recommended Practice*, ITE Committee 5A-5, Institute of Transportation Engineers, Washington, DC, 1994.

8. *Traffic Engineering Handbook*, Institute of Transportation Engineers, Washington, DC, 1992.

CHAPTER 4

PEDESTRIAN & MOTORIST SIGNS & MARKINGS

Signs and markings are governed by the *Manual on Uniform Traffic Control Devices* (MUTCD), which provides specifications on the design and placement of traffic control devices installed within the public right-of-way.[1] The MUTCD encourages a conservative use of signs. Signs should only be installed when they fulfill a need based on an engineering study or engineering judgement. In general, signs are often ineffective in modifying driver behavior, and overuse breeds disrespect and diminishes their effectiveness.

Unnecessary signs and posts represent a hazard to errant motorists and may cause an obstruction to pedestrians and bicyclists. Unnecessary signs also represent an ongoing maintenance cost and are a source of visual blight. Sign placement and location criteria are provided in the MUTCD.

REGULATORY SIGNS

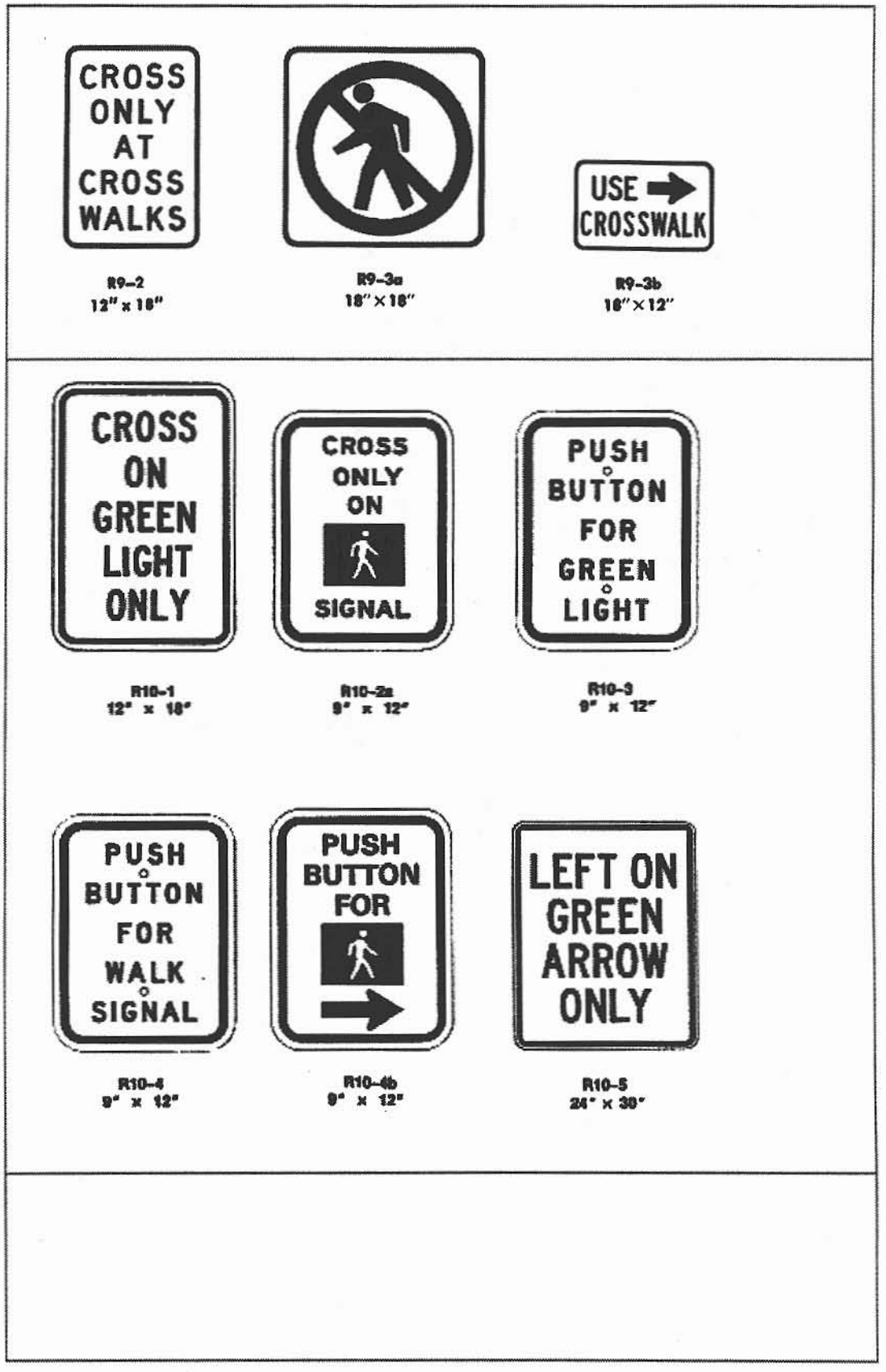
Regulatory signs are used to inform motorists or pedestrians of a legal requirement and should only be used when the legal requirement is not otherwise apparent. They are generally rectangular in shape, usually consisting of a black legend on a white background and must be reflectorized or illuminated.

The most common types of regulatory signs related to pedestrians are shown in Figures 5 and 6. Many motorist signs, including STOP and YIELD signs, turn restrictions, parking restrictions and speed limits, have a direct or indirect impact on pedestrians.

The NO TURN ON RED (R10-11a) sign may be used in some instances to facilitate pedestrian movements. The MUTCD lists six conditions when no-turn on red may be considered, three of which are directly related

Signs should only be installed when they fulfill a need based on an engineering study or engineering judgement.

Figure 5.
Typical regulatory signs relating to pedestrians.[1]



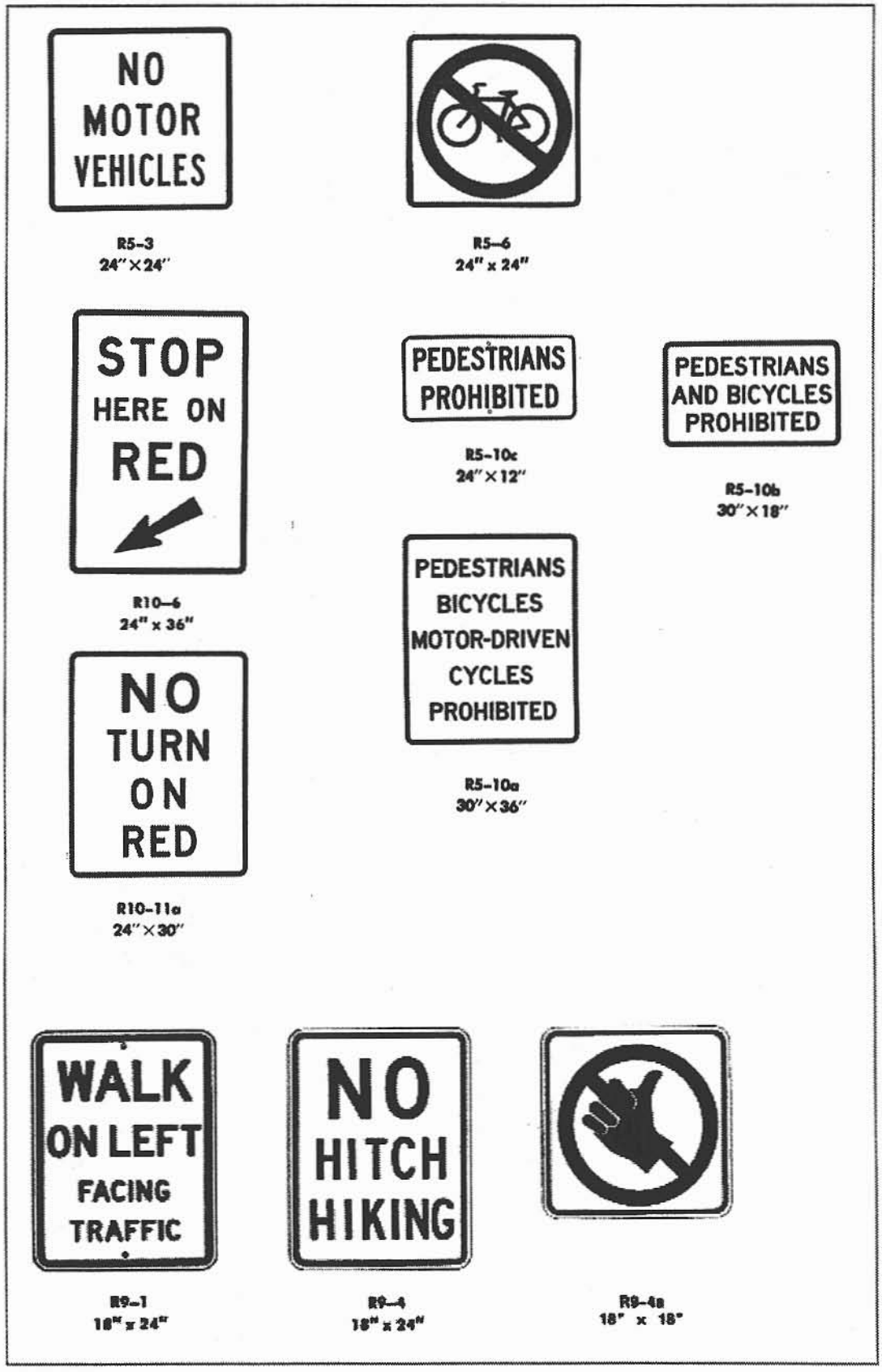


Figure 6.
Typical regulatory signs relating to pedestrians.[1]

to pedestrians or signal timing for pedestrians. Considerable controversy has arisen regarding pedestrian safety implications and right-turn-on-red operations, ranging from one study which indicated a significant increase in pedestrian accidents with right-turn-on-red[2] to other studies which concluded that right-turn-on-red does not pose a pedestrian safety problem under most circumstances.[3,4]

Consideration should also be given to pedestrian conflicts associated with right-turn-on-green (where the pedestrian has a WALK indication and the motorist has a green ball indication) if right-turn-on-red is prohibited. When overly restrictive, motorist compliance to NO TURN ON RED signs is low, particularly when the signs are poorly located and low pedestrian and cross street traffic exists.

The Institute of Transportation Engineers has taken the position that no overall significant safety detriments occur with right-turn-on-red, and right-turn-on red results in significant benefits in reduced energy consumption, positive environmental impacts, and reduced operational delays[5]. Pedestrian volumes should not be the only criteria for prohibiting right turns on red.

The use of NO TURN RED signs at a traffic signal should be evaluated on a case-by-case basis, and less restrictive alternatives should be considered in lieu of NO TURN ON RED signs. There are occasions when no-turn-on-red may be beneficial, as at school crossings, where the unpredictable behavior of children may create special problems with pedestrian conflicts.

Part-time restrictions should be discouraged, but they are preferable to full-time prohibitions when the need only occurs for a short period of time. Although not in the MUTCD or the North Carolina inventory, the use of the NO TURN ON RED WHEN PEDESTRIANS ARE PRESENT sign may be an appropriate alternative.

Other regulatory signs relating to pedestrians include:

- Pedestrian prohibited signs (R5-10c, R9-3a, R5-10a, R5-10b) to prohibit pedestrian entry at freeway ramps.

- Pedestrian crossing signs (R9-2, R9-3a, R9-3b) are used to restrict crossings at less safe locations and divert them to optimal crossing locations. Various alternatives include the USE CROSSWALK (with supplemental arrow) sign which may be used at signalized intersection legs with

high conflicting turning movements or at midblock locations directing pedestrians to use an adjacent crosswalk. The signs have the most applicability in front of schools or other major pedestrian generators.

- Traffic signal signs (R10-1 to R10-4) include the pedestrian push button signs or other signs at signals directing pedestrians to cross only on the green light or WALK signal. Pedestrian push button signs should be used at all pedestrian actuated signals. It is helpful to provide guidance to indicate which street the button is for (either with arrows or street names). The signs should be located adjacent to the push button and be visible to approaching pedestrians.

Other educational signs may be used for pedestrians at traffic signals to define the meaning of the walking man/hand symbol (or WALK, flashing DONT WALK and DONT WALK) signal indications. The decision to use these educational signs (or stickers placed directly on the signal pole) should be based strictly on engineering judgement. Their use may be more helpful near schools and in areas with a concentration of elderly pedestrians. This information may also be effectively

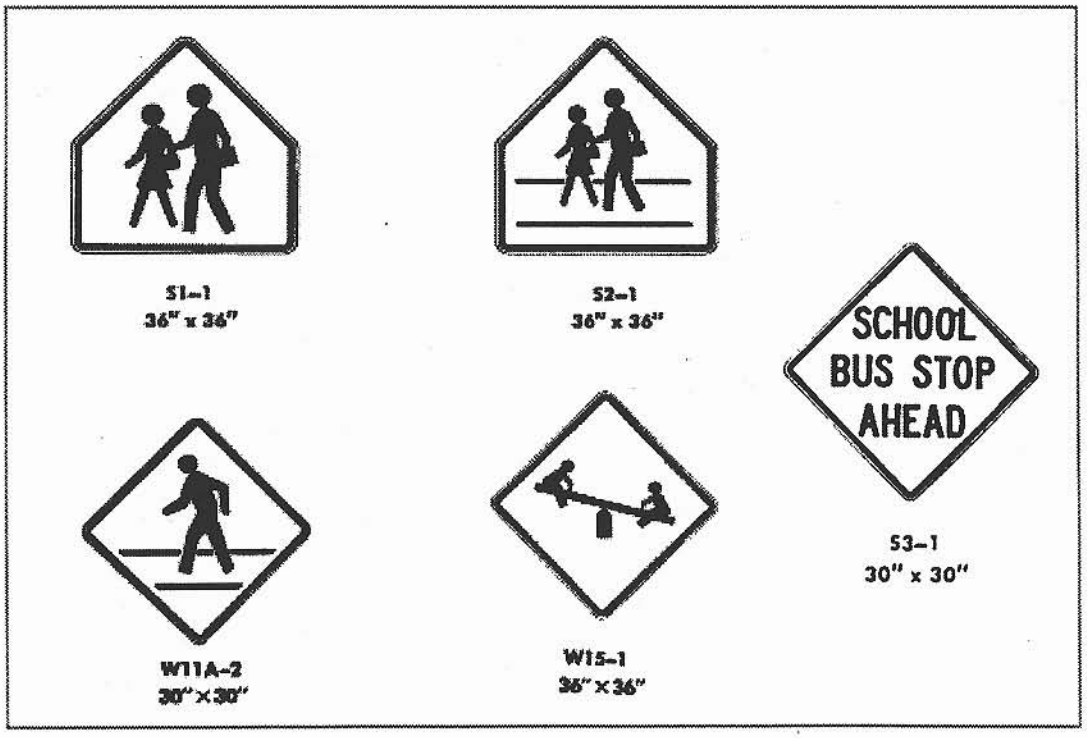


Figure 7. Typical warning signs relating to pedestrians.[1]

converted into brochures for distribution and ongoing education purposes.

WARNING SIGNS

Warning signs are used to inform motorists and pedestrians of unusual or unexpected conditions. Most warning signs fall under the permissive category ("may" condition), and when used, should be located to provide adequate response times. Warning signs are generally diamond-shaped with black letters or symbols on a yellow background and must be reflectorized or illuminated. Typical warning signs relating to pedestrians are shown in Figure 7.

The warning sign used to warn motorists of possible pedestrian conflicts is the Advance Pedestrian Crossing sign (W11-2). This sign should be installed in advance of midblock crosswalks or other crossing locations where pedestrians may not be expected to cross. This significantly minimizes their use at most urban intersections since pedestrians are an expected occurrence.

This sign may also be selectively used in advance of high volume pedestrian crossing locations to add emphasis to the crosswalk. The advance pedestrian crossing sign provides more advance warning to motorists than crosswalk markings, and on some occasions may be used when crosswalk markings do not exist.

Where there are multiple crossing locations which cannot be concentrated to a single location, a supplemental distance plate may be used (NEXT XXX FEET). The advance pedestrian crossing signs should not be co-mounted with another warning sign (except for a supplemental distance sign or an advisory speed sign) to avoid information overload. Care should be taken in sign placement in relation to other signs to avoid sign clutter and allow an adequate motorist response. The MUTCD specifies a 75 cm by 75 cm (30 in by 30 in) sign size. However, it may be helpful to use larger 90 cm by 90 cm (36 in by 36 in) signs on high speed or wider arterial streets.

The Pedestrian Crossing sign (W11A-2) is similar to the Advance Pedestrian Crossing sign, but has the crosswalk lines shown on it. This sign is intended for use at the crosswalk, which is the only warning sign not used in advance of the condition being warned (except for the large arrow sign and object markers). Because of its placement and the motorist's inability to distinguish and comprehend the subtle difference between the two signs (W11-2 versus W11A-2), its usefulness is limited. If used, it should be preceded by the advance crossing

warning sign and should be located immediately adjacent to the crossing point. To help alleviate motorist confusion, a black and yellow diagonally downward pointing arrow sign may be used to supplement the pedestrian crossing sign (W11A-2).

The Playground sign (W15-1) may be used in advance of a designated children's play area to warn motorists of a potential high concentration of young children. This sign should generally not be needed on local or residential streets where children are expected. Furthermore, play areas should not be located adjacent to high speed major or arterial streets, or if so, should be fenced off to prevent children from running into the street.

CAUTION - CHILDREN AT PLAY or SLOW CHILDREN signs are not valid MUTCD signs and should not be used, since they may encourage children to play in the street and may encourage parents to be less watchful of their children.[6] These signs provide no guidance to motorists in terms of a safe speed, and the sign has no legal basis for determining what a motorist should do. Furthermore, motorists should expect children to be "at play" in all residential areas, and the lack of signing on some streets may indicate otherwise. The use of this non-standard sign may imply that the local agency approves of streets as playgrounds, which may result in extra vulnerability to tort liability.

School Warning signs include the advance school crossing signs (S1-1), the school crossing sign (S2-1), SCHOOL BUS STOP AHEAD (S3-1) and others. School related traffic-control are discussed in detail in Part VII (Traffic Controls for School Areas) of the MUTCD.

The MUTCD allows for the development of other specialty warning signs based on engineering judgement for unique conditions. These signs can be designed to alert unfamiliar motorists or pedestrians of unexpected conditions and should follow the general criteria for the design of warning signs. Their use should be minimized to retain their effectiveness and minimize sign clutter.

PAVEMENT MARKINGS

Pavement word and symbol markings such as "SCHOOL XING" or "PED XING" may also be used as motorist warning devices. These may be helpful on high speed arterial or major streets with unusual geometrics (such as vertical or horizontal curves) in advance of a pedestrian crossing area. Markings should be white and placed to provide adequate

motorist response. Their use should be kept to a minimum to retain their effectiveness.

Consideration should be given to snow conditions which may obliterate the markings during portions of the year and the agency's ability to maintain these markings. If used, the word or symbol markings shall be white and should generally be used in each approach lane (except for the SCHOOL message). Pavement word markings need not be used on both approaches to a crosswalk if conditions differ between the approaches.

All pavement word and symbol messages require periodic maintenance, and replacement after resurfacing. If used, it is advisable to maintain an inventory of pavement stencils to assist in periodic monitoring and maintenance.

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CHAPTER 5

SIGNALIZATION

SIGNAL WARRANTS

Traffic signals are intended to assign the right-of-way for vehicular and pedestrian traffic. When installed appropriately, traffic signals can provide many benefits, such as creating gaps in heavy motor vehicle traffic for pedestrians to cross safely at intersections or midblock. Unwarranted or improperly used traffic signals can cause excessive delay for pedestrians and/or motor vehicles, signal disobedience, and an increase in certain accident types. Even where warranted, traffic signal installations commonly result in an increase of rear-end and total accidents, but generally with a corresponding reduction in more severe right-angle accidents.

The *Manual on Uniform Traffic Control Devices* (MUTCD) provides 11 separate warrants (see Table 3) for installing new traffic signals.[1] Note that warrant numbers 3 and 4 relate directly to pedestrians, and warrant number 6 also makes some reference to pedestrians. In reality, only a small percentage of new traffic signals have been installed based primarily on pedestrian considerations. In most cases traffic signals are installed based on vehicular traffic considerations. However, revisions to the minimum pedestrian volume warrant (warrant 3) are expected to provide easier justification of traffic signals based on the needs of pedestrians.[1,2]

The revised minimum pedestrian volume warrant states that a traffic signal may be warranted when the pedestrian volume crossing the major street at an intersection or mid-block location during an average day is:

- 100 or more for each of any four (4) hours; or
- 190 or more during any one (1) hour.

When installed appropriately, traffic signals can provide many benefits, such as creating gaps in heavy traffic for pedestrians to cross streets safely.

Warrant	Title
1	Minimum vehicular volume
2	Interruption of continuous traffic
3	Minimum Pedestrian volume
4	School crossings
5	Progressive movement
6	Accident experience
7	Systems
8	Combination of warrants
9	Four-hour volumes
10	Peak-hour delay
11	Peak-hour volume

Table 3.
Warrants for installing new traffic signals.

These volume requirements can be reduced by as much as 50 percent when the predominant crossing speed is below 1.1 m per second (3.5 feet per second) as would be the case if there is a high percentage of elderly pedestrians. In conjunction with these volumes, there shall be less than 60 gaps per hour in the traffic stream of adequate length for pedestrians to cross during the same period.

Simply meeting a warrant does not necessarily justify installation of a traffic signal. Strong consideration must be given to signal spacing, signal synchronization, and sight distances. It is not unreasonable to expect a pedestrian to walk a block out of his or her way to cross at an existing traffic signal or a better location. Where practical, it is more desirable to signalize intersections instead of midblock crossing locations where drivers may be less likely to expect pedestrian crossings.

Warrant 6 (Accident Experience) may be used to justify a traffic signal if 5 or more "correctable" collisions occur in the previous 12 months, and at least 80 percent of the Minimum Volume warrant (warrant 1), the Interruption of Continuous Traffic warrant (warrant 2), or the Minimum Pedestrian Volume warrant (warrant 3) is met. Pedestrian collisions should be considered when using the Accident Experience warrant if the pedestrian is in the process of crossing the street in a reasonable manner. However, past experience shows that traffic signals are often among the highest pedestrian accident locations. Traffic signals cannot be expected to reduce or eliminate pedestrian collisions unless the signal is designed, operated and maintained properly and if pedestrians and motorists use reasonable care when crossing and when driving.

PEDESTRIAN SIGNALS

Pedestrian signals may be needed at highly complex or multi-phase traffic signals where pedestrians regularly cross and where confusion may exist. Pedestrian signals may also be

needed for crossings of wide streets where the vehicle signal indication does not provide ample signal change (clearance) information to pedestrians (Figure 8).

Pedestrian signal indications consist of the symbolic man/hand signal display or the WALK/DONT WALK signal display in conjunction with traffic signals. The steady hand symbol (or DONT WALK) indicates that the pedestrian should not be in the street. The flashing hand symbol (or flashing DONT WALK) is a clearance interval that means pedestrians should not start crossing, but should have enough time to complete their crossing if they are already in the street (i.e., don't start).

The walking man symbol (or WALK) indicates that pedestrians may cross the street in the direction of the signal. Pedestrian signal displays are illustrated in Figure 9. The WALK/DONT WALK signals are currently suitable alternatives to the (walking man/hand) symbolic displays, however, the next version of the MUTCD plans to phase out the use of the word message at new signal installations.

It has been well documented that many pedestrians do not understand the meaning of the pedestrian signal indications, particularly the flashing hand (or flashing DONT WALK).[3] These problems highlight the need for more effective education of pedestrians. Education should include distribution of educational pamphlets or programs through schools, libraries, and community centers as well as signage such as the R10-4B "PUSH BUTTON FOR WALK (or Pedestrian

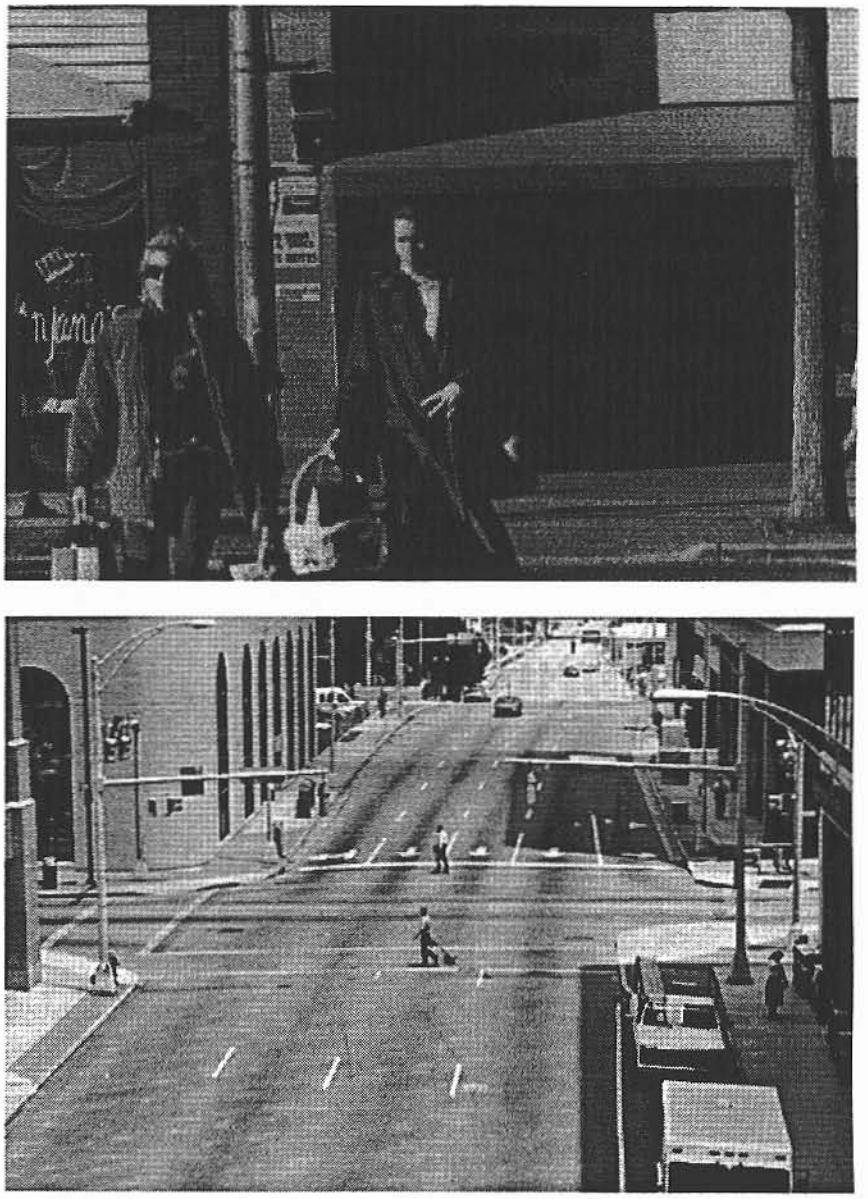
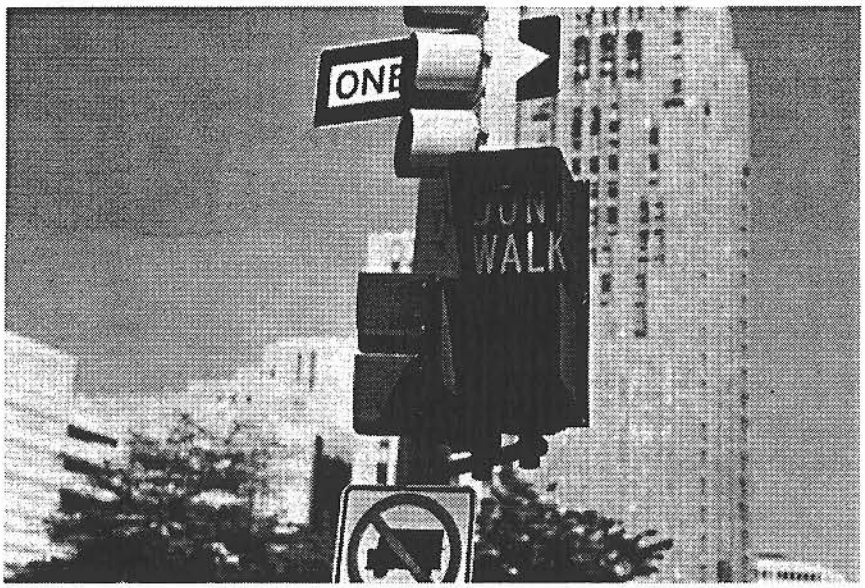


Figure 8
Crosswalks, traffic signals, and pedestrian signals give pedestrians the opportunity to cross wide streets.



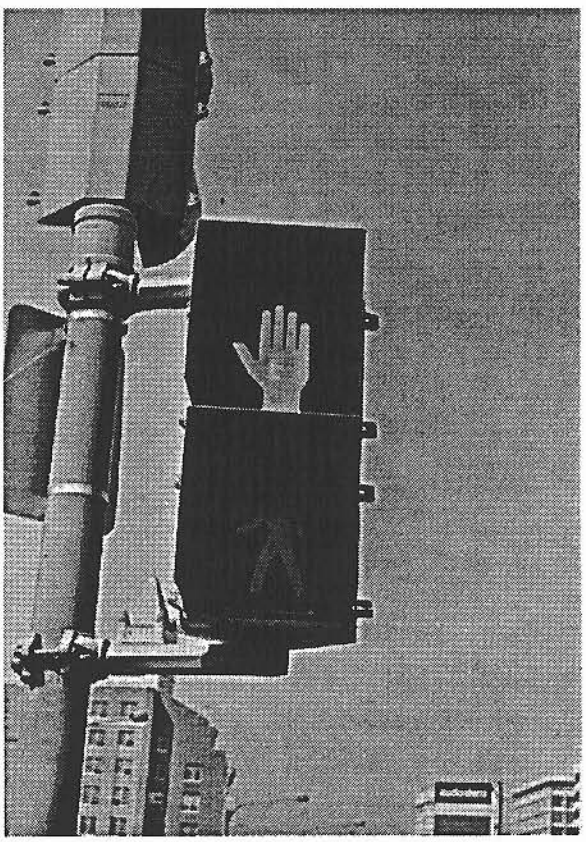


Figure 9
Pedestrian signal displays.[1]

Symbol)" sign (see Figure 10). Although not incorporated into the MUTCD, an additional pedestrian education sign that may be used is shown in Figure 11 and is similar to ones used in cities throughout the U.S.

Besides a lack of understanding, some pedestrians violate signals due to impatience. Motorists put pedestrians at risk when they run red lights and when making right and left turns while failing to yield the right-of-way to pedestrians lawfully in the crosswalk. Police enforcement is often the best solution for these problems.

Warrants for Pedestrian Signal Indications

Pedestrian signal indications need not be installed at all traffic signals, especially if pedestrian crossings are rare. Pedestrian signal indications are normally required under the following circumstances:[1]

- When the traffic signal is installed based on meeting the Minimum Pedestrian Volume or School Crossing Warrant.
- When an exclusive pedestrian crossing interval is provided (i.e. all conflicting vehicular traffic is stopped for pedestrians).
- When the vehicle signals are not visible to pedestrians (such as at one-way streets or "T"-intersections) or when the

vehicle indications are not in a position to adequately serve pedestrians.

- Signalized intersections at established school crossing locations.

It is also advisable to install pedestrian signals under the following conditions where pedestrian crossings are common:

- Crossings of wide streets where the vehicle signal does not provide an adequate pedestrian clearance interval.
- When multi-phase timing (as with split phasing or left turn arrows) is used and extra guidance is needed for pedestrians.
- When pedestrians can only cross a portion of the street to a refuge island during the crossing interval.
- When pedestrian push buttons are used.
- When optically programmed signal heads or tunnel visors are used and the traffic signal is not visible to the pedestrian.

Studies have shown that for typical 4-leg intersections with concurrent timed 2-phase traffic signals, signalized locations with pedestrian signals often do not result in any different levels of pedestrian crashes than signal locations without pedestrian signal indications. This may result from low compliance to the pedestrian signal and a false sense of security associated with the walking man (or WALK) signal. If pedestrian signal indications are used, they should have the same level of maintenance as the vehicular signal indications to help ensure pedestrian compliance.

Figure 10.
Example of an instructional sign for pedestrians to activate the signal.

Figure 11. Example of an educational sign for pedestrian signal displays.

Location of Pedestrian Signal Indications

The pedestrian signal heads must be positioned in alignment with the crosswalk so they can be seen by pedestrians while they are waiting on the curb at the other side of the street, and while crossing the street. The base of the signal housing is required to be between 2.1 m (7 ft) and 3.1 m (10 ft) high so that it will not normally be blocked by a car.

On wide streets, it may be advisable to install pedestrian signals in the medians, particularly where there are high numbers of elderly or visually impaired pedestrians.

Visors should be used for the pedestrian signal indication so that the signal is not readily visible outside of the crosswalk (to the extent practical). This should encourage more pedestrians to cross in the crosswalk.

After the pedestrian signal is installed, each crosswalk should be inspected to make sure that traffic signs, trees, utility poles and other obstacles do not block the view of the signal indication. Periodic maintenance of landscaping may be needed to make sure the signal indications remain unobstructed.

Pedestrian Signal Timing

For traffic signals at wide intersections, pedestrian crossing times are often the overriding factor used in determining green splits and cycle lengths. This also often leads to using minimum WALK and clearance (flashing DONT WALK) intervals.

The MUTCD recommends at least a 4 to 7 second WALK interval. However at times this may present a dilemma to pedestrians who see a flashing hand (or flashing

DONT WALK display) before they are more than one or two lanes across the street. While in actuality most pedestrians almost always continue to cross rather than return to their starting point, it is desirable to provide a longer WALK interval where possible.

A slower walking speed should be used for calculating the clearance interval at locations with high numbers of elderly pedestrians. In the absence of a specific study, a walking speed of 0.9 to 1.2 m per second (3 to 4 ft per second) is recommended.

Pedestrian Push-Button

At locations with actuated traffic signals and signals where pedestrian activity is infrequent (and pedestrian phasing is not warranted on a full-time basis), the use of pedestrian-actuated signals (i.e. push-buttons) may be justified. Pedestrian push-buttons are appropriate where occasional pedestrian movements occur and adequate opportunities do not exist for pedestrians to cross. Where no pedestrian signals are present, actuation of the push-buttons may be used to extend the green phase to allow pedestrians sufficient crossing time. Push-button detectors may also be used with pedestrian signals to extend the time for a longer pedestrian crossing.

Pedestrian push-buttons should be mounted a maximum of 1.1 m (3.5 ft) above the sidewalk and placed in a conspicuous, convenient location, preferably next to the curb ramp where the pedestrian will cross. In all cases the push-button must be accessible to a pedestrian in a wheelchair. Such placement will enhance pedestrian compliance and use of the push button.

Signs such as PUSH BUTTON FOR WALK SIGNAL are needed with the actuation devices to explain their meaning and use. When two actuation devices are placed close together for crossings in different directions (e.g. at intersections), it is important to indicate which crosswalk signal is controlled by each push-button (e.g., PUSH BUTTON TO CROSS CENTRAL AVE or the standard arrow symbol indicating which street to cross). Push-button devices may also be needed on medians and refuge islands where signal timing does not allow pedestrians to cross the complete street width during the signal phase.

The following are recommendations to improve the effectiveness of pedestrian push-buttons.

Figure 12.
Right-turn-on-red restrictions can improve pedestrian safety.

- Repair and maintain the push-button as necessary so that it is always operating properly.

- Assure pedestrians that the push button is responsive to pedestrians by displaying the WALK signal within a reasonable amount of time after the button is pushed (i.e., preferably within 30-60 seconds).

It is best to use push-buttons that are large and do not require a substantial amount of force to activate. This will make it easier to use by young children, elderly and pedestrians with disabilities.

Left and Right Turn Phasing

Thirty-seven percent of all pedestrian accidents at signalized intersections involve left- or right-turning vehicles. One national study found that the left turn vehicle-pedestrian accident rate was twice that involving right-turning vehicles.[4] Potential solutions to pedestrian collisions involving right- or left-turning vehicles in some situations include:

- Design compact intersections with small turning radii which force slower turning speeds. This may not be practical where large truck traffic exists.

- Prohibit right-turn-on-red (Figure 12). However, consideration should be give to the potential increase in right-turn-on-green conflicts.

- Where channelized right-turn slip lanes are used to accommodate high right-turn volumes or truck traffic, place the crosswalk as far upstream as possible to make pedestrians more visible to the right-turning driver.

- Use a separate left-turn phase for motorists (where pedestrians cannot cross during the left-turn interval).

The prohibition of a turn movement may shift the problem to another location and have a very negative effect on vehicle capacity and delay. However, heavy

pedestrian volumes may justify left-turn prohibitions.

Partial Crossings

Walking distances at some wide intersections may be excessive even for very mobile pedestrians. These intersections require long pedestrian clearance intervals, and often result in the minimum walking man (or WALK) intervals. At congested intersections, especially with high volume left turns and four or more phases, the pedestrian timing requires a high percentage of the cycle length. This can often result in pedestrian timing dictating the length of the green phase. However, for pedestrian convenience and compliance, it is highly desirable to cross an entire approach in one signal cycle.

Where partial crossings are used, the following are recommended:

- Use raised channelizing islands (particularly for right-turn lanes) to reduce the curb-to-curb walking distance and signal cycle lengths.

- Construct a median refuge island to reduce the walking distance. Where pedestrians can only cross to the refuge island on one interval and the signal is actuated, push-buttons must be installed on the median island. Median widths should be 3 m (10 ft) or wider to provide space for groups of pedestrians.

As a last resort, pedestrian crossings may be prohibited at one crossing and redirected to another crossing at the intersection or a nearby intersection. However, if the pedestrian movement across one approach of a four-legged intersection is prohibited, a pedestrian may have to cross the other three legs of the intersection to reach the intended corner. This could greatly increase the walking distance and the exposure to conflicting vehicle traffic. Thus, a balance is needed between motor vehicles and pedestrians.

Pedestrian Signal in a Coordinated Signal System

The accommodation of pedestrians in a coordinated signal system may significantly influence the effectiveness of the signal system. It is not unusual to have signalized intersections where the pedestrian timing needs exceed those for its companion vehicular movement.

The length of the WALK and flashing DONT WALK clearance intervals can have a major impact on the cycle length on a coordinated signal system. This

may result in longer cycle lengths, which will result in longer waits for pedestrians and vehicles on minor street approaches to traffic signals.

One solution is to design the system timing to operate without the pedestrian timing unless pedestrian actuation is detected. Then when a pedestrian push button is activated, the local intersection is disconnected from the system for one cycle to service the pedestrian movement. While this may work for areas with low pedestrian volumes, frequent pedestrian activations will severely disrupt the efficiency of the system. If high numbers of pedestrian crossings exist, it is best to accommodate the pedestrian on every cycle and minimize the need for pedestrian actuation.

Pedestrian Signal Phasing

Five signal phasing alternatives exist to accommodate pedestrian crossings at signalized intersections. The second and third alternatives have not been used in North Carolina.

1. *Standard (concurrent) timing* - a walking man (or WALK) indication is displayed concurrently with the green light for motorists on the parallel street. Left or right turning motorists must yield to pedestrians in the crosswalk.

2. *Early release of pedestrians* - the signal displays red for the parallel vehicle movement, particularly the right turn, while the walking man (or WALK) signals are displayed. The vehicular traffic then gets a green signal indication.

3. *Late release of pedestrians* - vehicles on the parallel street get a green signal indication before pedestrians get the walking man (or WALK) indication.

4. *Exclusive pedestrian phasing* - All vehicular traffic is stopped while pedestrians are allowed to cross in any crosswalk.

5. *Scramble pedestrian phasing* - All vehicular traffic is stopped while pedestrians are allowed to cross in any crosswalk or diagonally across the intersection.

In actual practice, the concurrent signal timing is appropriate in most applications. Early or late release of pedestrians may be appropriate where there is a very high volume of right or left turning traffic. Left-turn phasing is an example of late or early release of pedestrians (depending on the use of leading or lagging left turns

respectively). Under rare circumstances where there are very high pedestrian volumes (more than 1,200 pedestrians per day) and vehicle flow and signal synchronization is not a concern, the exclusive pedestrian phase or scramble phasing may be used.

Studies of various pedestrian signal phasing reveal that overall delay is lowest when using the standard or concurrent signal timing. Exclusive or scramble pedestrian intervals may be safer for pedestrians where there are very high pedestrian crossing volumes (over 1,200 pedestrians per day), but results in the highest overall delay. If scramble timing is used, the clearance interval must be based on the longest crossing which is usually one of the diagonal crossings.

Considerations for Persons with Disabilities

Pedestrians with disabilities may include those with a lack of mobility, stamina, visual impairments, hearing impairments and others. While it may be impossible to accommodate everyone, reasonable measures should be taken to make sure all pedestrian push-buttons are visible, unobstructed and accessible to persons in wheelchairs, and the clearance interval will accommodate the population that the signal is intended to serve.

Accommodation of blind and visually impaired pedestrians at traffic signals presents a unique challenge to the traffic engineer. Many visually impaired pedestrians are taught to use audible cues from the traffic to determine when it is appropriate to cross. When this is not possible there is often a request to install audible pedestrian signals.

While audible pedestrian signals may be appropriate near a school for the blind or community centers where large numbers of visually impaired pedestrians cross (and where they are taught to use the audible signal properly), this type of signal may provide a false sense of security and may not have the desired benefit. In addition there are no warrants for audible pedestrian signals and no standardization in the audible message which may lead to confusion to pedestrians. Therefore, the use of audible pedestrian signals should be left to the judgment of the local traffic engineer based on site specific conditions and the characteristics of the pedestrian population that routinely uses the intersection.

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CHAPTER 6

CROSSWALKS, CURB RAMPS & REFUGE ISLANDS

Crossing a street at an intersection or designated midblock crosswalk generally requires a pedestrian to proceed from a sidewalk, down a curb ramp, through the crosswalk, up the curb ramp, and onto the sidewalk. If the street is excessively wide or if traffic volumes are extremely heavy, a refuge island may be encountered in the middle of the street. This chapter discusses the design criteria for these three elements associated with crossing the street (Figure 13).

CROSSWALKS

A crosswalk is defined as the portion of roadway designated for pedestrians to use in crossing the street. Crosswalks may be marked or unmarked. At intersections, there is no legal difference between a marked or unmarked crosswalk. If no markings are present, the width of the sidewalk or path extended across the street defines a legal crosswalk. Where markings are present, the legal crosswalk is defined by such markings. While markings are not always needed at intersections, they are needed to designate a midblock crosswalk.

In the 1950's and 1960's, crosswalk markings were thought of as a public service under the assumption that marked crosswalks were generally safer than unmarked crosswalks, and the more the better. Studies conducted since that time have produced mixed results with respect to the safety benefits of marked crosswalks.

Two studies indicated that marked crosswalks were successful in encouraging more pedestrians to cross within the markings, but that pedestrian safety may be reduced at unsignalized intersections where marked crosswalks are used.[1,2] One of the conclusions of these findings was that pedestrians may "feel safer" within a marked crosswalk and expect motorists to act more

A crosswalk is defined as the portion of roadway designated for pedestrians to use in crossing the street.

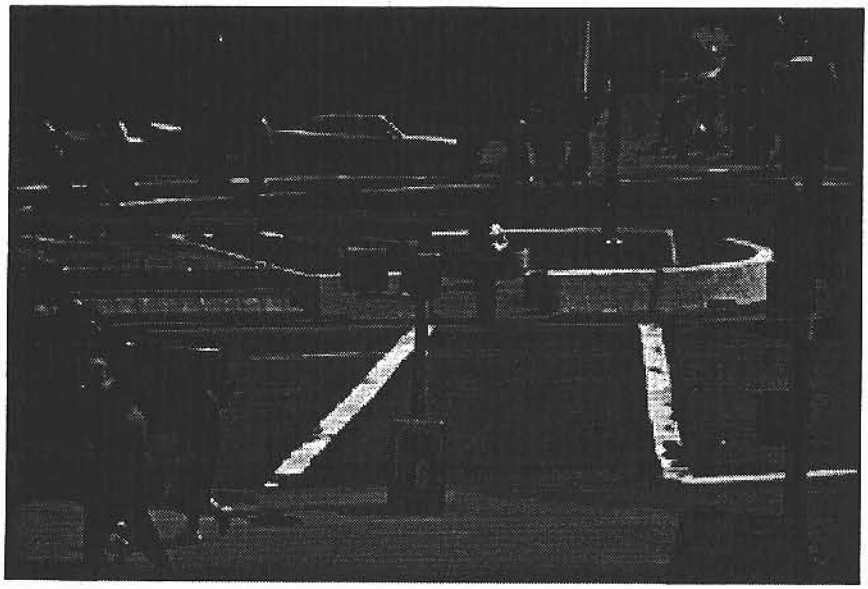


Figure 13.
Properly designed crosswalks, curb ramps and refuge islands can greatly enhance a pedestrian's ability to cross a street.

cautiously. In reality, crosswalk markings are not as visible to motorists as they are to pedestrians, and the pavement markings cannot stop an inattentive or impaired driver. Another research effort showed marked crosswalks to be as safe or safer than unmarked crosswalks for all conditions studied.[3]

In practice, marked crosswalks are typically assumed to be most beneficial at signalized intersections, particularly in urban areas and where pedestrian signals (i.e., walking man/hand signals) are present. The use of marked crosswalks is discouraged at midblock locations and at unsignalized intersections of high-speed roads. This is particularly important where sight distance restrictions exist since pedestrians may be encouraged to step into the street in front of a motor vehicle, and motorists may not see crossing pedestrians in time to stop.

Placement

Crosswalks should be placed in accordance with the *Manual on Uniform Traffic Control Devices* (MUTCD).[4] A summary of the MUTCD provisions for crosswalk markings is provided in Table 4. Other criteria, based on various levels of pedestrian and vehicle volumes, have also been developed to assist in determining when and where crosswalk markings may be beneficial.[5] As shown in Figure 14, if the combination of pedestrian and vehicle volumes are great enough to produce an intersecting value to the right of the appropriate curve, then a crosswalk may prove to be beneficial on that particular leg of the intersection. Note that the chart does take into account the type of pedestrian, number of lanes, presence or absence of a refuge area, and also assumes that the basic criteria (shown in the top right-hand corner) have been met.

Perhaps the most essential tool for use in determining crosswalk placement is engineering judgement. No set of guidelines can cover every situation or guarantee improved safety. Agencies should strive for uniformity to give motorists and pedestrians a consistent,

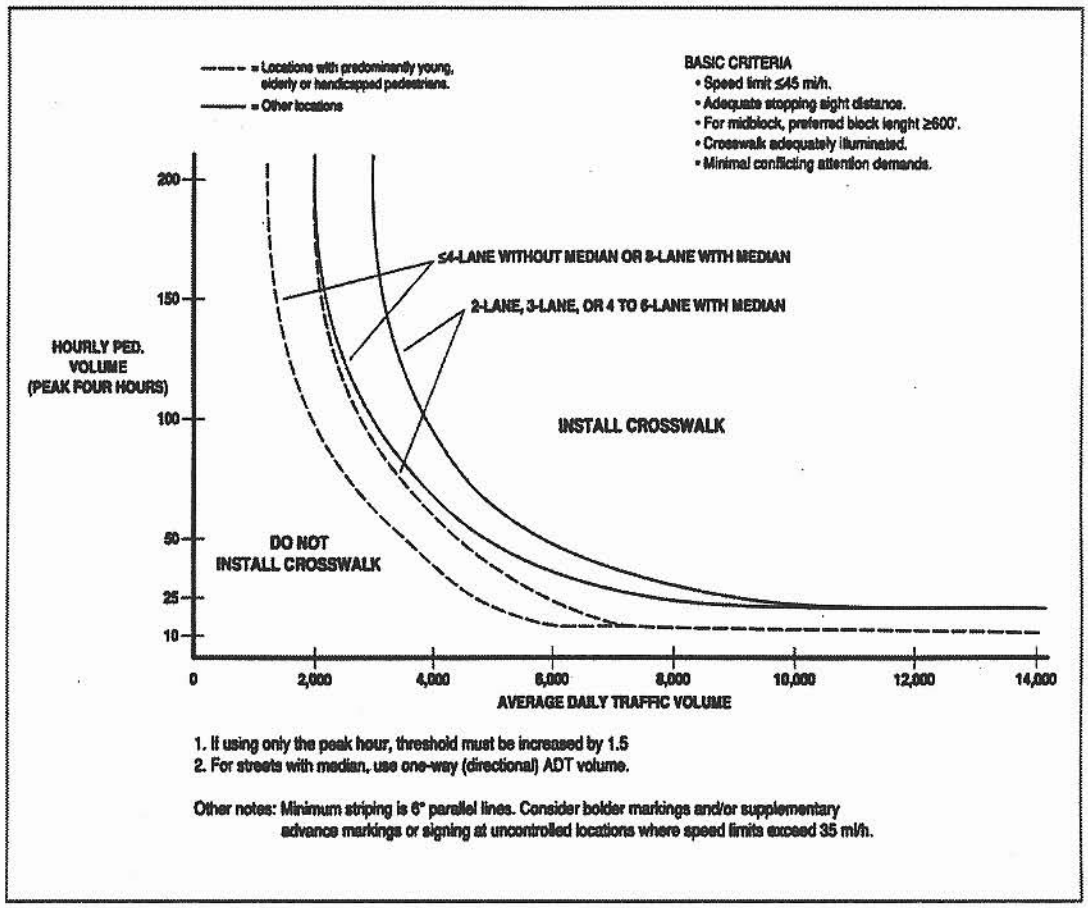
predictable traffic environment. Overuse should be avoided to maximize the effectiveness of those crosswalks that are marked. Based on past collective knowledge, marked crosswalks are generally recommended at the following locations:[6]

- Signalized intersections with pedestrian indications where pedestrian crossings are common.
- Locations where a marked crosswalk can concentrate or channelize multiple pedestrian crossings to a single location.
- Locations where there is a need to delineate the optimal crossing location, which is unclear due to confusing geometrics or traffic operations.

Condition Level	Requirement Description
Shall	Have 15 cm (6 in) minimum width markings of solid white lines.
Should	Have 1.8 m (6 ft) minimum [3 m (10 ft) desirable] crosswalk width.
	Be used where substantial pedestrian/vehicle conflicts exist.
	Be used at appropriate points of pedestrian concentration or where pedestrians could not otherwise recognize the proper place to cross (e.g., loading islands, mid-block pedestrian crossings).
	Not be used indiscriminately.
	Be installed based on an engineering study if located other than at a STOP sign or traffic signal.
	Have advance warning signals installed at mid-block crossings where pedestrians are not expected, and allow for restriction of parking for adequate visibility.
May	Be marked with white diagonal or longitudinal lines (parallel to vehicle traffic) for added visibility.
	Omit the transverse crosswalk lines when the extra diagonal or longitudinal markings are added.
	Use unique markings for diagonal crossings at signals when an appropriate exclusive pedestrian phase is used.

Table 4. Recommended guidelines for crosswalk design and placement:[4]
The MUTD has three condition levels that apply to the design and implementation of traffic control devices: SHALL implies a mandatory condition; SHOULD implies an advisory condition; and MAY implies a permissive condition.

Figure 14. Guidelines for crosswalk installation at uncontrolled intersections and midblock crossings.[6]



- Approved school crossings or at crossings on recommended safe routes to school.

- Other locations with high numbers of pedestrian crossings (more than 25 pedestrians per hour) and/or pedestrian/vehicle conflicts.

Midblock crosswalks are generally discouraged, particularly on streets with motor vehicle speeds of 75 kph (45 mph) or higher. Motorists are least likely to expect pedestrians to cross midblock, and it is reasonable to expect pedestrians to walk less than a block out of their way to a better crossing location.

Where it is considered desirable to install midblock crosswalks, advance pedestrian warning signs should be used to warn motorists of pedestrian crossing activity (see Chapter 4 for more information on pedestrian/motorist signing). The use of signs is especially important in jurisdictions where marking maintenance is low. Also markings may be difficult to see during adverse weather conditions.

Design

Due to operational concerns with narrow crosswalks and the costs associated with installation, it is recommended that wider crosswalks with wider pavement markings be installed than is required by the MUTCD. It is suggested that a 3 m (10-ft) wide crosswalk be installed, while wider crosswalks may be used where higher pedestrian volumes exist or where it is desirable to increase the conspicuity of the crosswalk. Similarly, crosswalk lines of 25 to 30 cm (10 to 12 in) in width are recommended with wider lines or advanced stop lines used when greater emphasis is considered helpful.

The crosswalk markings must align with the curb ramp so that a pedestrian in a wheelchair or otherwise in need of the ramp should be able to access the ramp without having to leave the crosswalk. Figure 15 shows recommended crosswalk placement for various wheelchair ramp designs.[7]

Three different designs, as shown in figure 16, are typically used to designate crosswalks. The standard crosswalk consists of two parallel white lines (scenario a). However, diagonal (scenario b) or longitudinal (scenario c) lines may be used for increased emphasis. The latter two are referred to as "high-visibility"

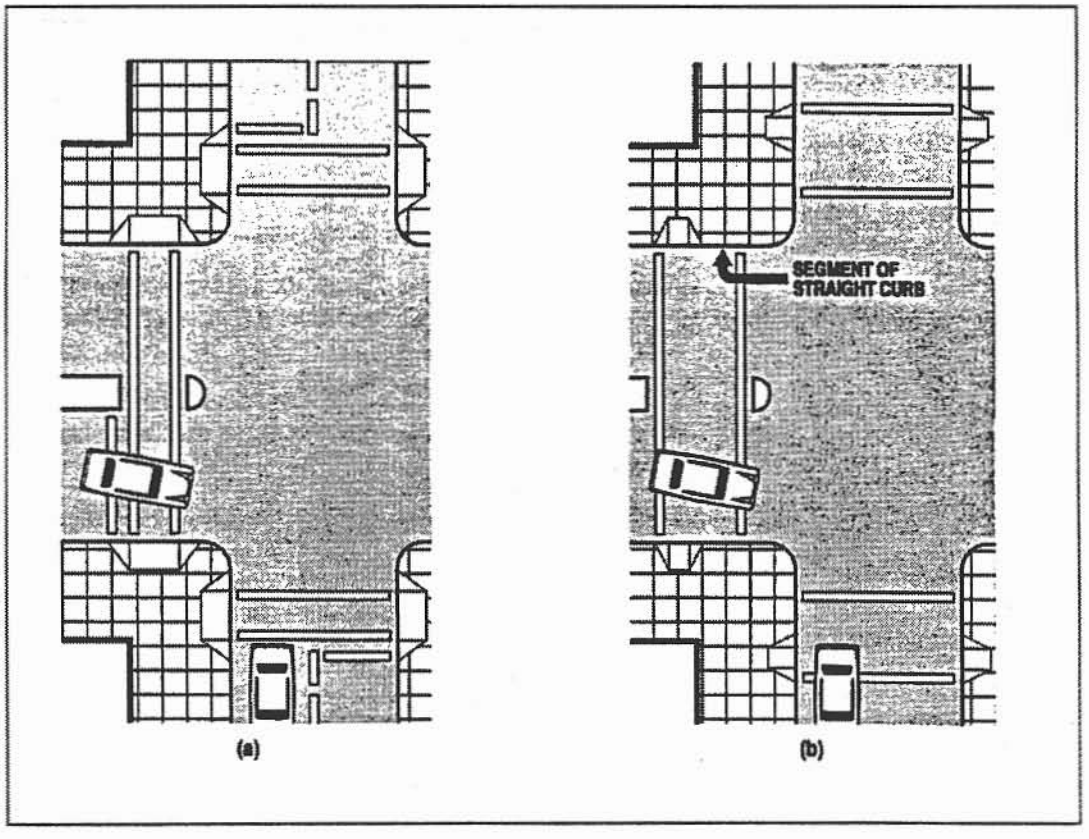
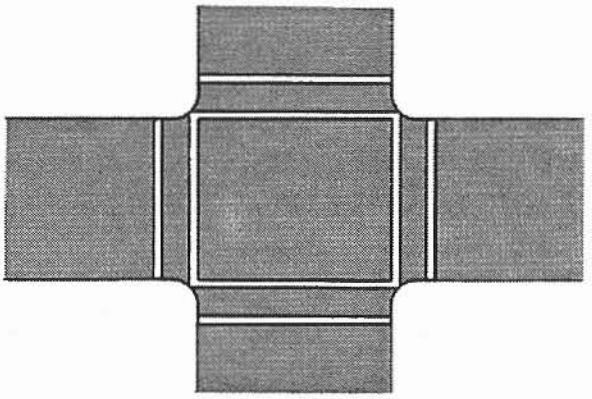


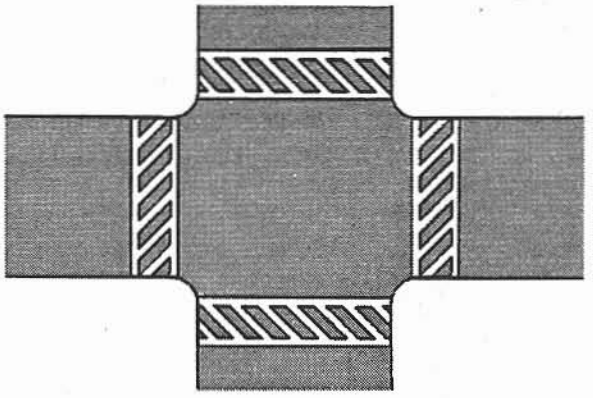
Figure 15. Crosswalk placement in accordance with various ramp designs.[6]

Figure 16.
Typical crosswalk markings.[6]

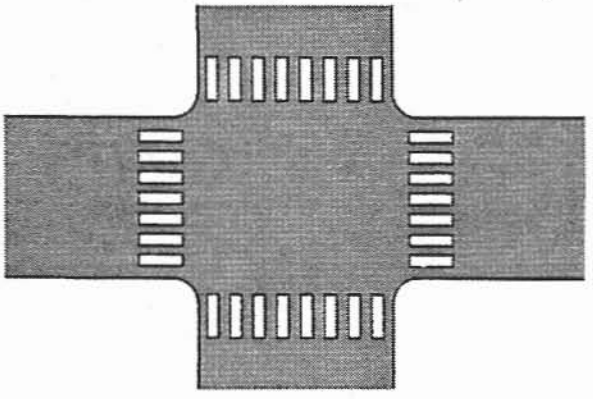
a — Standard crosswalk marking.



b — Crosswalk marking with diagonal lines for added visibility.



c — Crosswalk marking with longitudinal lines for added visibility.



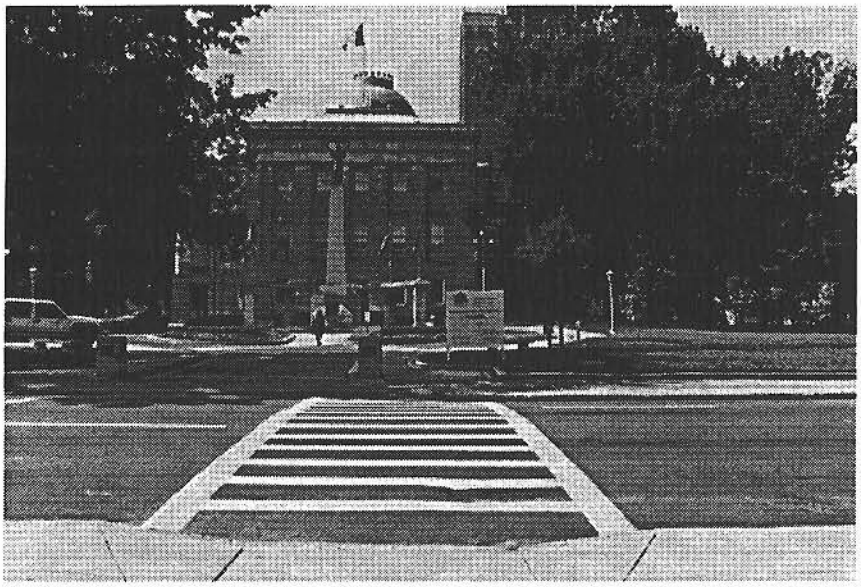


Figure 17
High-visibility markings such as longitudinal lines may be used in crosswalks for increased emphasis.

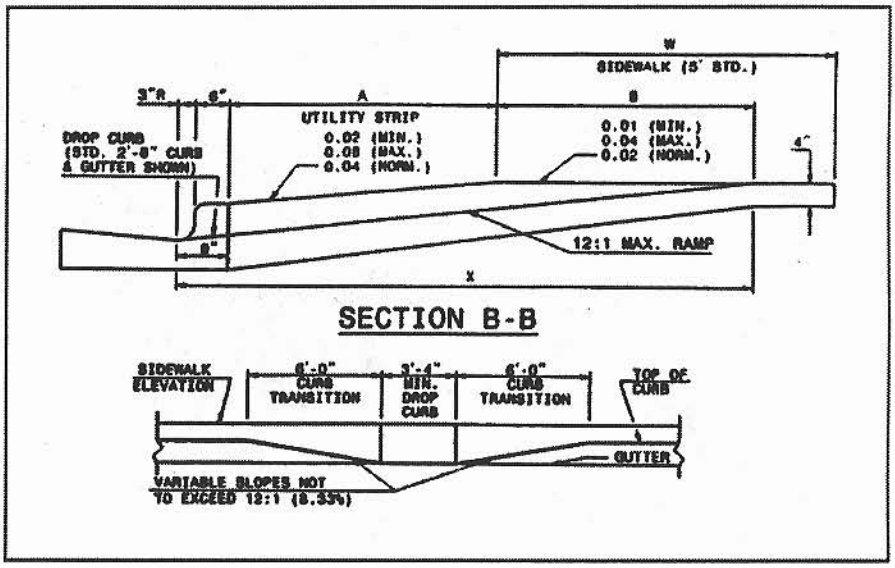
markings (Figure 17).

There is no evidence to prove that more crosswalk markings will provide safer conditions, and there is no requirement to install high-visibility markings. There are offsetting concerns of an increased false sense of security to pedestrians on the one hand with improved conspicuity to motorists and greater pedestrian recognition of the designated crosswalk on the other. Without conclusive accident studies to compare the relative value of each design, these extra markings seem to be of questionable value when compared to their installation and maintenance costs.

High-visibility crosswalks may be used at those locations where greater motorist information is considered beneficial and where pedestrians may not be expected to cross (e.g., midblock) or where there are substantially higher pedestrian crossing volumes. These crossings are generally not recommended where other traffic control exists (such as STOP signs and traffic signals) or at all marked crosswalk locations since the extra emphasis will be diminished at those locations where it is needed. When used, the 30-cm (12-in) line with the 60-cm (24-in) gap will provide the most cost-effective pattern. It may also be helpful to consider vehicle tire paths when selecting the spacing of markings for the ladder or continental crosswalk designs to reduce maintenance needs.

Consideration should also be given to the slipperiness of the marking surface where wet weather or snow conditions exist. If this problem occurs, an alternate marking pattern or more slip-

Figure 18.
Measurement of curb ramp slopes (from Appendix C).[8]

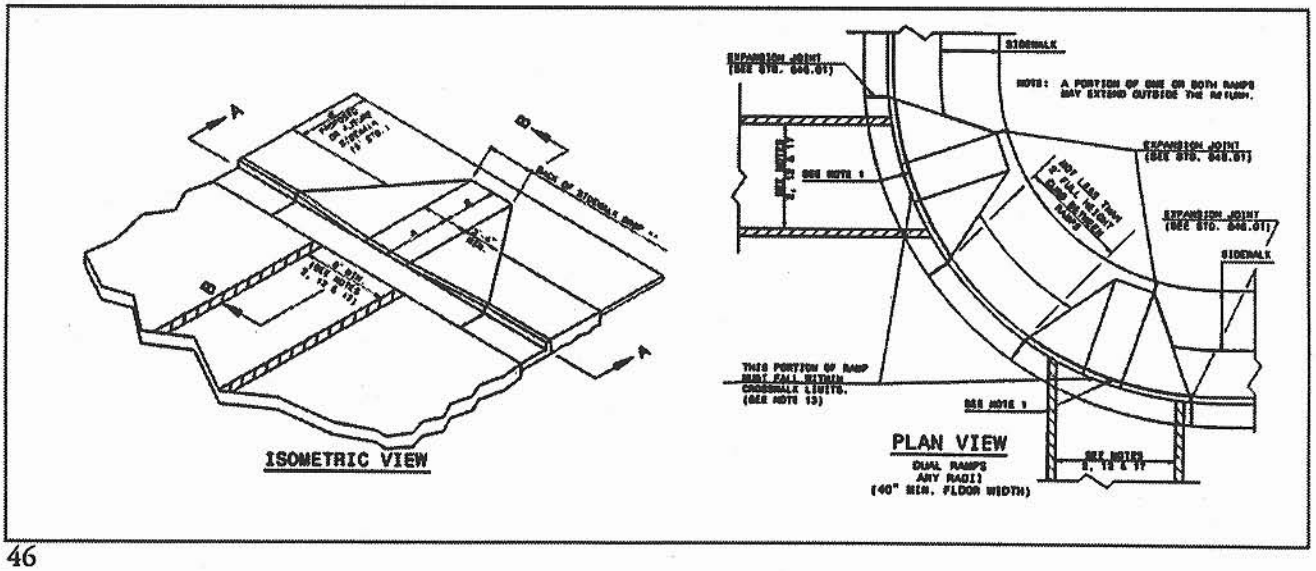


resistant crosswalk materials should be considered.

Crosswalks marked with buttons or reflective raised pavement markers (RPMs) are generally not recommended. Any rumble effect given to motorists at this point is provided too late for use as advance warning, and the pedestrians who walk along the lines may trip on the RPMs. RPMs are also detrimental to wheelchairs and bicyclists and snow plows may displace the markers. RPMs may be used upstream from a crosswalk in conjunction with advance pedestrian warning signs in an attempt to enhance motorist awareness of the upcoming crosswalk.

Other factors that should be considered in the design and installation of crosswalks include:

Figure 19.
Side treatments for curb ramps (from Appendix C).[8]



- Adequate sight distance for the motorist and pedestrian should exist. This includes examination of on-street parking, street furniture (e.g., mailboxes, utility poles, newspaper stands), and landscaping.

- Marked crosswalks should not be located immediately downstream from bus stops, traffic signals or other marked crosswalks.

- An examination of street lighting should be conducted. It is advantageous to locate a marked crosswalk at a streetlight, particularly if nighttime crossings are common.

- When possible, it is best to mark crosswalks at 90 degrees to vehicle traffic to designate the shortest path for pedestrians to minimize exposure to traffic and to avoid having the pedestrian's back turned to traffic.

Maintenance

Marked crosswalks should be kept in good condition and should be removed when no longer needed. Shorter service life, longer dry times and the need for more extensive barricading makes painted crosswalks less desirable than longer life plastic materials and ultimately more expensive to maintain. However, plastic pavement markings are more difficult to remove, often requiring special equipment.

It is desirable to maintain an inventory of crosswalk locations for periodic maintenance and monitoring purposes. Once installed, the crosswalks should be monitored for continued applicability and usefulness. When no longer useful, crosswalk removal may be coordinated with a street resurfacing project.

CURB RAMPS

Properly designed curb ramps allow for a safe and efficient transition from the elevated sidewalk surface to the street surface or vice versa. It is important that these ramps be designed and installed to meet the needs of those persons for whom they were intended, i.e., the physically disabled, elderly, and others who are physically challenged.

Placement

In accordance with the Americans with Disabilities Act, curb ramps shall be provided wherever an accessible route crosses a curb. The ramps shall be wholly contained within the crosswalk, as

In accordance with the Americans with Disabilities Act, curb ramps shall be provided wherever an accessible route crosses a curb, and shall be wholly contained within the crosswalk.

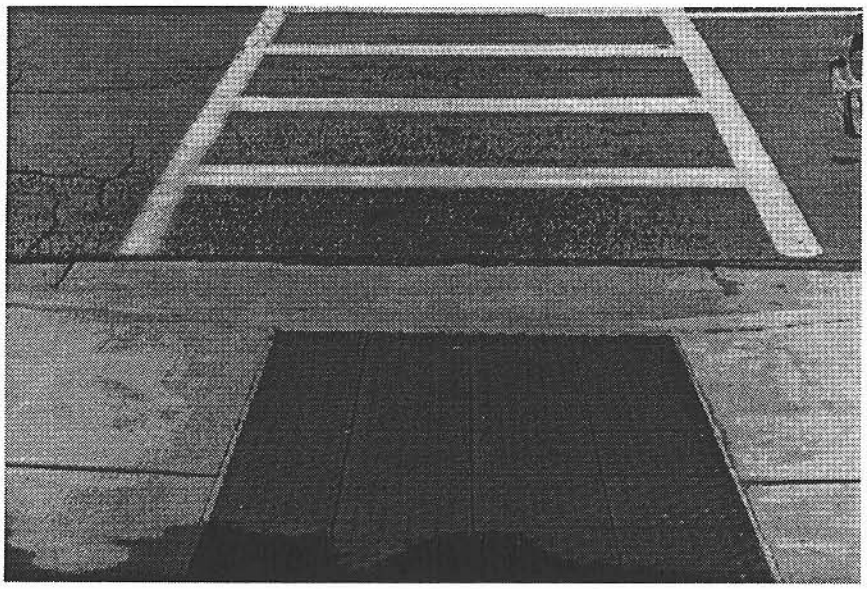


Figure 20.
A tactile curb ramp.

previously shown in Figure 15. Diagonal ramps are not recommended; instead, one ramp should be used for each crossing direction. However, if diagonal ramps are used, a minimum 1.2-m (4-ft) clear space is required at the bottom of the ramp to allow pedestrians in wheelchairs enough room to maneuver into the appropriate crosswalk without entering the motor vehicle lane. Other considerations for the placement of curb ramps are as follows:[7]

- Curb ramps should not be placed so that pedestrians have to cross storm water grates or inlets, manhole covers, or other access lids.
- Curb ramps that service adjoining crosswalks should be separated as much as possible.
- Curb ramps should be located outside the direct line of travel to aid blind pedestrians searching for a curb edge, but should still remain within the crosswalk.
- Curb ramps should be located to prevent their obstruction by parked vehicles.

The NC DOT's guidelines for curb cuts and ramps are given in Appendix C.

Design

The slope of a curb ramp (measured as shown in Figure 18) shall not exceed 1:12 in order to comply with the ADA. If the curb ramp is located where pedestrians would normally walk across the ramp, or where it is not protected by handrails or guardrail, then flared sides should be used as shown in Figure 18. The flared sides should have a maximum slope of 1:12. If the curb ramp is located where pedestrians would not normally cross it, then returned curbs, like the one shown in Figure 19, may be used. The minimum width of a curb ramp,

exclusive of the flared sides, shall be 1 m (40 inches).

The surface of a curb ramp should be stable, firm, and slip-resistant. The texture of the ramp should be coarse enough so that it is not slippery when wet, yet smooth enough not to cause problems for wheelchair users. The ADA's requirements for tactile curb surfaces are currently being reviewed (Figure 20).

Maintenance

A program of routine maintenance should be developed to inspect and clean curb ramps, and to repair any damage noted during the inspections. During the winter, efforts must be made to remove all snow, ice and any debris left from deicing agents as soon as possible.

REFUGE ISLANDS

Pedestrian refuge islands are defined as the areas within an intersection or between lanes of traffic where pedestrians may safely wait until vehicular traffic clears, allowing them to cross a street. Refuge islands, like the one shown in Figure 21, are commonly found along wide, multilane streets where pedestrians may not be able to safely cross without adversely affecting motor vehicle traffic flow. These islands provide a resting area for pedestrians, particularly those who are disabled, elderly, or otherwise unable to completely cross an intersection within the available gap or provided signal time.

Refuge islands also provide pedestrians with the advantage of having to search for vehicles in one direction only as they cross from the curb to the island or from the island to the curb. The delay for pedestrians can also be reduced significantly. One study found that pedestrians crossing an undivided, multilane street may experience delays 10 times longer than the delay incurred crossing a street with a median.[9]

The effect of refuge islands and medians on pedestrian safety is unclear. Studies have reported both increases and decreases in accidents after pedestrian islands have been installed. However, a 1978 study in

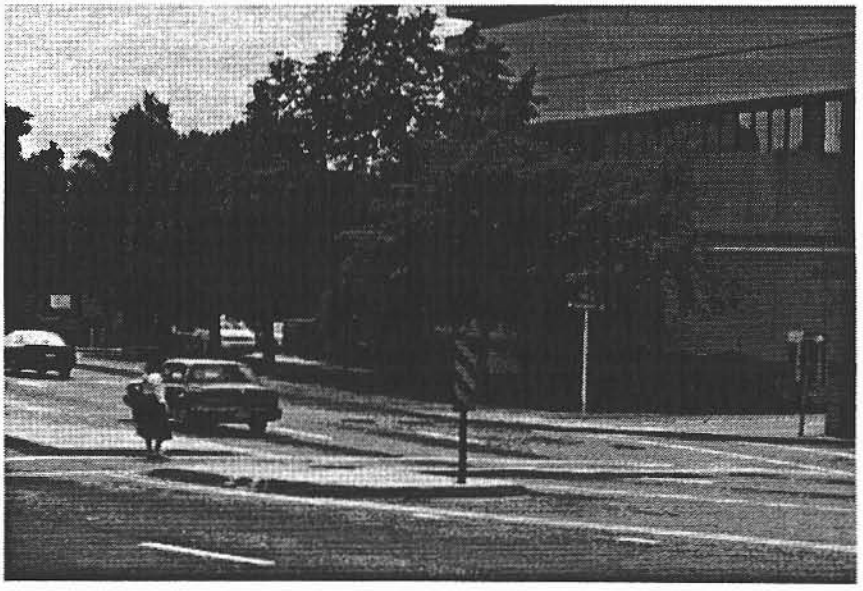


Figure 21.
Refuge islands allow pedestrians to cross one direction of traffic, wait if necessary, and then cross the other direction of traffic.

western Australia indicated that the rate of pedestrian accidents at a four-lane unsignalized intersection was reduced to 11.5 percent of its original level when raised median islands were installed.[10]

Placement

Pedestrian refuge islands may be installed at intersections or midblock locations deemed appropriate through engineering studies. Refuge islands should be considered during the design of complex intersections or streets rather than after construction has been completed. They must be visible at all times with the stopping sight distance as the minimum distance requirement. Refuge islands should be designed to minimize the potential hazard to motorists and pedestrians alike.

Refuge islands are recommended for wide, two-way streets with high traffic volumes, high travel speeds, and large pedestrian volumes.

Refuge islands can be beneficial under certain conditions but may involve some tradeoffs and can cause increased problems if not designed and installed properly. The typical conditions where refuge islands can provide the greatest benefit, and thus are recommended, include:[6]

- Wide, two-way streets (four lanes or more) with high traffic volumes, high travel speeds, and large pedestrian volumes;
- Wide streets where the elderly, people with disabilities, and child pedestrians cross regularly;
- Streets with insufficient green signal phasing time for safe pedestrian crossing during a single phase.
- Wide, two-way intersections with high traffic volume and significant numbers of crossing pedestrians; and
- Low volume side street traffic demands with insufficient green time to cross.

Seven-lane streets, with a center two-way left-turn lane, are not very "pedestrian friendly." It is more desirable to construct a six-lane street with a raised median that includes left turn slots at intersections. This will provide a better continuous pedestrian refuge island and allow for a landscaping buffer between traffic flows for improved aesthetics.

To avoid pedestrian problems with refuge islands, they should be of sufficient width for safe pedestrian storage. Consideration should also be given to large trucks which could encroach over the refuge island and strike a pedestrian. It is also important to avoid other potential problems,

such as conditions in which the roadway alignment obscures the island, thereby making it likely for vehicles to drive into the island.

In areas where refuge islands are designed and maintained properly, the advantages to pedestrians are many, including:[6]

- Reducing pedestrian crossing time by splitting crossing distances (i.e., providing staged crossing of pedestrians), thereby reducing green time required for pedestrian crossing phase;
- Providing pedestrians with a resting place when crossing wide roads or intersections;
- Providing a pedestrian storage area;
- Increasing the capacity of the intersection with a near-side island that provides a better location for the stop bar;
- Loading and unloading transit riders (although curbside locations provide a better alternative); and
- Providing location for traffic control and utility pole installations.

Design

Pedestrian refuge islands should be designed in accordance with the AASHTO policy and the MUTCD requirements.[4,11] Design considerations should include:

- Signalized intersections where the total length of crosswalk cannot be readily travelled in one pedestrian phase should be constructed with refuge islands. Special consideration should be given to intersections where a large number of elderly pedestrians and/or people with disabilities will be present. Special consideration also should be given to complex or irregularly shaped intersections where islands could provide a pedestrian with the opportunity to rest and become oriented to the flow of oncoming traffic.
- Raised curbs with cut-through ramps at pavement level or curb ramps should be provided for wheelchair users. Cut-through ramps should be graded to drain quickly and should also have special provisions to assist the visually impaired in identifying the refuge island. Islands with ramps should have a level area

at least 1.2 m (4 ft) long at the same level as the top of the raised median to provide a level area for wheelchair users.

- The smallest curbed island that should be considered is 4.6 square meters (50 square feet) for urban areas and 7.0 square meters (75 square feet) for rural areas with 9.3 square meters (100 square feet) preferable for both. Triangular islands should not be less than 3.7 m (12 feet), and preferably 4.6 m (15 feet) on a side after the rounding of corners. Elongated or divisional islands should not be less than 1.2 m (4 feet) wide and 6.1 to 7.6 m (20 to 25 feet) long.

- An approach nose, offset from the edge of the traffic lane, should be constructed and appropriately treated to provide motorists with sufficient warning of the island's presence. This can be achieved through various considerations such as illumination, reflectorization, marking, signage, and/or size.

- Pedestrian push buttons and signage adjacent to crosswalks may be needed.

- Guidestrips for the blind should be considered, particularly if they are provided on other nearby facilities.

- No obstruction to visibility by such features as foliage, barriers, or benches.

- Barriers that may be necessary to keep pedestrians from stepping into traffic at improper locations.

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CHAPTER 7

SCHOOL ZONE PRACTICES

Traffic control in school areas is a highly sensitive subject. If all the demands of parents and others were met, there would be many more police, adult crossing guards, traffic signals, flashers, signs, and crosswalks. However, past experience has shown that school crossing controls requested by parents, teachers and others are often unnecessary, costly, and tend to lessen the respect for traffic controls that are warranted. Safe and efficient traffic control can best be obtained through uniform application of realistic policies, practices and standards developed through engineering studies (Figure 22).

Pedestrian safety depends in large part on public education and an understanding of accepted methods for efficient traffic control. Nonuniform procedures and devices cause confusion among pedestrians and vehicle operators, and can contribute to accidents. In order to achieve uniformity of traffic control near schools, comparable traffic situations must be treated in the same manner. Each traffic control device and control method must fulfill a

Figure 22.
Properly designed facilities in school zones are necessary to create a safe environment for children.

A school area traffic safety program consists of two parts: the physical facilities and the operation plan. It requires a partnership among traffic engineers, school officials, parents and students.

specific function related to specific traffic conditions.

Pedestrians under the age of 15 experience a pedestrian collision involvement twice that of all pedestrians. Five through eight years old are the most common ages for child-pedestrian accidents. Young children are not able to judge the speed of approaching vehicles, nor the adequacy of gaps in traffic, and their peripheral vision is not well developed. Young children are also often inattentive and careless in crossing streets. Despite this, the trip a child walks to and from school, in general, is a safer one in relation to other pedestrian activities of children.

SCHOOL SAFETY PROGRAM

School area traffic safety requires a partnership between traffic engineers, school officials, parents and students. The lack of commitment by any one of the partners will seriously diminish the safety program.

A school area traffic safety program consists of two parts: The physical facilities and the operation plan. Sidewalks and walkways separate school children from the flow of vehicular traffic, and along with fencing, driveway and school location are a key part of the physical facilities for walking school children. The operation plan consists of the traffic control devices and the supervisory/control elements for the school walking trip.

The selection of the appropriate school zone traffic control is dependent upon the traffic characteristics, school location, the number of students crossing, and the ages of the students. In general, the most effective school zone traffic control includes well-trained adult crossing guards. On-site school safety near bus loading areas, driveways, and parent loading zones often require adult supervision, generally by teachers or teacher aids.

School Location and On-Site Safety

Site selection and school layout are some of the most important factors in obtaining safe traffic conditions near schools. Donated land or land presently owned by the school district may not always be the best site for a school. Sites should be of sufficient size to accommodate the school buildings, playgrounds and athletic areas, bicycle and motor vehicle parking areas, bus loading areas and parent pick-up zones.

The school site must be readily accessible from the street network to avoid traffic congestion that may put pedestrians at risk. In addition, schools must be

accessible to students in wheelchairs. It may also be advisable to provide separate bikeways and sidewalks at schools or wider sidewalks to accommodate the many users adjacent to schools.

School sites should have separate parking areas for teachers, students and visitors. Bus loading areas should always be separated from all other vehicle traffic. Driveways should be located to minimize crossings by students, and students should never be required to cross parking areas.

Elementary schools and middle schools should be located inside residential neighborhoods, close to the students that the school is serving. The need to cross major streets on foot should be minimized. Elementary schools should not be located on high speed major streets. It may be best for school districts to change school boundaries or institute busing rather than expose young children to crossings of wide arterial streets with high volumes or high speed traffic.

Sites for high schools are generally larger, require substantially more on-site parking areas, and are generally located on collector streets or major arterials. Driveway and school crossing locations should be coordinated with local traffic engineers to optimize existing traffic control and provide optimal spacing for future traffic signals.

Parking shall be restricted at driveways and in advance of all school crossing areas. Such parking restrictions protect school children by maximizing their visibility to motorists.

School fencing or other pedestrian barriers should be used to control student crossings and direct students to optimal crossing locations that can be better supervised. Crossing and student loading areas adjacent to the school should be reviewed for street lighting, particularly where student activity occurs during the hours of darkness. Street lighting also helps reduce the incidence of vandalism at the school site.

School Operating Plan

Each school should establish a program which includes a safe walking trip to school, utilizing existing traffic controls to the extent practical, and work with local officials to identify areas requiring improvements in accordance with the ITE Recommended Practice *School Trip Safety Program Guidelines.*[2] In addition a supervision and control plan should be adopted by each school.

The six steps in developing a school program based upon the

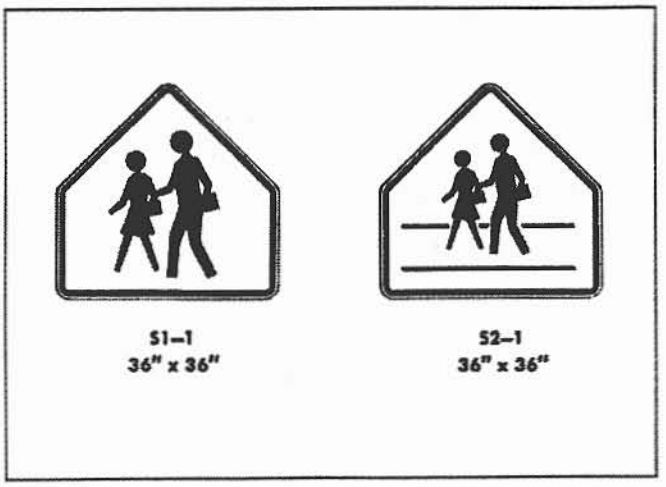

Figure 23. Warning signs used to alert motorists to schools and school crossings.

School Trip Safety Program Guidelines are:

1. Set up the school trip safety process.
2. Identify deficiencies in routes.
3. Designate route maps for safe routes to school.
4. Select route improvements and control measures.
5. Implement route improvements.
6. Evaluate routines periodically.

Sidewalks and walkways should exist along all designated safe school routes. Crosswalk markings are helpful in designating and directing students along the safe school route. Traffic signals are sometimes needed to create adequate gaps in vehicular traffic at school crossings to allow children time to cross major streets safely.

Factors such as sight distance, accident history, vehicle speeds, street width, age of students and other location and traffic characteristics should be considered in selecting the specific type of traffic control appropriate at each school crossing location.

Traffic signals are generally warranted at established school crossing locations when the number of gaps in the traffic stream during school crossing periods is less than the number of minutes in that same period.[2] Traffic signals should not be installed if there are only small numbers of students crossing; instead an alternate crossing location or mode of transport should be considered.

If installed under the School Crossing warrant, traffic signals should be coordinated with adjacent signals, and operate in an actuated mode to minimize traffic disruption. The signals should be equipped with pedestrian signal indications and pedestrian push buttons, and the designated crosswalks should be marked. School traffic signals may require adult crossing guards, particularly for younger students.

School Advance warning signs (S1-1) should be installed in advance of all school boundaries and at major school crossings. When used, the S2-1 School Crosswalk sign shall be placed at the school crosswalk, and must be preceded by the S1-1 Advance

School warning sign. Both of these signs are shown in Figure 23.

All decisions on the use of traffic control devices near schools should be coordinated with the school principal or district transportation director. The school principal should be contacted to coordinate any traffic control changes or construction activities near the school, even if not directly related to the school.

SCHOOL CROSSING GUARDS

Supervision of crossing school children should be carried out by adult crossing guards and may be supplemented by members of the school safety patrol (Figure 24). Control of vehicular traffic can only be exercised by police officers.

Crossing guards should be considered when special problems exist which make it necessary to assist school children in crossing safely. The primary functions of crossing guards are:

- To instruct, direct and control students crossing the streets and highways at or near schools.

- To assist teachers and parents in the instruction of school children in safe crossing practices.

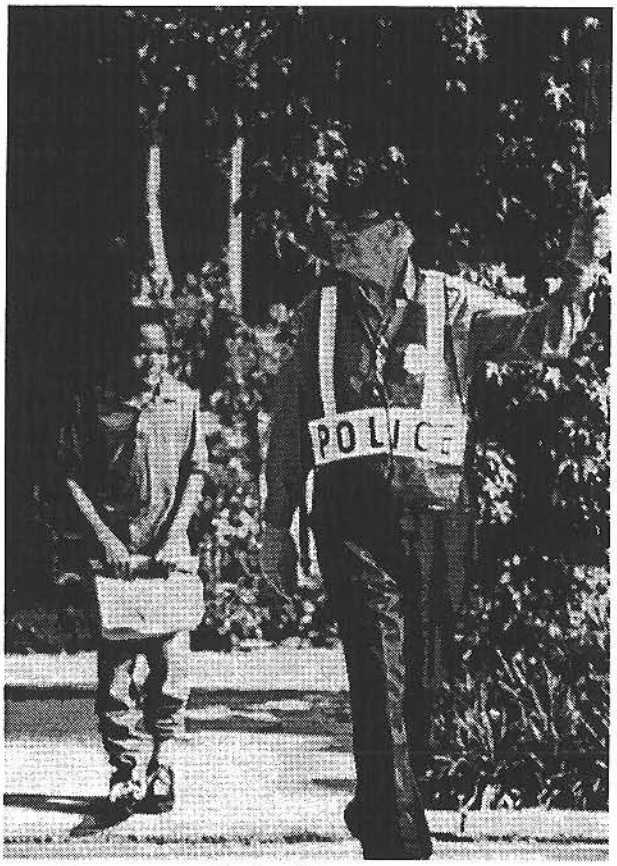

Figure 24.
Crossing guards help school children to cross streets.

Crossing guards should operate under the jurisdiction of the local school district, police department, or traffic engineering department. Crossing guards should normally be trained employees (instead of unpaid volunteers) for reliability and insurance purposes. The decision on where to place adult crossing guards should be made jointly by the school principal or transportation director and local traffic engineer. In the absence of other guidelines, the following criteria may be used to select appropriate locations for crossing guards:

- Uncontrolled marked crosswalks, where there is not a controlled crossing location within 180 m (600 ft), and

Urban Areas - 40 or more students cross a street where there is more than 350 vehicles per hour during each of two hour crossing periods, or

Rural Areas - 30 or more students cross a street where there is more than 300 vehicles per hour during each of two hour crossing periods.

- When speed limits exceed 60 kph (40 mph), the rural criteria should be used.

- STOP sign controlled intersections of collector or arterial streets where there are more than 500 vehicles per hour during any period when children are going to or from school, and there are high numbers of students crossing.

- Traffic signals where there are high numbers of students crossing and high turning volumes or wide streets.

Above all else, engineering judgment should dictate when and where adult crossing guards are needed based on an engineering study.

Crossing guards have an important role in teaching children traffic safety skills that they will use whenever they cross a street. In order to command the respect of both motorists and children, proper appearance, equipment and behavior is needed. Crisp communication skills are essential, including use of voice, hand signals, whistle, head movement, facial expression and body position. Signals to motorists and children must leave no confusion as to whom is being addressed.[3]

It is recommended that crossing guards wear an easily recognized uniform and be equipped with a reflective safety vest and STOP paddle. In practice, school guards seldom wear uniforms identical to the police, and often a safety guard cap and reflective, bright orange vest worn over civilian clothes is all that is used as the uniform. Crossing guards should be provided with bright yellow or orange raincoats for use during wet weather conditions.

Crossing guards need to be constantly aware of where children and motorists are and to be alert to any potentially dangerous situation arising. Guards need to be familiar with the different crossing techniques for different types of crossings and intersections. There are also common hazardous

motorists' behaviors to be aware of, including speeding, running of stop signs or red lights, and turning left quickly through a gap in traffic.

Guards also need to be able to assess safe gaps in traffic for their own and the children's protection, and to prevent panic stops by motorists. Extra caution is needed when visibility is poor, especially in wet weather.[3]

A crossing guard training and certification process that requires periodic refresher instruction should be established to instruct guards of their duties, and to teach them how to work safely with traffic. Crossing guards should be provided with an identification card, a list of responsibilities, and a list of phone numbers in the event of an emergency or if other concerns arise with students or traffic conditions at their crossing.

SCHOOL SAFETY PATROL

School safety patrols offer a way of extending traffic safety education beyond the classroom. Careful instruction and supervision of patrol members are essential if the patrol is to be efficient and helpful to other students.

If used, the school safety patrol should be organized and administered by each school, with the school principal responsible for determining the overall school safety patrol policy. Administrative responsibility for actual operation of the patrol may be delegated to an individual teacher.

The school safety patrol members should be selected from the upper grade levels, preferably not below the fifth grade. Qualities such as leadership and reliability should be considered in selection, and patrol service should be voluntary and open to all who qualify. Patrol members should have written approval of parents or guardians.

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CHAPTER 8

TRAFFIC CALMING STRATEGIES

Neighborhood, residential access (local) streets are designed to carry low traffic volumes (less than 2,000 vehicles/day), at low speeds. As traffic volumes increase on a particular residential street, there is a significant decrease in the actual and perceived quality of life for the residents who live on that street because of safety, noise, and pollution.

It has been found that volumes exceeding 2,000 vehicles/day are considered a problem by residents. Local efforts to improve the pedestrian environment on neighborhood streets should try to reduce the number of possible conflicts (and the potential for injury when the conflicts involve speeding traffic) between cars and other users (e.g., pedestrians and children on bikes). Neighborhood traffic control measures serve this purpose by reducing the speeds and/or volumes of motor vehicle traffic.

An agency may find it necessary to rate the relative need of each location when allocating funds for popular traffic control measures. In cases where public funding is not available, neighborhoods may be willing to pay the cost of installing these measures themselves, as long as the proposed location is reasonable and otherwise fits the program criteria.

Two basic approaches can be used to facilitate pedestrian movement, safety, and general livability in neighborhoods: 1) installing physical controls requiring vehicular diversion; and 2) managing traffic in place. The primary difference between the approaches is the extent to which conflicts between vehicles and pedestrians are separated.

Two approaches can be used to facilitate pedestrian movement, safety, and livability in neighborhoods.

CONTROLS INVOLVING TRAFFIC DIVERSION

Neighborhood traffic control measures related to traffic diversion are geometric (physical) features

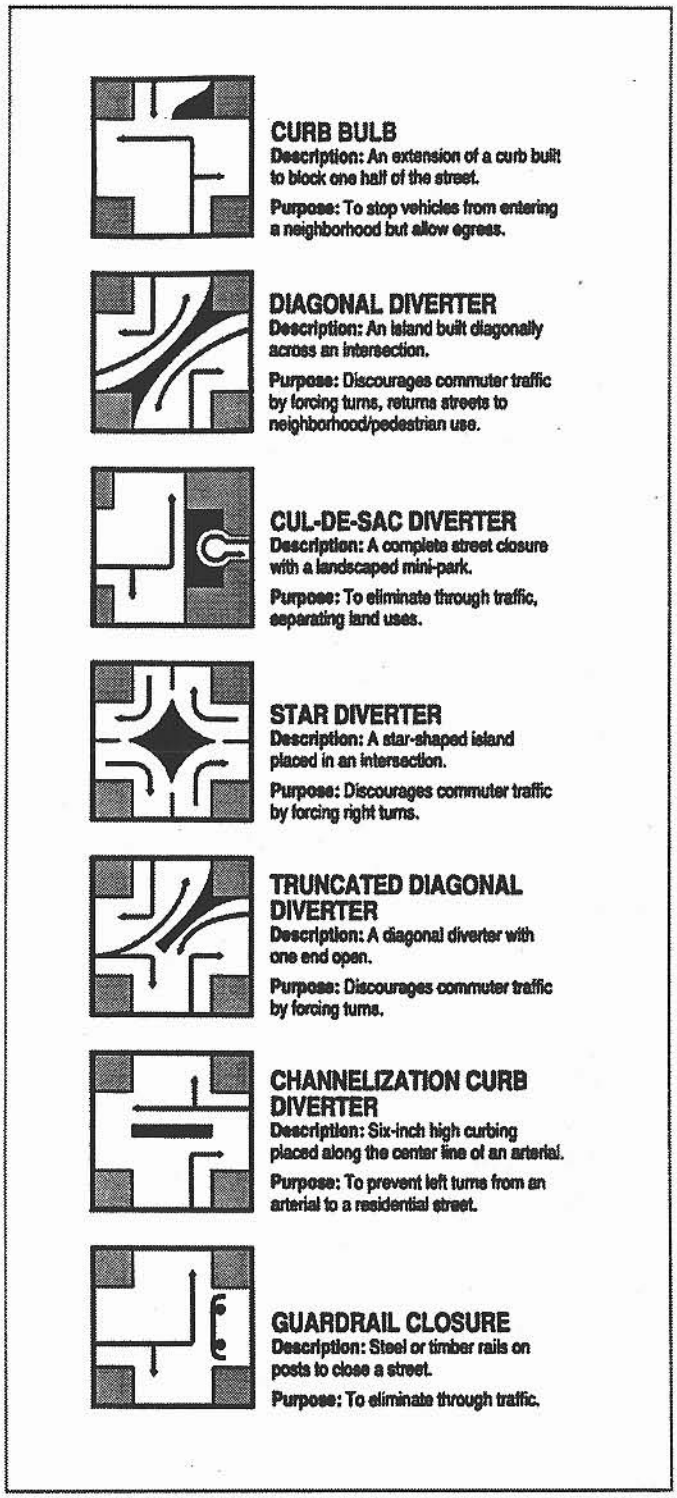

Figure 25.
Types of traffic diverters used for neighborhood traffic control.

that force or prohibit a specific action such as a turn or a through movement. Geometric features have the advantages of being largely self-enforcing and of creating a visual impression that a street is not intended for through traffic. Their disadvantages relative to other devices are their high cost, their negative impact on emergency and service vehicles, the loss of convenient access to some parts of a neighborhood, and a resulting increase in traffic on nearby streets.

Such measures are also static and must be appropriate at all hours of the day and night. Several examples of traffic control measures are shown in Figure 25 and include street closures, cul-de-sacs, and diverters. Each of these treatments is discussed in more detail below.

Street Closures

Street closures are generally installed with curbs forming street-ends, diagonals across intersections, or bulbs at intersections that restrict or limit vehicular traffic. Landscaping is often included with these measures to serve as a visual cue to motorists, and as a visual enhancement for the neighborhood. Street closures may adversely affect access by emergency vehicles.

Cul-de-sacs

An intersection cul-de-sac is a complete barrier of a street at an intersection, leaving the block open to local traffic at one end, but physically barring the other. Thus, a cul-de-sac represents the most extreme technique for deterring traffic short of barring all traffic from the street in question. A cul-de-sac, however, can be designed to allow emergency vehicles to pass through, by use of mountable curbs, or removable barriers. Enforcement may be required to prevent other vehicles from passing through.

Since a cul-de-sac is completely effective at its task of preventing through traffic, the choice of where or whether or not to use it depends largely on other aspects of traffic movement. For example, a cul-de-sac is less desirable in the vicinity of fire, police, or ambulance stations where emergency vehicle movements are frequent. It is also less desirable in areas where multi-alarm fires are more likely.

The provision of other services that require large vehicles, such as school bus routing and sanitation pick-up, also needs to be considered when designing cul-de-sacs. A cul-de-sac is desirable adjacent to schools and parks, where the vacated street can be converted into additional play space.

Cul-de-sacs are extremely effective at limiting traffic volumes. They normally reduce traffic to that generated by the land uses that are adjacent to the street. Although a cul-de-sac is not a speed attenuating device, it may serve that purpose, since the street comes to a dead end. However, cul-de-sacs will generally require additional right-of-way dedication on local streets, and must be large enough to accommodate a sanitation truck or fire truck that needs to turn around.

A cul-de-sac placed within the block, rather than at one end, performs the same function as an intersection cul-de-sac. Mid-block cul-de-sacs are typically used when two different traffic-generating land-use types are adjacent to each other. An example of this is when a commercial area is backed by a residential area. The cul-de-sac is placed at the transition so that the commercial area is afforded the access, yet its traffic does not intrude into the residential area.

Diagonal Diverters

A diagonal diverter is a barrier placed diagonally across an intersection to, in effect, convert the intersection into two unconnected streets, each making a sharp turn. The primary purpose of a diagonal diverter is the same as that of forced-turn channelization;

that is, to break up the routes, making travel through a neighborhood more difficult, while not actually preventing it.

Studies of systems of diverters have shown that traffic on streets with diverters can be reduced by 20 to 70 percent, depending on the system of devices in the area. In these studies, traffic on adjacent streets with no diverters increased by as much as 20 percent. These devices have little to no effect on speeding, other than in the immediate area of the diverter, and a minimal effect on traffic safety.

Diverters and cul-de-sacs should only be used in cases where a reasonable arterial or access street alternative is available and easily accessed. Otherwise, vehicular traffic will simply reroute to other residential streets and likely result in similar problems on those streets. Diverted traffic should be directed to the nearby arterial street, and signage should be used with diverters to discourage through motorists from entering the neighborhood.

Public participation in determining use and location of diverters is essential to successfully address traffic concerns of a neighborhood. Residents should have a voice in the design and operation of the streets on which they live. Community, neighborhood, and political forces also need to be in favor of these controls before proceeding.

Careful thought needs to be given to circulation patterns resulting from diverters/closures. A trial installation in the use of barricades, barrels, or guardrails is strongly recommended. A trial period on the order of six to eighteen months gives ample time to collect data showing new traffic patterns and to evaluate community support again. In the event of permanent installation, small park features can be included in the diverter/closure area to further enhance pedestrian and neighborhood surroundings.

MANAGING TRAFFIC IN PLACE

When the nature of the street system, community sentiment, or the local political climate do not favor street closures or diverters, there are numerous effective measures to manage traffic in place and still provide improved pedestrian surroundings. Each of the measures to manage traffic in place can be used in areas where there is a desire to slow down traffic and reduce collisions or collision potential. While reducing speeds and collisions, these measures normally have small effects on traffic volumes.

Cost may be an important factor in finally deciding which

measures to use; however, some can be installed inexpensively, using temporary installation schemes. Several of these measures are shown in Figure 26, and all of these measures have positive results for pedestrian use and activities on neighborhood streets.

Traffic Circles

Traffic circles involve the use of raised circular islands in the center of an intersection, which creates a one-way, circular flow of traffic within the intersection area. Traffic circles separate points of conflict and often slow speeds of vehicular traffic.[1]

Circles of an intermediate size (e.g., 3 m (10 ft) in diameter), have been used mainly as speed control devices within the intersection of two local streets, such as the one shown in Figure 27. A secondary objective is to reduce traffic volumes by using them as a part of a group of circles or other devices that slow or bar a driver's path.

The following three guidelines regarding traffic circles have been developed:

- If the objective is to reduce traffic speeds along a section of a residential street, two or more traffic circles at adjacent intersections should be used. A single traffic circle will slow traffic in the immediate vicinity of the intersection, but its impacts on traffic speed will generally be confined to within approximately 30 m (100 ft) of the circle.

- A traffic circle should not be installed in an intersection with a high volume of left-turn movements. Many motorists will make left turns on the left of the circle. This creates conflicts with traffic approaching from the left.

- Circles should be designed with mountable curbing on the perimeter to accommodate unusually large service vehicles.

Traffic circles are raised circular islands in the center of an intersection that separate points of conflict and often slow vehicular traffic speeds.

Chicanes

These are alternately placed curb extensions into the street that force motorists to drive in a serpentine (zig-zag) pattern (see Figure 26). The curb extensions narrow the road to one lane, with two-way operation. Chicanes are effective at reducing speeds and collisions. Installations result in loss of on-street parking, so if parking demand is high, this measure may not be appropriate. In such situations, parking controls should be used.

Chokers

A choker (also known as a curb bulb, nub, or gateway) is a narrowing of a street, either at an intersection or midblock, in order to reduce the width of the traveled way (see Figure 26). While the term usually is applied to a design which widens a sidewalk at the point of crossing, it also includes the use of islands which force traffic toward the curb while reducing the roadway width.

Streets narrowed at the crosswalk reduce the distance over which pedestrians are exposed to vehicular traffic. Bulbs provide safe areas for people to walk or play, or may provide added area for landscape or gateway features, thereby improving the appearance of the neighborhood. An example of a choker on a one-way residential street is shown in Figure 28.

Studies to date have shown that curb bulbs reduce traffic volume only when they either reduce the number of lanes of travel or add friction to a

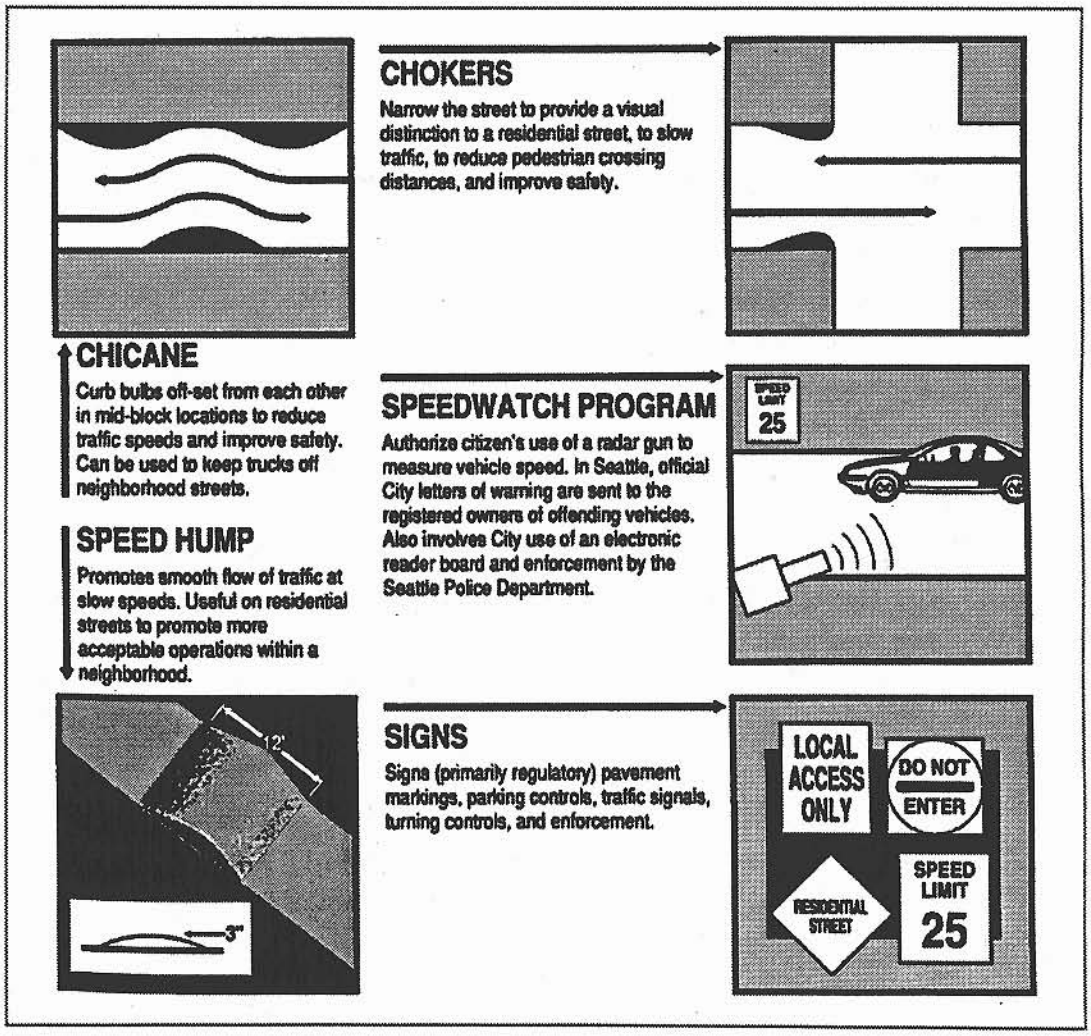

Figure 26. Traffic control measures used to manage traffic in place.

considerable length of street. Curb bulbs also appear to have a significant effect on speed and can improve the safety of an intersection by providing pedestrians and drivers with an improved view of one another. They also reduce pedestrian crossing distance, thereby lowering their exposure time to vehicles. Chokers or curb bulbs can be considered to be either normal extensions of the existing curb or channelizing islands.

Speed Limit Signs and Speed Zones

Speed limit signs are regulatory devices that are intended to inform the motorist of the speed limit of the roadway. Speed limit signs usually have no effect on traffic volumes and little if any effect on traffic speed, since drivers usually drive at what they perceive to be safe and reasonable under existing conditions.

Studies in Europe have also shown that the use of speed limit signs without any physical barriers to traffic generally results in no change in driver speeds. Reduced speed limit signing should generally be installed with other traffic calming facilities to obtain lower speeds.

Figure 27.
A traffic circle used at the intersection of residential streets.

Speed Watch and Enforcement Programs

Neighborhood residents often feel uneasy when they perceive motorists are traveling too fast on their streets. This uneasiness can keep residents from enjoying their own surroundings as pedestrians.

Speed watch programs normally include: the use of radar to check speeds of passing motorists, the recording of license plate numbers of speeding motorists, and notification of those speeding motorists and the residential nature of the street on which they were caught speeding. Enforcement presence or follow-up is often effective.

Many of the motorists speeding on residential streets live in the neighborhood themselves, so this is really a neighborhood awareness program, where neighbors participate in a process

to help return their streets to a safer, more comfortable atmosphere. Speed watch programs are less successful when speeding motorists live outside the neighborhood and are "cutting through."

Speed Humps

Also known as road humps, undulations, or "sleeping policemen," speed humps have undergone extensive demonstration and evaluation in Europe, Australia, and the United States. The purpose of speed humps is to promote the smooth flow of traffic at slow speeds (around 32 to 40 kph (20 to 25 mph)). They are not meant to reduce vehicle speeds to 8 to 16 kph (5 to 10 mph), as are speed bumps.

Figure 28.
A choker (curb bulb) used on a one-way residential street.

The speed hump is an elongated hump with a circular-arc cross-section rising to a maximum height of 8 cm (3 inches) above the normal pavement surface and having a chord distance of 3.6 m (12 ft) in the direction of vehicular travel (see Figures 26 and 29). Speed humps have proven to be more effective, quiet, and safer than conventional speed bumps, and speed bumps are not recommended for street use.

Humps can be effective in reducing traffic speeds to reasonable levels on local residential streets. Substantial reductions in the speeds of the fastest cars can be expected along with an 85th percentile speed of about 40 kph (25 mph). Typical average speeds on hump-equipped streets are under 32 kph (20 mph). Although humps can be traversed safely at moderately high speeds, most drivers will generally drive slower.

The ITE Technical Council Committee 5B-15 has stated that the individual municipal traffic engineer should be responsible for determining the safety of the design and the criteria used for installation of speed humps, including signs and/or markings. For guidance in the design and installation of speed humps, refer to the ITE's *Guidelines for the Design and Application of Speed Humps - A Proposed Recommended Practice.*[2] Representatives from the

municipality should evaluate speed humps once they have been installed by collecting speed, volume, and accident data to determine their continuing effectiveness.

Stop and Yield Signs

The purpose of a two-way stop sign is to assign the right-of-way at an intersection. Two-way stop signs are suitable for use at minor street approaches to arterials and collector streets, and when there is poor sight distance. Stop signs do not reduce speeding on local streets, except for approximately 60 m (200 ft) prior to the intersection, and are expressly prohibited for this purpose by the MUTCD. Stop signs, however, do stop vehicles at intersections, where pedestrians typically cross the street. Two-way stop signs have little or no effect on reducing traffic volumes and the results on traffic safety are mixed.

Four-way stop signs are rare outside of the U.S. and Canada. They are usually intended for intersections where traffic volumes or other conditions do not warrant traffic signals (see Table 3) or as a stop-gap measure when a signal is urgently needed, but is not yet constructed.

Four-way stops are frequently requested as a speed control device, yet studies have shown that when

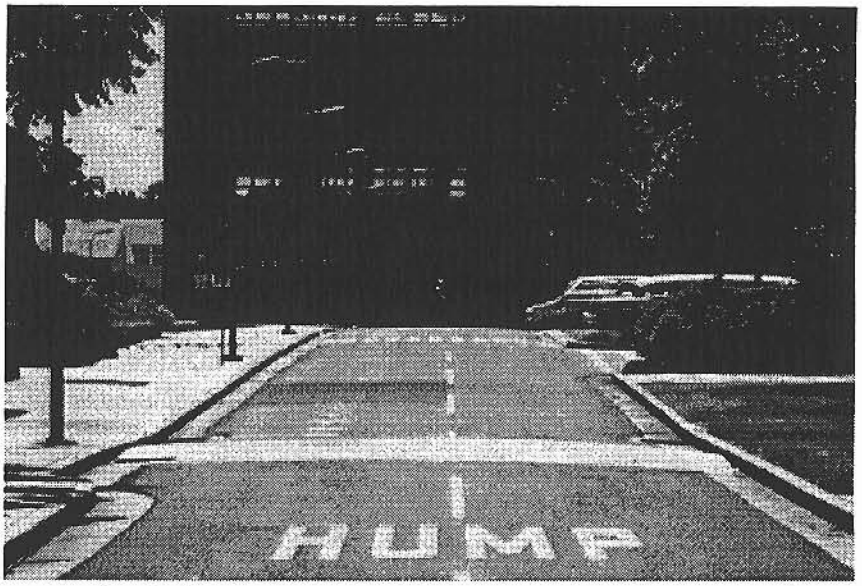

Figure 29.
Speed humps are intended to reduce traffic speeds to 20 to 25 miles per hour.

overused, only five to twenty percent of the motorists come to a complete stop, forty to sixty percent come to a rolling stop (below 8 kph (5 mph)), and twenty to forty percent pass through the stop sign at speeds higher than 8 kph (5 mph). Studies have also shown that violation rates are higher at stop signs that are placed as speed control devices.

Yield signs are used to assign right-of-way between two intersecting streets without requiring traffic on the other street to come to a complete stop. In the United States, this sign is used where sight distances at the intersection of two non-arterial streets permit traffic on the controlled street to approach safely at 24 kph (15 mph) or higher. In many countries, the sign is the standard for assigning the right of way of vehicles on an arterial street.

Yield signs offer little benefit to pedestrians, since motorists generally yield only to other motor vehicles, and pedestrians must choose gaps in traffic to cross.

Other Signage

Signs such as "Residential Street," and "Local Access Only," are not standard nor recommended for use in neighborhoods. These signs by themselves have little, if any, effect in reducing vehicle speeds or volumes. A number of more helpful measures for managing traffic in place involve warning or regulatory signs such as "Do Not Enter," "Not A Thru Street," "Dead End," or turn restrictions. The MUTCD and engineering judgement will serve as a guide as to what to use and when. As with diverters or street closures, residents should have an input into any traffic signs that will restrict their access.

PUBLIC PARTICIPATION

Three key groups should be included in the public participation process: the residents of the neighborhood, local traffic engineering and public works officials, and local elected officials. The residents of the area should have a voice in the design, function, and operation of the streets where they live, because they ultimately are the ones subjected to undesirable traffic conditions, and they must live with any restriction resulting from a traffic management program.

The public works professionals of the community, including city planners, traffic engineers, transit officials, sanitation officials, police, firefighters, and emergency medical services, have a responsibility to identify these problems and to assist the residents in formulating alternative solutions. School officials must also be involved if a potential solution will affect their bus routing or limit teacher/parent access to their school. The elected officials ultimately will make the decisions regarding the implementation of any proposed traffic management program. For this reason, they should be involved from the onset and should be made aware of the existing problems, alternative solutions, and the final implementation plan.

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CHAPTER 9

EXCLUSIVE PEDESTRIAN FACILITIES

Various alternatives have been implemented to restrict motor vehicles from the pedestrian environment, including residential yards, play streets, pedestrian malls, and transit malls. While pedestrian malls and other auto-free areas are usually developed as part of an urban renewal or downtown revitalization effort, they have the effect of improving pedestrian safety and facilitating pedestrian movement. This chapter discusses pedestrian malls and transit malls in more detail.

Pedestrian malls are streets that have been closed to all vehicular traffic and are reserved for the exclusive use of pedestrians, with few exceptions. Delivery of goods and refuse collection access may be permitted during specified times of the day, and emergency service access must be permitted at all times.

Transit malls are streets where pedestrians share the space with transit buses or light rail vehicles (and sometimes bicycles, delivery and refuse collection vehicles and taxis), but other vehicles are not allowed, except for emergency and maintenance vehicles. Transit vehicles operate on a narrow right-of-way within the mall space.

Pedestrian Malls can be developed in each of the following manners:

(a) Modified Street - One block of a conventional street is closed to vehicular traffic for the exclusive use of pedestrians.

(b) Plaza or Interrupted Mall - Several blocks of a retail street are exclusively designated for pedestrian use, with cross streets left open to vehicular traffic.

(c) Continuous or Exclusive Mall - A multiblock area, which may include more than one

Pedestrian malls are streets that have been closed to all vehicular traffic and are reserved for pedestrians. Transit malls are streets that pedestrians share with transit buses or light rail vehicles.

street, is exclusively designated for pedestrians, with the exception of emergency, maintenance, and delivery vehicles. The area extends the full length of the shopping area, through intersecting streets, without interruption (see Figure 30).

(d) Displaced Sidewalk Grid - A pedestrian walkway is developed away from the regular sidewalk grid through alleys and laneways, arcades, and/or lobbies within buildings.

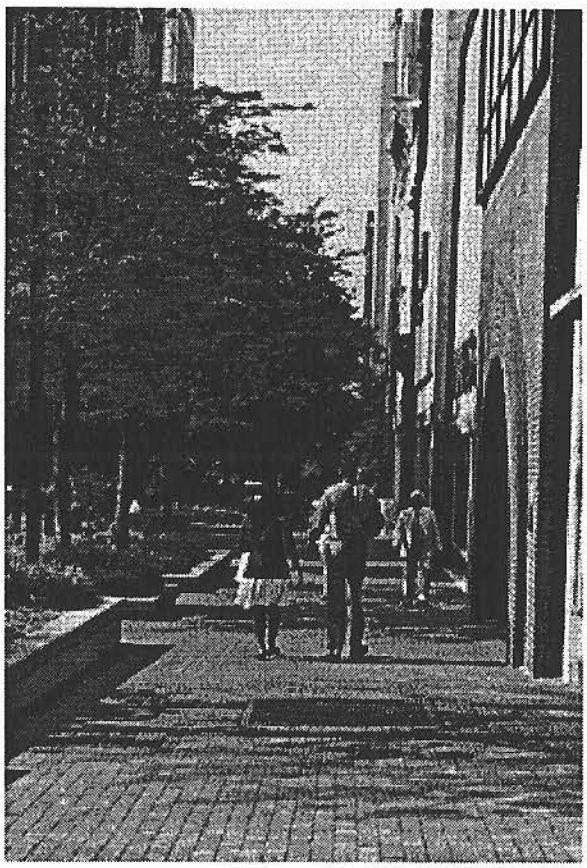

Figure 30.
Pedestrian malls can improve pedestrian safety and mobility.

PLANNING CONSIDERATIONS

For urban street malls to be successful, they must provide a viable and attractive alternative to regional shopping malls. This can be difficult when it is considered that street malls must necessarily be planned and designed around existing roadway configurations, traffic patterns, parking, retail mix and other constraints. Street widths can be too wide, walking distances too long, and retail development poorly located to encourage the patterns and volume of pedestrian activity needed to support a successful urban mall. In order to succeed, the street mall must, therefore, capitalize on its primary advantage as an outdoor activity space by promoting parades, street fairs, bicycle and track races, antique car rallies, marching band competitions, concerts, and other similar public events to encourage pedestrian activity and establish an area identity.

The primary objectives of the pedestrian mall should be to reestablish or fortify an urban area's economic viability while simultaneously creating a social setting capable of responding to a variety of needs. The success or failure of an urban pedestrian mall is dependent upon many factors, some of which are directly controlled during the planning

process. The following considerations identify elements of planning essential to the effective realization of pedestrian malls.

Relationship of Mall to Central Area Development

Pedestrian malls succeed or fail according to their degree of accessibility either by public transit or by private automobile. The success of a pedestrian zone is directly related to its ability to create a range of activities to suit a variety of users. For example, Albany's government mall in New York State has suffered a loss of vitality because it is only able to attract patrons during lunch break hours and is practically deserted otherwise. A more balanced use of the area's resources over extended periods of time, a high level of urban vitality, and an increased feeling of safety can be achieved by attracting a full spectrum of users through mixed use zoning.

Cooperation and Support

Progress in implementing the planned improvements can be much more rapid when commercial and public interests are found to coincide. Many proposals meet opposition from shop owners who believe that their trade will suffer if vehicular access is restricted along their premises. Shop keepers are often resistant to the mall concept until they are made aware of the potential benefits. It is important to obtain the cooperation of commercial interests at the initial planning stages in order to ensure viability of the proposals.

Eliciting public support during the course of the pedestrian mall development is important in guaranteeing the success of the mall. The creation of a pedestrian mall affects a wide range of user groups whose participation is vital. These groups should be consulted and involved during the early planning stages of project implementation.

Existing Vehicle Traffic Patterns

Some cities have radically altered circulation patterns in order to decrease traffic congestion and redistribute vehicular traffic flow in the area of the pedestrian mall. This can be accomplished by developing one-way streets, restricting turning movements, limiting access to certain categories of vehicles, redesigning intersections, and retiming traffic signals.

Public Transit Services

Most cities with successful pedestrian malls have introduced policies that encourage the use of public transport. The success of these policies has varied depending

on the extent of traffic congestion and the efficiency of the public transportation system. As always, public transit should be inexpensive, fast, comfortable, safe and enjoyable to ride. Other tactics that can be successful are reserved lanes for public vehicles, low fares, convenient pickup and drop-off locations within the mall, and better security. Those pedestrian malls that are built as transit ways can provide increased mobility to pedestrians by dropping them at major department stores or activity centers within the mall itself.

Parking Supply

Effective parking policies have a significant impact on both the regulation of parking density and the attractiveness of parking spaces to mall users. Some cities use different strategies to meet the demands of employees seeking day-long parking and visitors looking for short-term parking.

Some cities offer park-and-ride systems to allow downtown or mall employees to park their cars at the periphery of the city limit and ride to work via rapid transit or special buses. On-street parking meters and multi-level parking facilities at the edge of the pedestrian mall areas can provide short-term parking needs. Time can be charged in incremental rates to promote a quick turnover.

Delivery of Goods

The opposition of many merchants to the idea of a pedestrian mall results from the problem of delivering merchandise to stores and making it possible for customers on foot to handle the purchases easily. One of the most common strategies has been to allow structural changes in the street pattern to make possible store deliveries from courtyards and alleys as well as using time restrictions on the use of pedestrian mall space by commercial trucks. Some downtown merchants have introduced free pushcarts in order to meet customer demand for assistance in delivering their goods to either the central transportation terminal or to where their car is parked. Other establishments that sell bulk goods, such as grocery stores, should be relocated to the periphery of the mall where ready access to parked vehicles is available.

Essential Services

Essential services such as emergency fire, police, medical, refuse removal, taxis, vehicle pick-up and drop-off, truck delivery and pick-up, and mall cleaning must also be considered. Provisions must be provided to allow emergency service vehicles to quickly access areas within the pedestrian mall. Additional amenities within the

pedestrian mall such as canopies and covered ways will need to be sufficiently high in order to enable emergency vehicles to pass underneath.

There are also certain types of businesses that require such access for other vehicle types. For example, a hotel located on the street to be made into a pedestrian mall will need to provide continuous access to taxis for its viability. Similarly, security vehicles will need to reach banks and businesses located within the pedestrian mall during nighttime hours.

Accessibility Needs

Care must be taken that the paving system used does not impede the safe and easy movement of wheelchairs. Planters, benches and other amenities should be placed in a straight line to satisfy the expectancy of the visually impaired. ADA guidelines should be consulted concerning the design and placement of amenities.

Design Considerations

Quality of design and durability of construction materials have proven to be essential elements in the success of pedestrian malls. The ideal pedestrian mall is designed in a relatively narrow street right-of-way, with concentrated shopping and commercial land uses within the normally accepted walking distance limit of 0.4 km (0.25 mi), and larger traffic generators ("anchors") located at opposite ends of the mall to encourage walking along the mall. Excessively wide streets dilute pedestrian activity, making a mall appear dull and uninteresting, and also reduce exposure to retail edges due to the increased sight distances.

Some successful street malls are located in areas such as historical districts where there is an established pattern of tourist and visitor activity. When this pattern exists, it can be enhanced by designing storefronts and street furniture to keep with the local "theme." Otherwise, it is necessary to develop design and marketing strategies which will encourage downtown activities and use of the mall.

The primary advantage of a street mall is the ability to conduct large-scale outdoor events. Event spaces for setting up concerts, grandstands, and other activities should be considered in the mall design.

Street furniture, paving treatments, lighting, and landscaping are important design considerations. To reduce clutter, street furniture elements should be of modular design incorporating several components in a single

The ideal pedestrian mall is designed in a relatively narrow street right-of-way, with shopping and commercial land uses concentrated to encourage walking along the mall.

unit. Other amenities such as benches arranged in groups in small rest areas, local street maps and points of interest displays, programs of future events, transit stop enclosures, and transit system information displays will improve the convenience and attractiveness of the mall.

Pavers are a popular surface treatment in malls, but the pavers must be placed on a substantial sub-base to avoid settlement or "frost-heaving" and dislodgement, which can result in tripping. Since emergency vehicles require access to all parts of the pedestrian mall, the paved areas need to be designed to take the weight of service and emergency vehicles and allow them to move around easily.

Pedestrian-oriented lighting, with control of overhead illumination so as not to overpower shop window lighting, is preferred to restore a more intimate and natural scale to the converted street. Landscaping should be carefully chosen, not only for appearance, but for maintenance and growing characteristics. Plants or trees that interrupt sight lines and potentially provide concealment can reduce perceived security and discourage pedestrian activity at night.

Crosswalks must be provided for pedestrians in transit malls, interrupted malls, and plazas where pedestrian-vehicle conflicts are present. Such conflicts may be minimized through: 1) one-way cross streets, and 2) signals and warnings to motorists and pedestrians, such as signs or contrasting pavements at the mall crossings.

IMPLEMENTATION CONSIDERATIONS

Feasibility studies which determine the levels of political, business, and general public support are essential. Included in these evaluations should be potential effects on traffic, area economics, and the social environment. Temporary pedestrian malls or street closures can be set up as part of a feasibility study to determine a more permanent need.

Successful implementation requires a great deal of cooperation and organization. A primary leadership group and working committees must coordinate and administer the process. Public and private interest should be developed through the media, informational meetings, pamphlets and displays. Management, financial and scheduling plans should be developed and followed. In addition, periodic review sessions should be held to: 1) consider and develop alternative concepts, and 2) ensure that all concerned parties have adequate

opportunity to contribute as they see fit.

Several advantages exist from the design and implementation of pedestrian malls, including:

- A reduction in pedestrian delays and/or pedestrian congestion.
- Enhancement of the aesthetic and social environment of the downtown area.
- Greater pedestrian accessibility to retail merchants.
- An increase in the use of public transportation.
- A decrease in noise and air pollution on affected streets.
- A potential increase in revenues, sales, and land values.
- Implementation can occur in stages.
- Increase in the efficiency and time savings of mass transit in transit malls.

Along with the advantages of pedestrian malls, there also exist several disadvantages, including:

- A potentially high cost of installation, maintenance and operation.
- Rerouting of vehicle traffic to other streets.
- Potential reduction in retail activity and an increase in noise and air pollution on nearby streets.
- Disruption of utility and emergency services.
- Disruption of bus routes and delivery of goods.
- Placement problems with street furniture for visually handicapped pedestrians.
- Potential parking problems for visitors and employees.
- Potential security and policing problems.
- Potential maintenance problems (e.g., snow removal).
- Conflicts between pedestrians and transit vehicles in transit malls.
- Pedestrian-vehicle conflicts at cross streets in a plaza or interrupted mall.
- Conflicts between pedestrians and vehicles at midblock locations where displaced sidewalk grids are used.

In summary, the conversion of streets to full pedestrian malls is an ideal way to provide for safe and free-flow movement of pedestrians in a desired area, such as for retail shopping. Although the conversion of streets to pedestrian malls is usually the result of efforts to revitalize downtown areas, improved pedestrian safety can be a beneficial result of such malls.

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CHAPTER 10

WORK ZONE PEDESTRIAN SAFETY

Proper planning for pedestrians through and along construction areas is as important as planning for vehicle traffic, especially in urban and suburban areas. Pedestrian considerations including access to bus stops and crosswalks, must be an integral part of each construction project. There are three considerations for pedestrian safety in highway and street work zones:

1. Pedestrians must be separated from conflicts with the work site, and work site vehicles, equipment and operations.

2. Pedestrians must be separated from conflicts with mainline traffic moving through or around the work site.

3. Pedestrians must be provided with a safe, convenient travel path that duplicates as nearly as possible the most desirable characteristics of sidewalks or footpaths.

When construction requires closing existing crosswalks and walkways, contractors and other work crews must provide temporary walkways and direct pedestrians to the safest, most convenient route possible. Walkways must be clearly identified and wheelchair accessible, protected from motor vehicle traffic and free from pedestrian hazards such as holes, debris, dust and mud.

When a parking lane exists next to a work site that closes a sidewalk, the parking lane may be used for the pedestrian detour route. When there is no continuous parking lane, pedestrians must be diverted from a direct encounter with the work site by using advanced signing as approved in the *Manual on Uniform Traffic Control Devices.*[1] If

Pedestrian considerations, including access to bus stops and crosswalks, must be an integral part of each construction project.

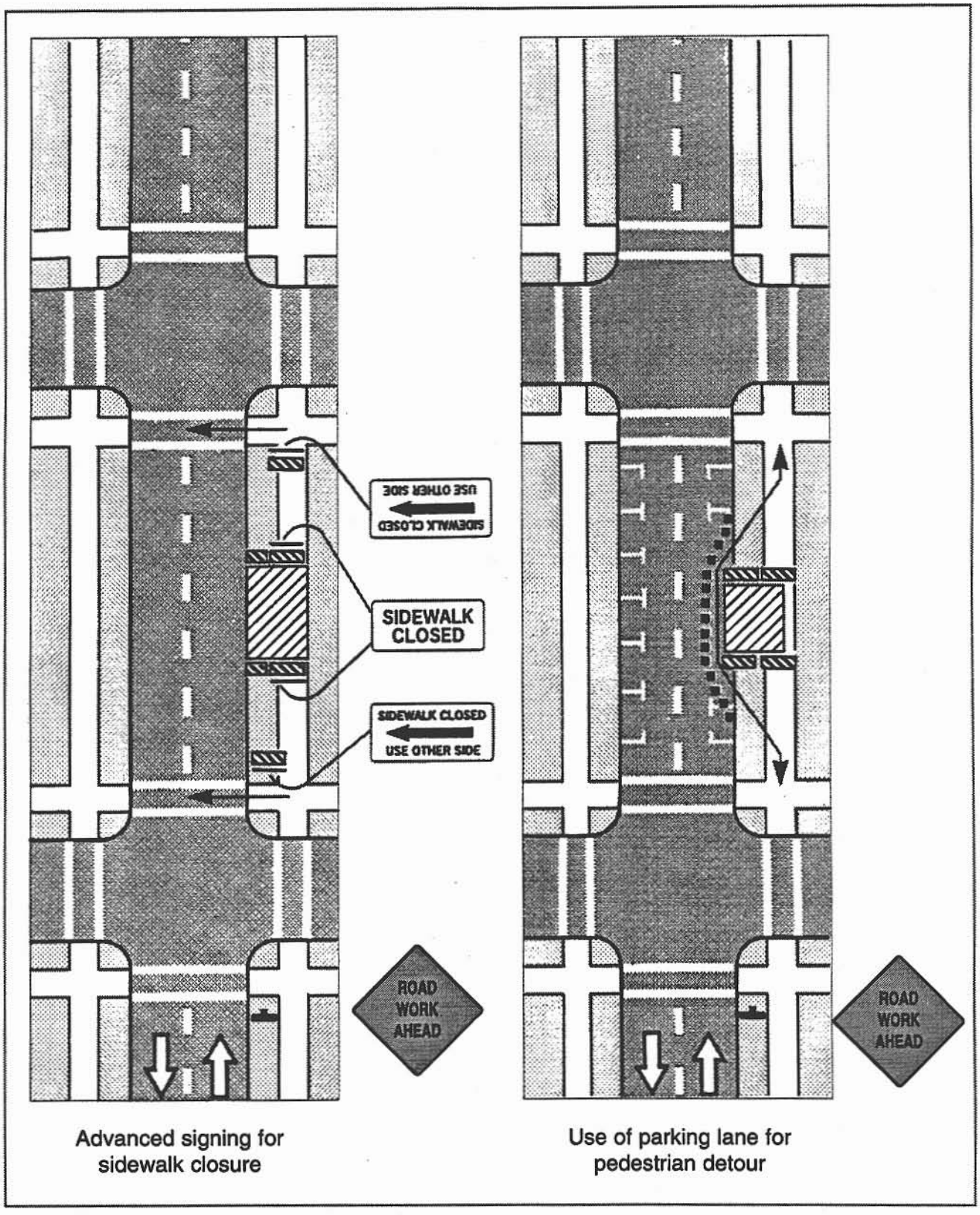

Figure 31. Two approaches to accommodate pedestrians in a midblock work zone.[2]

required, safe crossings must be provided to the opposite sides of the street. Signing for these crossings should be placed at intersections so that pedestrians are not confronted with mid-block work sites that will induce them to attempt skirting the work zone or making a mid-block crossing. Pedestrians will infrequently retrace their steps to a prior intersection for a safe crossing. Therefore, ample advance notification is needed. Two approaches to accommodate pedestrians in a mid-block work zone are shown in Figure 31.[2]

For temporary work zones of short duration, and under low speed conditions, it is acceptable to use traffic barricades, cones and traffic signs to separate pedestrian traffic from work zone and vehicle traffic, if approved by the local engineer.

At fixed work sites of significant duration, especially in urban areas with high pedestrian volumes, pedestrian fences or other protective barriers may be needed to prevent pedestrian access into a construction site. This is particularly important near school areas. When used, pedestrian fences should be 2.4 m (8 feet) high to discourage people from climbing the fences.

For construction or demolition of buildings adjacent to sidewalks, a covered walkway may be needed to protect foot traffic from falling debris. These covered walkways should be sturdily constructed and adequately lit for nighttime use. External lighting and diagonal white and orange stripes on the exterior of the pedestrian walkway may be needed when placed next to traffic.

Covered walkways and pedestrian fences and other barriers must be designed to provide ample sight distance at intersections and crosswalks. Solid construction fences must be angled at corners or be replaced with chain link fencing to provide adequate visibility.

When pedestrians are judged especially vulnerable to impact by errant vehicles, foot traffic should be separated and protected by longitudinal barrier systems. Where a positive barrier is clearly needed, it must be of sufficient strength to avoid intrusion by an impacting vehicle into the pedestrian space. Short intermittent segments of longitudinal systems should be avoided. Upstream ends of the system must be flared or protected with impact attenuators properly fastened to the longitudinal barrier. For work zones adjacent to high speed traffic, wooden railings, chain link fencing with horizontal pipe railing and other similar systems are not acceptable.

Construction work zones should be inspected daily and monitored continuously for vehicle and pedestrian needs. Security guards or flagmen may be needed to monitor work sites and help control pedestrian traffic. Where construction vehicles and equipment need to cross pedestrian walkways, flagmen, police officers or traffic signals should be used during crossing times.

Good engineering judgement in each work zone situation should readily determine the extent of pedestrian needs. Particular attention should be paid to nearby pedestrian generators, particularly schools, parks and community centers. Officials should be contacted at these facilities to alert them of up coming traffic control changes and accommodate special pedestrian needs, particularly for long-term and major construction activities.

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CHAPTER 11

OTHER PEDESTRIAN FACILITY CONSIDERATIONS

There are several other design and operational features that may benefit pedestrians and should be considered when designing for pedestrians. Not all may be relevant in every instance, and many may only be applicable in areas of high pedestrian flows. A few of these considerations are discussed in this chapter.

TRANSIT STOPS

A transit rider is usually also a pedestrian, and as such, there is a need to make sure an available pathway exists to accommodate pedestrian travel to and from all transit stops (Figure 32). This may involve paving sidewalks, building wheelchair ramps, providing a special accessway through a neighborhood, or paving a waiting area for transit patrons. Improved ridership may also be encouraged with other amenities such as benches, shelters and landscaping. There should be a great incentive to encourage more transit use since each rider represents one less vehicle on the street, which can be translated into less congested roads, fuel savings and improved air quality.

The most common type of transit stop is a bus stop along a shared right-of-way street or highway. There are three types of bus stops; far side of intersection,

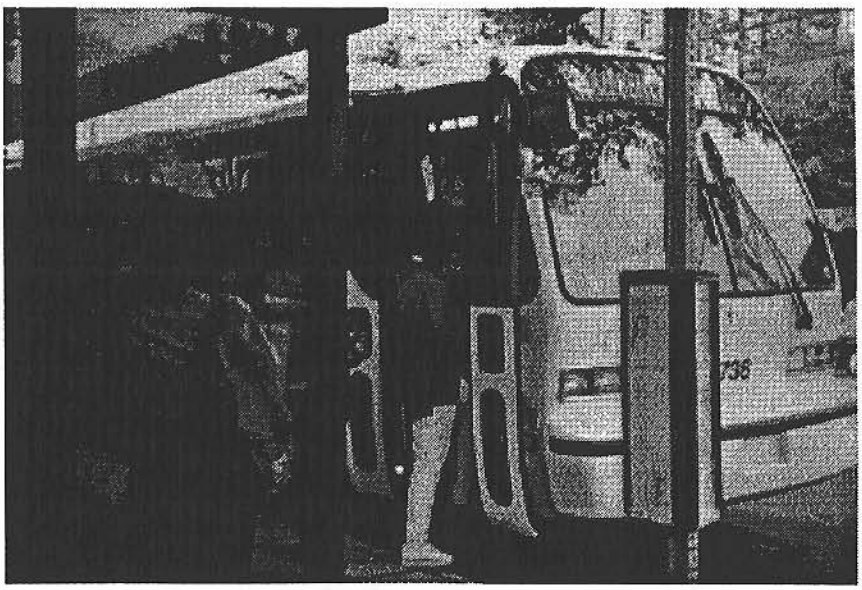

Figure 32. A transit stop with sidewalk access, a shelter, and route information.

near side of intersection, and mid block. The far side bus stop offers the most advantages to traffic safety and operations. This type of stop encourages pedestrians to cross behind the bus which allows motorists and pedestrians better visibility of each other. This also allows motorists to make right turns, and provides better visibility for side street traffic (since the bus is down stream from the intersection).

Near side bus stops are sometimes needed when a transit route turns, at crossings of some one-way streets, where it will prevent pedestrians from crossing a busy street, or when there is not a good far-side stopping location. Some transit agencies use a combination of near side and far-side stops at major intersections when there is heavy transfer traffic between two routes. However, a near side bus stop should be avoided in advance of an unsignalized marked crosswalk.

Midblock bus stops are sometimes on long blocks when there is a midblock pedestrian generator such as a church, shopping center or stadium. These types of bus stops may require a longer bus stop if the operator has to maneuver between parked vehicles.

All bus stops must be accessible to pedestrians in wheelchairs, and should be marked by a sign at or near where the door of the bus is expected to stop. Bus stop signs, benches or shelters and other street furniture should not obstruct access along the sidewalk or block access to the bus, and should be located far enough from the curb so they will not be hit by over hanging mirrors. Where practical, it is best to route the sidewalk behind the passenger waiting to improve the operation of the sidewalk and minimize conflicts between pedestrians.

Consideration must also be given to the possibility of pedestrians being splashed while waiting at the bus stop in areas with poor drainage. While shade trees and landscaping are good amenities at a bus stop, they should not block the view between the bus driver and patrons waiting at the stop, and should not obstruct access to the bus.

Route information and a phone number to the transit office on the sign or at the bus stop is always helpful to pedestrians. Other amenities such as trash barrels, benches, shelter, lighting, etc. are also service enhancements to pedestrians that should be considered.

ON-STREET PARKING

In a roadway environment shared between motorists and

pedestrians, consideration must be given to the need for parking and parking restrictions. The primary purpose for restricting parking is to improve sight distance. A common type of pedestrian collision involves pedestrians, particularly children darting out between parked cars and being struck by a passing motorist.

The Uniform Vehicle Code and Model Traffic Ordinance encourages local jurisdictions to adopt standards that state that "No person shall:

1. Stop, stand or park a vehicle:
   a. on a sidewalk;
   b. within an intersection;
   c. on a crosswalk;
2. Stand or park a vehicle, whether occupied or not, except momentarily to pick up or discharge a passenger or passengers:
   a. within 6 m (20 ft) of a crosswalk at an intersection;
   b. within 9.1 m (30 ft) upon the approach to any flashing signal, STOP sign YIELD sign or traffic-control signal located at the side of a roadway".

Since crosswalks (unmarked or marked) exist at all intersections, state law automatically prohibits parking within 6 m (20 ft) on the approach to an intersection. On occasion, signing may be needed to reinforce state or local laws or to extend the "No Parking" zone for extra visibility. This may be accomplished through signs such as NO PARKING HERE TO CORNER or NO PARKING WITHIN 50 FEET. On higher speed streets, it may be advisable to prohibit parking 15 to 30 m (50 to 100 ft) in advance of a crosswalk. Advance pedestrian warning signs may also be useful in informing motorists of a crossing area.

There generally is no reason to prohibit parking immediately downstream from a crosswalk on a one-way street unless the area is needed for vehicle operations and maneuvering. It is best to provide fencing along play areas and parks near roadways to prevent children from darting into the street or chasing balls into the street. Fencing will also concentrate crossing activity to a single location.

Off-street parking areas for parks, playgrounds and play fields are important to help avoid visibility obstructions created by on-street parking. Often parents and others refuse to park in off-street lots because it is further to walk or for other reasons. When this occurs it may be advisable to prohibit on-street parking. Parking restrictions should be considered

The primary purpose for restricting parking is to improve sight distance.

Figure 33.
Street lights improve pedestrian operations and security.

on a case-by-case basis, with consideration of where the parking will be transferred. In some cases it may be best to prohibit on-street parking across from a play field so that people exiting cars do not have to cross a street to access the play area or park.

Those people who will be most affected by the parking restriction (residents, businesses, soccer leagues, etc.) should be contacted when considering parking removal, and should be notified before a new restriction is implemented to avoid unnecessary ticketing and as a courtesy.

STREET LIGHTING

Street lighting should be considered whenever there is significant pedestrian activity during the hours of darkness, particularly around schools, churches and parks (Figure 33). Nighttime field checks should be conducted if a pattern of nighttime accidents exist or if concerns are expressed about conditions during hours of darkness. Lighting should be installed if there is a nighttime accident problem involving pedestrians. Lighting has the major benefit of helping to reduce crime and is often requested in residential areas to improve nighttime security. Lighting also improves vehicle and pedestrian operations, and helps pedestrians identify any obstacles in their path which may cause them to trip or fall.

On major arterials in urban or suburban areas, continuous street lighting is recommended. On wide arterials, it is recommended to install double-sided lighting. For new construction, street light poles should be located at least 1.8 m (6 feet) in back of the curb face and out of the sidewalk. Street lights, traffic signals and power distribution lines should be mounted on the same poles when ever possible. If lighting exists in an area, placement of a marked crosswalk should take the street light location into account.

It is generally not practical to install lighting in outlying rural areas, particularly where there is not a nearby power source. Fortunately, these areas generally experience little or no pedestrian traffic that would warrant lighting.

PEDESTRIAN UNDERPASSES AND OVERPASSES

Grade separated crossings are expensive to build, but on occasion are needed to safely get high numbers of pedestrians across a high speed or very busy street. Grade separated crossings can improve pedestrian safety by eliminating vehicle-pedestrian conflicts, and can improve highway capacity and reduce vehicle accidents related to cars slowing for pedestrians (see Figure 34).

When used, they must meet ADA requirements to be wheelchair accessible and accommodate all types of pedestrians (and bicyclists). This may create a long ramp system which may discourage usage by pedestrians. Therefore, various measures may be needed to encourage usage, such as fencing and signs to prevent or prohibit at-grade crossings.

A separate stairway may be built to supplement the ramp and provide for a shorter crossing. At school crossings, adult supervision is often needed during school crossing times to make sure the students use the grade-separated crossing.

Underground passages, or tunnels, are less common due to concerns about crime, vandalism, drainage and higher construction costs. At times underpasses are desirable to connect with an underground garage, shopping center, or due to the existence of an elevated roadway. Underpasses should always be well lit, and should be kept clean, free from debris and graffiti.

Overpasses are more appropriate where there is a

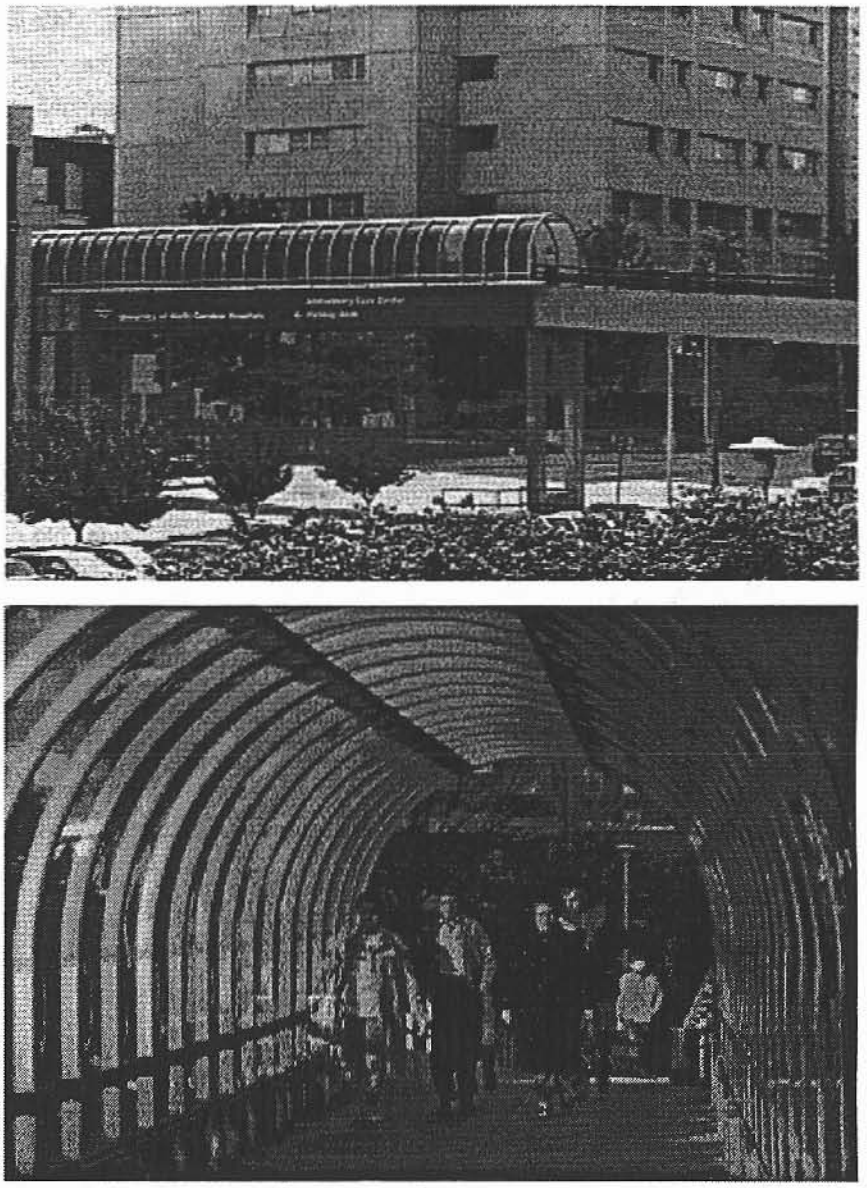

Figure 34.
Grade-separated crossings improve pedestrian safety.

depressed road, or where crime and security considerations are major factors. Overpasses are generally less expensive to build than underpasses, but are generally cost prohibitive for most situations. Overpasses often require larger parcels of land on either side of the street to accommodate the ramps, and require considerable vertical separation which may cause a problem where utilities exist along one or both sides of the street. Overpasses should be enclosed to prevent pedestrians from throwing objects off of the overpass, and should be lit at night.

Before installing grade-separated crossings, other options should be thoroughly explored. It may be best to reroute pedestrian crossings to a better location, or in the case of schools, provide bussing for young children.

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APPENDIX A

SUMMARY OF PEDESTRIAN FACILITY PROBLEMS AND POSSIBLE SOLUTIONS

Description of Problem	Magnitude of Problem	Possible Solutions	Current Level of Use or Acceptance	Limitations in Applicability	Potential Effectiveness	Barriers to Implementation	Cost	Impact on Other Groups	Comment
Cross-section Design									
Difficulty of crossing wide arterial streets, especially undivided arterials	Major	1. Install medians on all new suburban highways of 4 or more lanes.	Moderate	Virtually no limitations for new highways. However, some limitations are currently perceived.	High	Moderate	Moderate	Positive	Potentially the most effective solution to street crossing problems.
		2. Install European style refuge islands in strategic locations on existing undivided highways.	Low	Must usually narrow lanes on existing hwys. to accommodate refuge islands. Must be well lighted.	High	Moderate	Low to moderate	Minimal impact	This solution is greatly underutilized in U.S.
		3. Design for reduced street width between signalized intersections (since capacity constraints are at signals).	Low	Could only be done where spacing between intersections is high.	Moderate	High	Low	Negative	Probably not feasible as a general practice.
		4. Introduce additional traffic signals to facilitate ped crossings.	Low	Could only be done in a few selected locations.	Moderate	High	Moderate	Highly negative	More feasible where ped crossings are concentrated at a point.
		5. Provide midblock actuated flashing ped signal.	Low	Should only be installed in key locations.	Moderate	Moderate	Low	Slightly negative	Designed to inform driver of presence of ped. Does not necessarily make crossing easier.
		6. Provide ped overpass.	Low	Only effective where at-grade crossing is blocked or is inconvenient.	Moderate - depends on no. peds.	Moderate	High	Positive	Lack of use of facility continues to be a problem.
Difficulty of crossing highways with two-way left turn lanes	Moderate to major	1. Reduce use of this technique and provide medians to control access.	Low	Would need to design in frequent U-turn capability.	High	High	Moderate to high	Negative	Merchants and drivers will object heavily.
		2. Install refuge islands in spots where no turning is necessary.	Low	Must have at least some "dead spots" where turning would not generally occur.	High	Moderate	Low	Minimal impact	Islands must be well lighted and marked.

Description of Problem	Magnitude of Problem	Possible Solutions	Current Level of Use or Acceptance	Limitations in Applicability	Potential Effectiveness	Barriers to Implementation	Cost	Impact on Other Groups	Comment
No facilities provided for ped to walk along side of road	Major	1. Require sidewalk/ pathway with all new hwy. construction. Paved or stabilized shoulder adequate in outlying areas.	Moderate	Only allowed exclusion should be low volume residential streets.	High	Moderate	Moderate	Minimal impact	Could be required by FHWA for Federal projects.
		2. Provide easier methods for obtaining easements, to address existing highways constrained by right-of-way.	Low	Probably would be viewed as giving excess authority to public agencies.	High	High	Low	Negative	Would put property owners at a disadvantage.
Narrow bridges with no pedestrian accommodations	Moderate	1. Design all new bridges with shoulder or raised walkway.	Moderate	None	Moderate to high	Moderate	Moderate to high	Positive	
		2. Design low-cost walkway system for attaching to outside of bridge.	Low	Feasibility and design dependent on structural nature of existing bridge.	Moderate to high	Moderate	Moderate	Positive	
Excessive traffic speeds in residential or commercial areas	Moderate to major	1. Design curvature and circuity into road system. Keep streets narrow.	Moderate	Limited mostly to local and collector streets. Not appropriate on major highways.	High	Moderate	Moderate	Slightly negative	Can create some waste or inefficiency in lot layout.
		2. Increased enforcement.	Moderate	Cost is primary limitation.	Moderate	Moderate to high	High	Negative	Better to control speed through geometric design.
		3. Provide speed control devices (e.g., speed humps, traffic circles, intersection flares, etc.)	Low	Primarily used in residential areas. Not appropriate for major highways.	High	High	Low to moderate	Negative	Devices have been controversial and not yet widely accepted.
Safety/convenience of walking in commercial area with many poorly channelized driveways	Moderate to major	1. Consolidate driveway entrances - requires local regulation.	Low	Feasible in some newly developing strips. Generally infeasible in existing strips.	High	High	Moderate in new strips	Both pos. and neg. impacts	
		2. Provide service road in newly developing areas.	Low	Must have ample right-of-way.	Low to moderate	High	High	Both pos. and neg. impacts	Greatly amplifies problems at intersections.

Description of Problem	Magnitude of Problem	Possible Solutions	Current Level of Use or Acceptance	Limitations in Applicability	Potential Effectiveness	Barriers to Implementation	Cost	Impact on Other Groups	Comment
Security problems on certain isolated pedestrian pathways	Major	1. Refrain from constructing pathways in secluded areas. Provide paths primarily along street frontages.	Moderate	Residents must be willing to accept pathways in front of homes.	High	Moderate	Low	Minimal impact	Rear yard walkways known to have security problems in some areas.
		2. Provide clear view of pathways from residences and/or street.	Moderate	Difficult to maintain visibility on many recreational pathways.	High	Moderate	Low to moderate	Slightly negative	Residents can perceive visibility as invasion of privacy.
		3. Provide more lighting, telephones, patrols, or alarm systems.	Low	Primarily needed where visibility is a problem.	Moderate	Moderate	Moderate to high	Minimal impact	Security problem will still be perceived.
Signalization									
No accommodation for peds at some suburban signals, but ped volumes are low	Moderate to major	1. Provide ped actuated signal regardless of ped volume.	Moderate	Only needed where min. crossing time not provided each cycle.	High	Moderate	Moderate to high	Slightly to very negative	Represents the classic dilemma in facilitating ped. vs. vehicular flow.
		2. Inform ped that full crossing time may not be available in one phase.	Low	None	Moderate to high	Low	Low	Minimal impact	If adequate full crossing time not provided, ped should be informed of this.
Minimum ped clearance time inadequate to accommodate slow walking peds	Moderate to major	1. Lengthen ped clearance times where proportion of slower peds is higher than normal. Take time from WALK phase if WALK longer than minimum.	Low	Needed primarily near elderly housing, schools, etc.	High	Moderate	Low	Varies by circumstance	Impact depends on nature of traffic congestion.
Peds frequently do not obey signal indications	Moderate (see comment)	1. Upgrade ped enforcement efforts.	Low	If done, should be selective enforcement.	Low	High	High	Slightly positive	Although lack of compliance is rampant, impacts are not necessarily negative.
Lack of or improper application of crosswalk markings	Moderate	1. Develop and implement reasonable crosswalk application guidelines.	Moderate	None, but acceptable guidelines need to be developed.	High	Moderate	Low	Positive	

Description of Problem	Magnitude of Problem	Possible Solutions	Current Level of Use or Acceptance	Limitations in Applicability	Potential Effectiveness	Barriers to Implementation	Cost	Impact on Other Groups	Comment
		3. Improve driveway channelization. Would require local mandate.	Moderate	Particularly needed where parking areas open directly to street.	Moderate to high	High	Moderate	Positive	Public participation in financing would usually be needed.
Difficult and hazardous pedestrian movement thru interchange area	Major	1. Provide sidewalk and markings on all new interchanges accessible to peds	Moderate	Applies only to facilities not excluding ped traffic.	High	Moderate	Moderate	Positive	Should become routine practice, required in state/ local guidelines.
		2. Provide barrier between traffic lanes and ped walkway.	Low	Not necessary for low speed facilities.	Moderate	High	Moderate	Minimal impact	Provides additional measure of safety for pedestrians.
		3. For existing interchanges w/o sidewalk or shoulders, consider routing peds onto median.	Low	Primarily applicable to full or partial cloverleaf interchanges.	Moderate	Moderate	Low	Low	Removes peds from hazardous ramp crossings.
Missing sidewalk links	Major	1. Perform sidewalk inventory, priority improvement program, and master plan of walkways.	Moderate	None	High	Low	Low	Minimal impact	Must be followed with funding and construction.
		2. Provide public funds for sidewalk construction with provision for recovering costs from landowner when development occurs.	Low	Legal mechanism must be provided to recover costs.	High	Moderate	Low	Minimal impact	Allows sidewalk to be completed even if area is only partially developed.
		3. Obtain easements or take part of roadway lane to fill in missing links where barriers exist (e.g., retaining walls).	Low	Will be unusual to be able to take part of roadway lane.	Moderate	High	Moderate	Slightly negative	Practical only for limited set of conditions.
Obstructions in sidewalk	Moderate	1. Provide local guidelines limiting location of obstacles.	Low	None	Moderate	Moderate	Low to moderate	Minimal impact	Can easily be provided in local ordinances. Alternate locations not always possible.
		2. Obtain easements, where necessary, to locate objects out of ped path.	Low	Most common objects are controller cabinets, mail boxes, and trash containers.	High	High	Moderate to high	Minimal impact	Easement process time consuming and sometimes costly.

Description of Problem	Magnitude of Problem	Possible Solutions	Current Level of Use or Acceptance	Limitations in Applicability	Potential Effectiveness	Barriers to Implementation	Cost	Impact on Other Groups	Comment
		2. Develop symbol to identify preferred crossing location without marking crosswalk.	Low (some in Europe)	Needs to be more fully tested before widespread application.	Moderate	Moderate to high	Low	Uncertain	Primary purpose is to reduce false sense of security.
Open parking areas, not enforcing disciplined traffic flow and making pedestrian crossings hazardous	Moderate to high	1. For new parking lots, enact local parking lot landscaping standards, emphasizing landscaped islands.	Moderate	None	High	Moderate	Moderate	Positive	
		2. For existing parking lots, islands sufficient to discipline traffic flow.	Low	Parking lot must have ample spaces to accommodate users.	High	Moderate	Moderate	Positive	Owners often more concerned about having adequate space than having landscaping.
Overpass or underpass underutilized because at-grade route more convenient	High	1. Install barrier in median.	Low	Must have median available and no nearby intersections.	High	Moderate	Moderate	Minimal impact	Limits accessibility but increases safety.
		2. Design over/underpass to minimize travel path (e.g., provide stairs in addition to ramps and grade approaches).	Low	Topography must be conducive.	High	Low	Moderate to high	Minimal impact	Handicapped requirements sometimes counterproductive in accessibility for others.
Inadequate street lighting at pedestrian crossing points	Moderate to major	1. Provide traditional street lighting.	Moderate	None	Moderate	Moderate	High	Positive	Should be more intense at intersections and key crossing points.
		2. Provide special pedestrian-oriented lighting.	Low	Provide only at temporary crossing points with heavier ped volumes.	High	Moderate	Moderate		Contrast to normal lighting provides greater conspicuity at key points.
Institutional and Legal Problems									
General lack of respect of pedestrians by drivers	Major	1. Selective enforcement (preceded by publicity) of ped right-of-way.	Low	Should focus on situations where driver yielding is a problem.	High	High	High	Perceived negative	Effect on accident rates is uncertain.

Description of Problem	Magnitude of Problem	Possible Solutions	Current Level of Use or Acceptance	Limitations in Applicability	Potential Effectiveness	Barriers to Implementation	Cost	Impact on Other Groups	Comment
		2. Increase fines for violations of ped right-of-way.	Low	None	Moderate	Moderate	Low	Perceived negative	Needs to be backed by increased enforcement.
Lack of coordination and continuity in pedestrian facilities	Major	1. Make master planning for pedestrian facilities mandatory in state law.	Moderate	None	High	Moderate	Low	Positive	Only way to ensure ped planning takes place is to require it by law.
		2. Increase public investment in completing sidewalks and pathways.	Moderate	None	High	Moderate to high	High	Positive	Consider specifying minimum funding levels by law.
Lack of communication in development process	Major	1. Develop more rigorous administrative procedures to force communication.	Moderate	None	Moderate	High	Low	Positive	Cannot make administration so elaborate that it slows down the development process.
		2. Designate person in public agency as the pedestrian advocate.	Low to moderate	None	High	Moderate	Low	Positive	One of the most effective low-cost actions.
Lack of vocal, organized advocacy group addressing ped needs	Major	1. Establish citizen task force on pedestrian needs.	Low	None	High	Moderate	Low	Positive	Relies on citizens taking an interest.
		2. Establish pedestrian facility "hot line."	Low	None	Moderate	Moderate	Low	Positive	Provides recognized avenue for input.
Inflexibility in zoning and subdivision regulations	Major	1. Build in flexibility to regulations (e.g., performance zoning).	Moderate	Usually depends on local perspective on development.	High	High	Low	Depends on situation	Offers greater potential benefit but also greater risk.
		2. Provide special zones of development for pedestrian orientation.	Low to moderate	Subject to state and local law.	High	Moderate	Low	Positive	Special ped-oriented design guidelines would be provided.

Description of Problem	Magnitude of Problem	Possible Solutions	Current Level of Use or Acceptance	Limitations in Applicability	Potential Effectiveness	Barriers to Implementation	Cost	Impact on Other Groups	Comment
Suburban land use patterns discourage pedestrian travel	Major	1. Provide incentives for mixed-use and development clustering.	Low to moderate	Some areas not physically or politically suited to ped-oriented development.	Moderate	Low	Low	Possibly negative	Higher density development needed for ped-orientation - sometimes opposed by community
		2. Employ "urban village" concept.	Moderate	Must be planned under right physical conditions.	High	Moderate	Low	Positive	Applicable to original development or redevelopment.
		3. Provide for minimum F.A.R.'s as well as maximum.	Low	Only in areas planned for higher density development.	Low	High	Low	Possibly negative	Developers usually incentive toward higher F.A.R.'s anyway.

(Adapted from *Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas*, National Cooperative Highway Research Program Report 294A, Transportation Research Board, Washington, DC, 1987, pp. 85-89.)

APPENDIX B

SITE PLAN AND HIGHWAY DESIGN REVIEW FOR THE PEDESTRIAN — A CHECKLIST

SITE PLAN AND HIGHWAY DESIGN REVIEW FOR THE PEDESTRIAN

A CHECKLIST

NCHRP 20-19(2) — Paper #8
Target Audience = public agency staff
Target publication = Civil Engineering, Public Works, and/or ITE Journal

This text was originally prepared by JHK & Associates, based on National Cooperative Highway Research Reports 294A and 294B.

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DISCLAIMER

On the surface, walking would not seem to be one of those issues that drives community priorities or has a major political consequence. How many candidates have you heard run on the "sidewalk slate"? But politicians have risen and fallen over and over again on issues of urban growth, development and transportation. These issues are often at the heart of local politics.

Walking is an inseparable part of all three of these issues; it is the link between land development and transportation. We walk from our cars into the office building; we walk from the bank to the restaurant; we walk from our homes to the park; and some of us even walk to and from the bus, which takes us to other places we want to go.

While not a national issue, walking is a major, albeit usually unnoticed, factor in how our urban areas are put together. It needs to be looked at as a potential resource, as an ally in shaping the way cities grow. It is inevitable that cities will grow. But we must shape how they grow. One of the important roles of public agency staff is in reviewing the details of how this growth, both in terms of land development and highway construction takes place.

Presented later in this article is a checklist for state and local planners and highway designers for use in site planning and highway design review. The checklist is intended as a practical tool for preventing the inadvertent omission of features that provide for improved pedestrian safety and mobility in suburban communities. It does not provide all the details necessary to produce the designs, but is a simple reminder of what to look for. As such, it should be applicable to the preparers of plans as well as those responsible for review.

The checklist recognizes that pedestrian needs must be integrated into the planning and design process — they cannot be treated independently from the other daily activities of land development and provision of transportation facilities. Often, the pedestrian is simply forgotten altogether or as an afterthought. But the integration of the pedestrian into the site planning and highway design process need not take a great deal of time and effort. Most of these needs can be treated quickly and simply.

Assigning Review Responsibility

To ensure that pedestrian needs do not fall through the planning and designing "cracks," an effective system of site plan and highway design review is needed. The pedestrian perspective is one of many perspectives that need to

be considered in plans review, but is one of the most commonly overlooked. It is here (in site plan and highway design review) that public agency staff can prevent problems that will later be much more difficult and costly to correct.

One of the ways these omissions and missed opportunities can be prevented is to assign someone responsibility of viewing site plans and highway designs from the pedestrian point of view. Often, this is all that is necessary to bring potential deficiencies to light. This need not be a full-time person, but one who gives serious thought (and is given serious opportunity) to review and comment on pedestrian provisions in the site plan or set of highway plans. Within this process, it is important to remember that just because a set of plans adheres to all the applicable standards does not necessarily mean that it adequately accommodates the pedestrian. There is more than one design approach possible and some will be more sensitive to pedestrian needs than others.

The Checklist

Site planning is one of the major planning and design activities that shapes suburban communities. It is handled primarily by the private sector with public agency review. Highway design and traffic operations is largely handled by the public sector. The pedestrian is handled on the borderline of these two domains. This may explain, in part, why the pedestrian is often neglected in the building of communities — both the public and private sectors can think that the pedestrian is either a peripheral part of their responsibility or the responsibility of the other party. The pedestrian should be an integral design factor in site planning and highway design, from the initial concepts, through the final drawings. The site plan reviewer (or site plan preparer, for that matter) can think in terms of four areas in which to be watchful for coverage of pedestrian elements:

- Building arrangements (these usually need to be discussed at a preliminary site plan stage. Little can be done to change building arrangements at the end of the process)
- Overall pedestrian system
- On-site circulation and parking lots
- Walking surfaces and amenities
- Highway design and traffic operations

Specific checklist items are presented in the table. It should be noted that many of these items are equally applicable to highway design review and to site plan review.

Summary

Site planning and highway design are two of the major activities in the development process. Unfortunately, the pedestrian often gets lost in the shuffle of other major site and highway decisions. This can be guarded against by remembering to include pedestrian elements at each stage of the planning and design process, from initial concepts to final details. This can be done quickly and simply, but failure to include pedestrian considerations at any step could result in lost opportunities and added costs later on.

The integration of pedestrian elements is a responsibility of both the private and public sectors, of the private sector in the preparation of site planning details and of the public sector in their review and in highway design itself. The checklist presented in the table is a simple tool for both groups to elevate their awareness of pedestrian needs in both the development and review of site plans.

Table. Checklist for Site Plan and Highway Design Review from the Pedestrian Perspective

Building Arrangements and Land Use types

- Has consideration been given to keeping walking distances between buildings to a minimum? Can walking distances to nearby sites be shortened?
- Does the density and mix of land uses foster walkability, within the zoning constraints that exist on the site?
- Will the building arrangements avoid requiring pedestrians to take awkward paths through parking lots?
- Has future development within and adjacent to the site been considered in terms of walkability?

Overall Pedestrian System

- Are both utilitarian walking and opportunities for recreational walking considered?
- Are utilitarian paths direct? Do they provide for connections to existing pedestrian magnets nearby?
- Do recreational pathways take advantage of unique site features?
- Is there easy walk access out of residential areas? Mid-block pathways or pathways at the end of cul-de-sacs may be needed.
- Does the pedestrian system consider the type and probable location of future development on adjacent or nearby parcels of land? Is there flexibility to provide direct connections to adjacent parcels, should that be desired later on?
- Are pedestrian entrances clearly evident, through either design features, topography, signing or markings?
- Are openings through walls, fences and hedges provided for pedestrian access?
- Are there reasonable walking routes to nearby bus stops?
- Are pathways generally visible from nearby buildings and free from dark, narrow passageways?
- Is adequate lighting provided for nighttime security?
- Do pathways lead to safest crossing points?

Walking Surfaces and Amenities

- Are the walking areas scaled to the pedestrian?
- Are the walking surfaces skid-resistant and sloped for drainage, but less than 12:1?
- Are provisions made for curb ramps and are they properly designed?
- Are major changes in grade properly treated with stairways and handrails?

Highway Design and Traffic Operations

- Is the number of vehicle driveways kept to a minimum?
- Is the parking lot circulation system designed for good vehicular disciple, using landscaped islands and other traffic control features?
- Are crossings of wide, open expanses of parking lot held to a minimum?

Table. Checklist for Site Plan and Highway Design Review from the Pedestrian Perspective (cont.)

- Are pedestrian/vehicle conflict points kept to a minimum?
- Are pedestrians clearly visible to traffic at pedestrian crossing locations?

Highway Design and Traffic Operations

- Is street width for local residential streets (and appropriate local commercial streets) kept to a minimum?
- Are curb radii kept to the minimum necessary to keep pedestrian crossing distances short?
- Are non-major intersection designs simple? Three-way intersections are preferred over four-way.
- Are medians or refuge islands provided where pedestrians must cross four or more lanes of traffic?
- Are walkways along the street separated and buffered from traffic as much as possible?
- Are crosswalk markings justified and are they placed at locations with good sight distance and roadway lighting?
- Are luminaries provided directly over pedestrian crossing locations?
- Have pedestrian accommodations along bridges been considered?
- Have pedestrian crossings at interchanges been considered?
- Where guardrail is necessary, can the pedestrian pathways be placed behind it for additional protection and separation?
- Have the potential problems of pedestrians crossing at traffic signals been adequately thought about? Will the phasing tend to confuse the pedestrian and what can be done to give people a clear indication of when to cross?
- Have pedestrian walking routes through construction areas been planned for?
- Are transit stops provided with a reasonable area to stand out of the mud and away from traffic?

APPENDIX C

GUIDELINES FOR CURB CUTS AND RAMPS FOR DISABLED PERSONS

GUIDELINES
CURB CUTS AND RAMPS
FOR
DISABLED PERSONS

DIVISION OF HIGHWAYS

HIGHWAY DESIGN BRANCH

DESIGN SERVICES UNIT

NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

JULY 1995

Table of Contents

INTRODUCTION

These guidelines for curb ramps were developed as part of an overall program of action to remove the restrictive barriers which severely impede the daily movements of physically handicapped and elderly persons. The common curb is probably the most encountered barrier which denies these citizens the mobility to enjoy the privilege and right of a full, active role in society.

The details and guidelines included in this booklet were originally developed as directed by legislation enacted by the 1973 Session of the General Assembly, identified as Ratified House Bill 1296 and codified as G.S. 136-44.14. A copy of this law is included. These guidelines were developed and revised through consultation with representatives of the Governor's Study Committee on Architectural Barriers which was composed of the Governor's Advocacy Council for Persons with Disabilities and The Division of Services for the Blind. The construction details of the ramp included in this booklet were revised in January 1992, to comply with 36CFR Part 1191 Title III of the Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Final Guidelines.

This booklet is intended to be a general guide for curb ramps or curb cut locations only. Many specific locations will involve problems particular to it alone, and therefore some deviation from this guide will be necessary. In these situations, the use of sound judgment, safety, and the recognition of those features which should be retained will produce a satisfactory design.

With the primary purpose of the program kept in mind and a positive approach taken to it, the success will be rewarding to more than one-half million handicapped North Carolinians. Thank you for doing your part.

GUIDELINES ON RESPONSIBILITY

In the case of construction or reconstruction of curbing on any existing or proposed public street, the city, county, or State having jurisdiction shall require complete conformance to this law prior to permitting the encroachment for the construction or prior to acceptance of the street onto its system.

In the case of the reconstruction of curbing, the responsibility for providing the curb cut and ramp and all the work necessary to accomplish this including any removal and replacement of any existing curbs and sidewalks or any other work required to achieve the complete facility shall be upon the party which causes the existing curb to be cut.

In the case of the new construction of the curbing, the responsibility for providing the curb cut and ramp and all the work necessary to accomplish this shall be upon the party causing the curb to be constructed.

Construction of curb cuts and ramps will be required when streets with curb and gutter and sidewalk (either existing or planned) are resurfaced.

CURB RAMPS OR CURB CUTS

FOR HANDICAPPED PERSONS

G.S. 136-44.14

(a) Curbs constructed on each side of any street or road, where curbs and sidewalks are provided and at other major points of pedestrian flow, shall meet the following minimum requirements:

(1) No less than two curb ramps or curb cuts shall be provided per lineal block, located at intersections.

(2) In no case, shall the width of a curb ramp or curb cut be less than 40 inches.

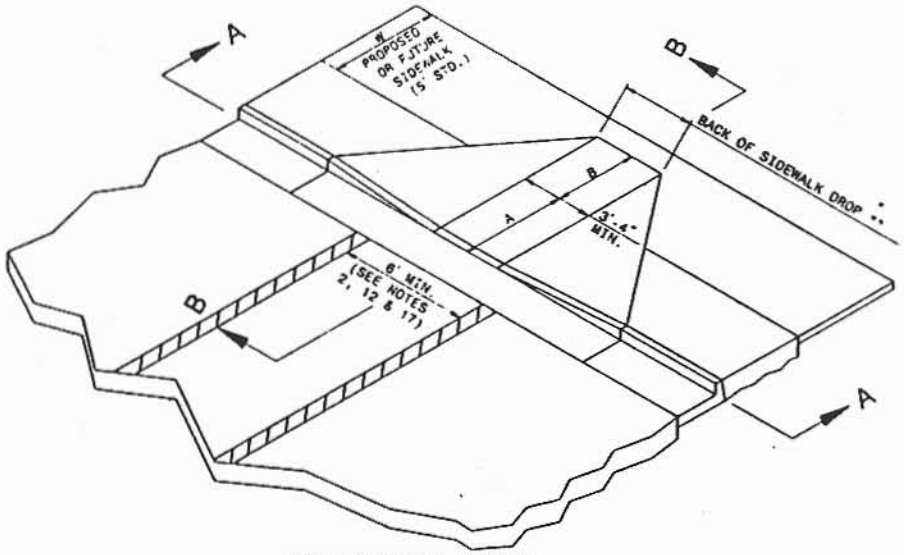
(3) The maximum gradient of such curb ramps or curb cuts shall be eight and thirty-three one-hundredths percent (8.33%) (12 inches slope for every one-inch rise) in relationship to the grade of the street or road.

(4) One curb ramp or curb cut may be provided under special conditions between each radius point of a street turnout of an intersection, if adequate provisions are made to prevent vehicular traffic from encroaching on the ramp.

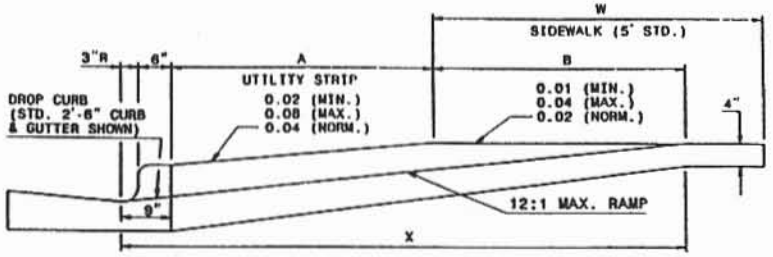
(b) Minimum requirements for curb ramps or curb cuts under subsection (a) shall be met (I) in the initial construction of such curbs, and (ii) whenever such curbs are reconstructed, including, but not limited to, reconstruction for maintenance procedures and traffic operations, repair, or correction of utilities.

(c) The Department of Transportation, Division of Highways, Highway Design Section, is authorized and directed to develop guidelines to implement this Article in consultation with the Governor's Study Committee on Architectural Barriers (or the Committee on Barrier-Free Design of the Governor's Committee on Employment of the Handicapped if the Governor's Study Committee on Architectural Barriers ceases to exist) . All curb ramps or curb cuts constructed or reconstructed in North Carolina shall conform to the guidelines of the Highway Design Section.

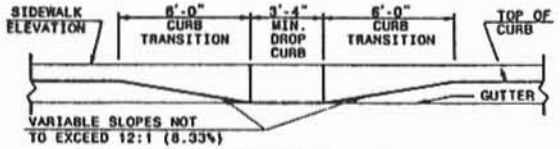
(d) The Department of Transportation, Division of Highways, Highway Design Section, is authorized and directed to provide free copies of this article together with guidelines and standards, to municipal and county governments and public utilities operating within the State. (1973, c.718, ss. 1-4.)



ISOMETRIC VIEW



SECTION B-B



SECTION A-A

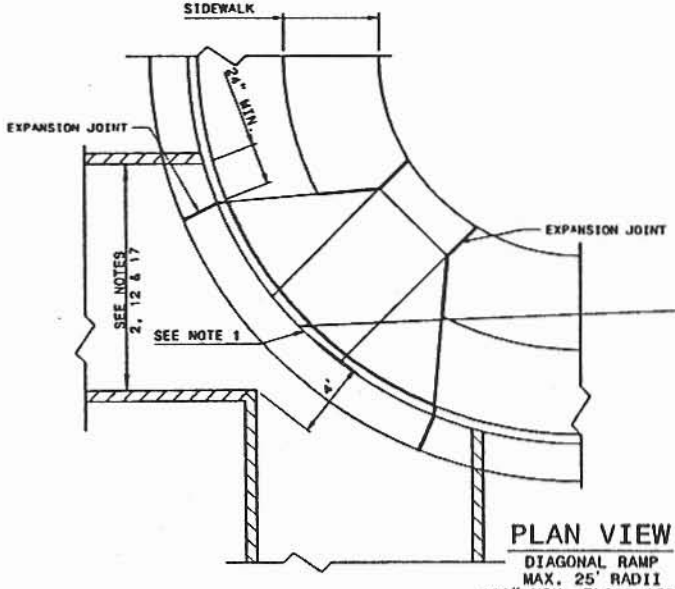
W	A	W+A+9"	X	B
5'	0.0'	5.8'	5.8'	5.0'*
6'	0.0'	6.8'	6.8'	6.0'**
7'	0.0'	7.8'	7.3'	6.5'**
8'	0.0'	8.8'	7.3'	6.5'**
5'	2.0'	7.8'	7.8'	5.0'
5'	2.5'	8.3'	8.1'	4.8'
5'	3.0'	8.8'	8.3'	4.4'
5'	3.5'	9.3'	8.4'	4.1'
5'	4.0'	9.8'	8.6'	3.8'
5'	4.5'	10.3'	8.7'	3.4'
5'	5.0'	10.8'	8.9'	3.1'

B = X-(A+9")

B = DISTANCE FROM FRONT EDGE OF SIDEWALK TO BACK POINT OF 12:1 (8.33%) SLOPE.

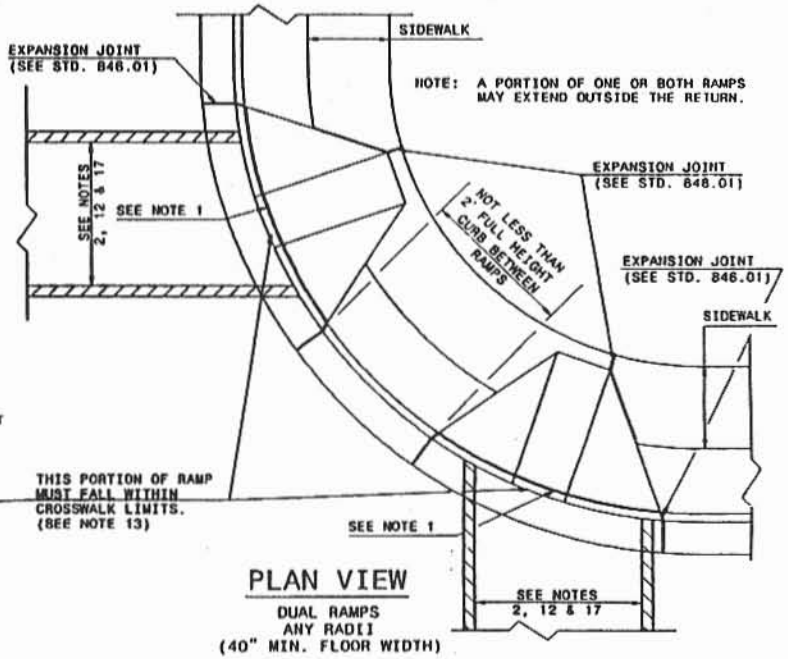
* BACK OF SIDEWALK DROP REQUIRED FOR ALL SIDEWALK SLOPES.

** BACK OF SIDEWALK DROP REQUIRED FOR SIDEWALK SLOPES 0.04.



PLAN VIEW

DIAGONAL RAMP
MAX. 25' RADII
(60" MIN. FLOOR WIDTH)
[NOT PERMISSIBLE FOR NEW CONSTRUCTION]



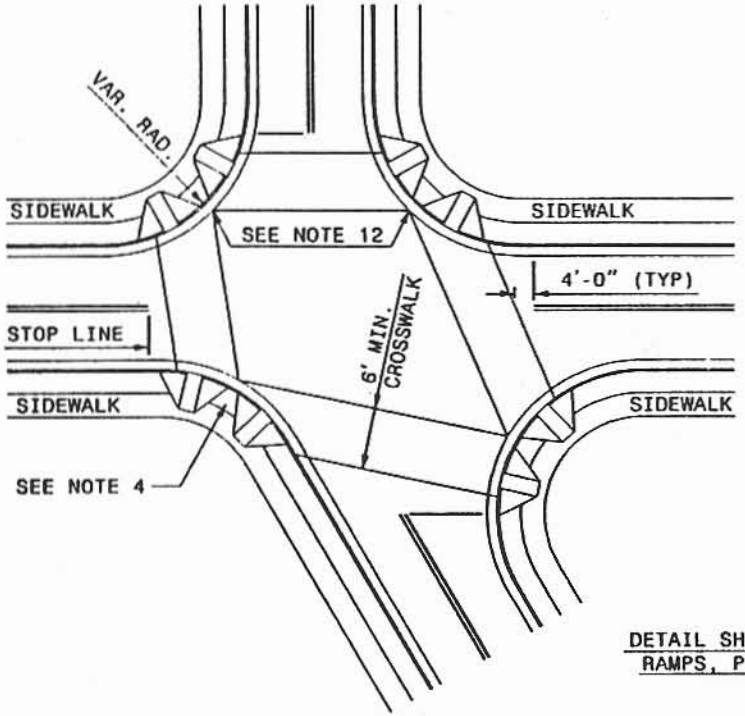
PLAN VIEW

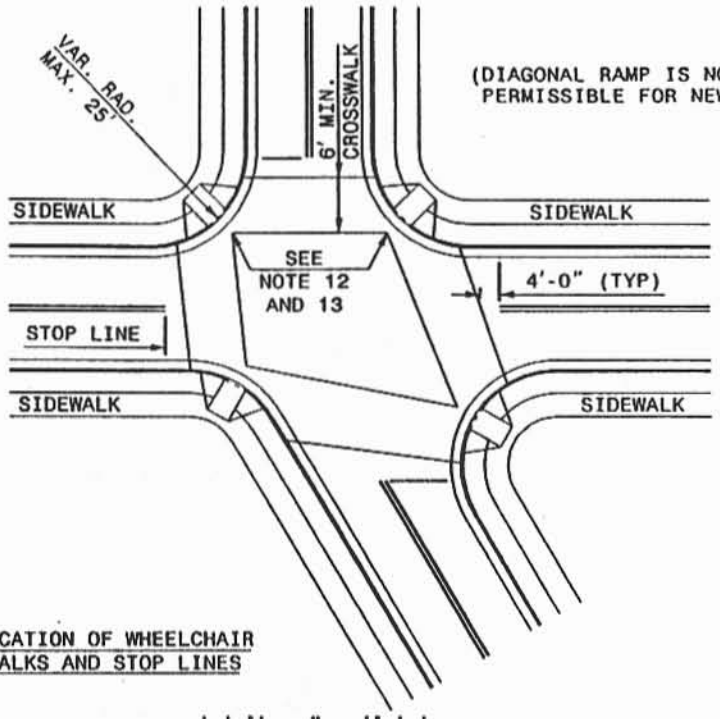
DUAL RAMPS
ANY RADII
(40" MIN. FLOOR WIDTH)

ROADWAY PLAN SYMBOL
CCFR
CURB CUT FOR FUTURE RAMP

ROADWAY PLAN SYMBOL
WCR
FOR PROPOSED WHEELCHAIR RAMP

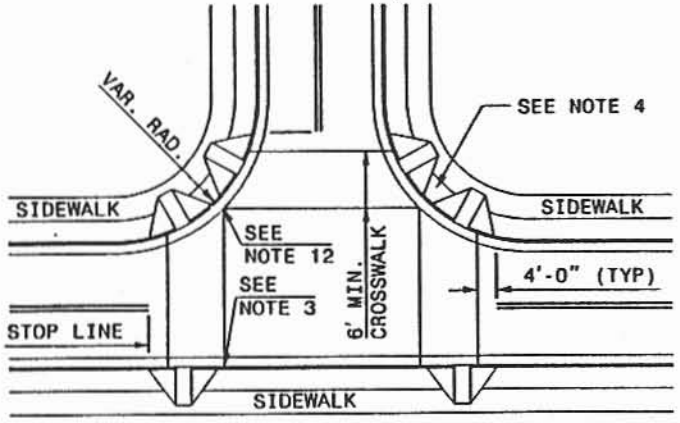
WHEELCHAIR RAMP
CURB CUT

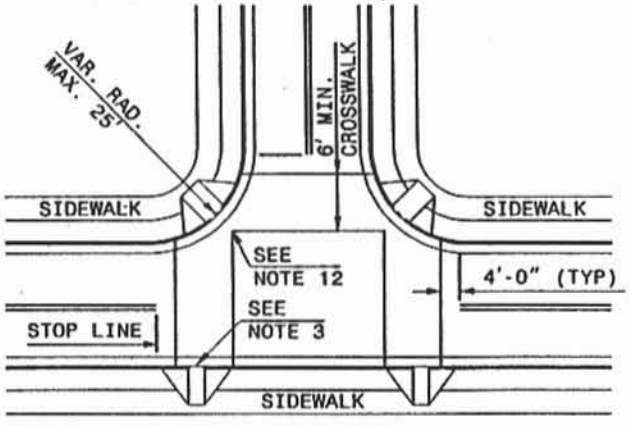




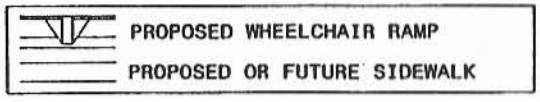
(DIAGONAL RAMP IS NOT PERMISSIBLE FOR NEW CONSTRUCTION)

DETAIL SHOWING TYPICAL LOCATION OF WHEELCHAIR RAMPS, PEDESTRIAN CROSSWALKS AND STOP LINES





DETAIL SHOWING TYPICAL LOCATION OF WHEELCHAIR RAMPS, PEDESTRIAN CROSSWALKS AND STOP LINES FOR TEE INTERSECTIONS



ALLOWABLE LOCATIONS

DUAL RAMP RADII.....ANY
DIAGONAL RAMP RADII...MAX. 25'
(DIAGONAL RAMP IS NOT PERMISSIBLE FOR NEW CONSTRUCTION)

WHEELCHAIR RAMP
CURB CUT

NOTES:

1. THE WALKING SURFACE SHALL BE SLIP RESISTANT AND A CONTRASTING COLOR TO THE SIDEWALK.

2. CROSSWALK WIDTHS AND CONFIGURATION VARY BUT MUST CONFORM TO TRAFFIC DESIGN STANDARDS.

3. NORTH CAROLINA GENERAL STATUTE 136-44.14 REQUIRES THAT ALL STREET CURBS BEING CONSTRUCTED OR RECONSTRUCTED FOR MAINTENANCE PROCEDURES, TRAFFIC OPERATIONS, REPAIRS, CORRECTION OF UTILTIES OR ALTERED FOR ANY REASON AFTER SEPTEMBER 1, 1973 SHALL PROVIDE WHEELCHAIR RAMPS FOR THE PHYSICALLY DISABLED AT ALL INTERSECTIONS WHERE BOTH CURB AND GUTTER AND SIDEWALKS ARE PROVIDED AND AT OTHER POINTS OF PEDESTRIAN FLOW.

   IN ADDITION, SECTION 228 OF THE 1973 FEDERAL AID HIGHWAY SAFETY ACT REQUIRES PROVISION OF CURB RAMPS ON ANY CURB CONSTRUCTION AFTER JULY 1,1976 WHETHER A SIDEWALK IS PROPOSED INITIALLY OR IS PLANNED FOR A FUTURE DATE.

   THE AMERICANS WITH DISABILITIES ACT (ADA) OF 1990 EXTENDS TO INDIVIDUALS WITH DISABILITIES. COMPREHENSIVE CIVIL RIGHTS PROTECTIONS SIMILIAR TO THOSE PROVIDED TO PERSONS ON THE BASIS OF RACE, SEX, NATIONAL ORIGIN AND RELIGION UNDER THE CIVIL RIGHTS ACT OF 1964. THESE CURB RAMPS HAVE BEEN DESIGNED TO COMPLY WITH TITLE III OF THE ADA BECOMING EFFECTIVE JANUARY 26, 1992. THE ADA REQUIREMENTS FOR DETECTABLE WARNINGS ARE SUSPENDED EFFECTIVE MAY 12, 1994.

4. WHEELCHAIR RAMPS SHALL BE PROVIDED AT LOCATIONS AS SHOWN ON THE PLANS OR AS DIRECTED BY THE ENGINEER. WHEELCHAIR RAMPS SHALL BE LOCATED AS DIRECTED BY THE ENGINEER WHERE EXISTING LIGHT POLES, FIRE HYDRANTS, DROP INLETS, ETC. AFFECT PLACEMENT. WHERE TWO RAMPS ARE INSTALLED NOT LESS THAN 2 FEET OF FULL HEIGHT CURB SHALL BE PLACED BETWEEN THE RAMPS. DUAL RAMPS SHOULD BE PLACED AS NEAR PERPENDICULAR TO THE TRAVEL LANE BEING CROSSED AS POSSIBLE.

5. ALL 4" CONCRETE USED FOR CONSTRUCTION OF WHEELCHAIR RAMPS WILL BE PAID FOR AS CONCRETE WHEELCHAIR RAMPS. (SQ. YDS.)

6. ALL DEPRESSED CURBS AT WHEELCHAIR RAMPS WILL BE PAID FOR AS THE TYPE CURB AND GUTTER USED ADJACENT TO DEPRESSED CURB. (LN. FT.)

7. SUCH PRICES AND PAYMENTS WILL BE CONSIDERED FULL COMPENSATION FOR ALL MATERIALS, LABOR, EQUIPMENT, TOOLS AND INCIDENTALS NECESSARY TO SATISFACTORILY COMPLETE THE WORK.

8. NO SLOPE ON THE WHEELCHAIR RAMP SHALL EXCEED 1"/1' (12:1) IN RELATIONSHIP TO THE GRADE OF THE STREET.

9. THE WIDTH OF THE WHEELCHAIR RAMP SHALL BE 40" (3'-4") OR GREATER FOR DUAL RAMPS AND 60" (5'-0") OR GREATER FOR DIAGONAL RAMPS.

10. USE CLASS "B" CONCRETE WITH A SIDEWALK FINISH IN ORDER TO OBTAIN A ROUGH NON-SKID TYPE SURFACE.

11. A 1/2" EXPANSION JOINT WILL BE REQUIRED WHERE THE CONCRETE WHEELCHAIR RAMP JOINS THE CURB AND AS SHOWN ON STD. DWG. 848.01.

12. THE INSIDE PEDESTRIAN CROSSWALK LINES SHALL BE SET NO CLOSER IN THE INTERSECTION THAN WOULD BE ESTABLISHED BY BISECTING THE INTERSECTION RADII, WITH ALLOWANCE OF A 4' CLEAR ZONE IN THE VEHICULAR TRAVELWAY WHEN ONE RAMP IS INSTALLED. (SEE NOTE 17)

13. THE CURB CUT AND THE PEDESTRIAN CROSSWALK LINES SHALL BE COORDINATED SO THE FLOOR OF THE WHEELCHAIR RAMP WILL FALL WITHIN THE PEDESTRIAN CROSSWALK LINES. DIAGONAL RAMPS WITH FLARED SIDES SHALL BE PLACED SO 24" OF FULL HEIGHT CURB FALLS WIHTIN THE CROSSWALK MARKINGS ON EACH SIDE OF THE FLARES.

14. THE MINIMUM WIDTH OF THE PEDESTRIAN CROSSWALK SHALL BE 6 FEET. A CROSSWALK WIDTH OF 10 FEET OR GREATER IS DESIRABLE.

15. STOP LINES, NORMALLY PERPENDICULAR TO THE LANE LINES, SHALL BE USED WHERE IT IS IMPORTANT TO INDICATE THE POINT BEHIND WHICH VEHICLES ARE REQUIRED TO STOP IN COMPLIANCE WITH A TRAFFIC SIGNAL, STOP SIGN OR OTHER LEGAL REQUIREMENT. AN UNUSUAL APPROACH SKEW MAY REQUIRE THE PLACEMENT OF THE STOP LINE TO BE PARALLEL TO THE INTERSECTING ROADWAY.

16. PARKING SHALL BE ELIMINATED A MINIMUM OF 20 FEET BACK OF PEDESTRIAN CROSSWALK.

17. ALL PAVEMENT MARKINGS SHALL BE IN ACCORDANCE WITH THE LATEST EDITION OF THE MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES (MUTCD) PUBLISHED BY THE FEDERAL HIGHWAY ADMINISTRATION AND THE NORTH CAROLINA SUPPLEMENT TO THE MUTCD. ALL PAVEMENT MARKINGS SHALL BE DONE BY OTHERS.

WHEELCHAIR RAMP
CURB CUT

INTERNATIONAL SYMBOL OF ACCESS
FOR THE HANDICAPPED